International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

Assessment of the Effects of Mining Activities on Soil Quality around Ijero, Ekiti State Nigeria.

Olanrewaju I. O., Adebayo A. E. Andogunleye O. O.

Submitted: 10-08-2022 Revised: 17-08-2022 Accepted: 20-08-2022

ABSTRACT
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 investigates the effects of mining on the soil quality of Ijero local govt. area, Ekiti State, through the determination of the physicochemical parameters and heavy metals composition of the soil within and out side the mine perimeter. Soil samples were 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 were analyzed using standard analytical method. The pH values ranged from 6.46 to 6.92, EC values ranged from 177.4 to 362.15 µS/cm, Organic carbon ranged from 1.58 to 2.08%, Chloride ranged from 0.068 to 0.18 mg/kg, Sulphide ranged from 2.41 to 6.05 mg/kg and Nitrite ranged from 0.013 to 0.09 mg/kg. Heavy metal analysis in mg/kg showed the concentration of As, Cd, Cu, Pb and Zn ranging from 0.33 to 0.120; 0.014 to 0.069; 0.417 to 1.318; 0.172 to 0.328 and 2.26 to 3.622 respectively. Several indexes were used to analyze the contamination levels of all the heavy metals generated on the samples. The results showed higher changes in the soil physicochemical properties and high heavy metals concentration on the samples within the mine perimeter with relation to the control samples which might have resulted from the mining activities and waste generation from the mine on those samples.

I. INTRODUCTION

Exploitation of mineral resources has assumed prime importance in several developing countries including Nigeria. Mineral resources are an important source of wealth for a nation but before they are harnessed, they have to pass through the stages of exploration, exploitation and processing (Ajakaye, 1985).

The exploitation of minerals influences different environmental domains of the exploited areas, thereby affecting the land, air, water, socio-economic and cultural environment. Besides this, mining greatly influences the health and sanitation condition of the area creating occupational health hazards. Mining activities lead to the environmental pollution of soil by heavy metals which adversely affect soil quality and pose a threat to human health which require a rapid and comprehensive evaluation (Figueroa et al., 2010).

Human activities are numerous and each contributes in one way or the other to the pollution of the environment. It has been observed that no single activity has caused more pollution to the environment than mineral exploitation(Muhammad et al., 2011).Mining and smelting activities, tailings (heavier and larger particles settled at the bottom of the flotation cell during mining) are directly discharged into natural depressions and consequently, many kinds of risk elements enter the environment, causing serious environmental problems resulting in elevated concentrations (Figueroa et al., 2010; Muhammad et al., 2011; Sharma et al., 2007).

Ijero-Ekiti and its environs are endowed with Tantalun-Niobium-Tin and Lithium metals and non-metallic deposits such as feldspar and kaolin hosted by muscovite and lepidolite respectively (Akinola et al., 2014). Lepidolite is a source of lithium and it is industrially useful in lithium storage batteries, ceramic wares, smelting of aluminum ores as well as reduction of shattering in glass (Akinola et al., 2014).

Environmental pollution by heavy metals adversely affects soil quality and poses a threat to human health requires a prompt and comprehensive solution. Numerous anthropogenic sources of pollutants can contaminate the soil and water environment, including inputs from waste waters

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

flowing from mines and waste storage (Song et al., 2010).

Pollution is a worldwide problem that has adverse effects on human health, animals, plants as well as the environment (Khan and Ghouri, 2009). Pollution is the prime causes of many diseases that affect human beings, plants and animals (Kanmony, 2009). Heavy metals are the most prominent pollutants in our world (Papatilippakiet al., 2008). The knowledge of the origin of heavy metals, their accumulation in the soil as well as their interaction with the soil properties and qualities are essential in environmental monitoring (Qishlaqi and Moore, 2007).

Thisworkpresentsassessment of the effects of mining activities on the soil quality of IjeroEkiti, Ekiti State.This was achieved by conducting physicochemical analysis on the soil samples as well as the accumulation of trace metals in the soil samples. The samples were analyzed to ascertain the effect of mining activities on the soil quality of the area through physical and chemical analysis such as particle size analysis, soil pH, organic matter, organic carbon, electric conductivity, chlorine ion, sulphide ion and nitrite ion. Also, some heavy metals contaminants such as Arsenic (As), Cadmium (Cd), Copper (Cu), Zinc (Zn) and Lead (Pb) were analyzed. This type of study is essential since the mine is situated close to farm land and residence.

II. MATERIALS AND METHODS

Samples Description

The material that was mainly used for this research was sand, which was collected at the subsurface of the earth crust.The samples were collected from the mine at Ijero local government, Ekiti state.Ijero-Ekiti under Ijero Local Government Area is located about 120 km NW of Ado-Ekiti the capital of Ekiti State. The study area falls within the Precambrian basement complex of southern Nigeria, and lies between longitudes 5°3’15.57’’E to 5°4’52.56’’E of the Greenwich Meridian and latitude 7°49’11.74’’N to 7°50’9.53’’N of the equator with a land mass area of 5.3 km^2. Thegeologicalmapofsamplinglocation ispresentedinFig.1.The area is characterized by the abundance of pegmatite which harbours minerals such as gemstones and rare earth metals as well as metallic-ores such as lepidolite among other minerals (Chukwuma et al., 2020). Other townsround the study area include Aramoko, Ikoro, Aiyegunle, Ipoti, and Oke-Asa, with Aiyegunle in the Northeast, Ikoro in the Northwest and Oke- Asa in the Southwest.

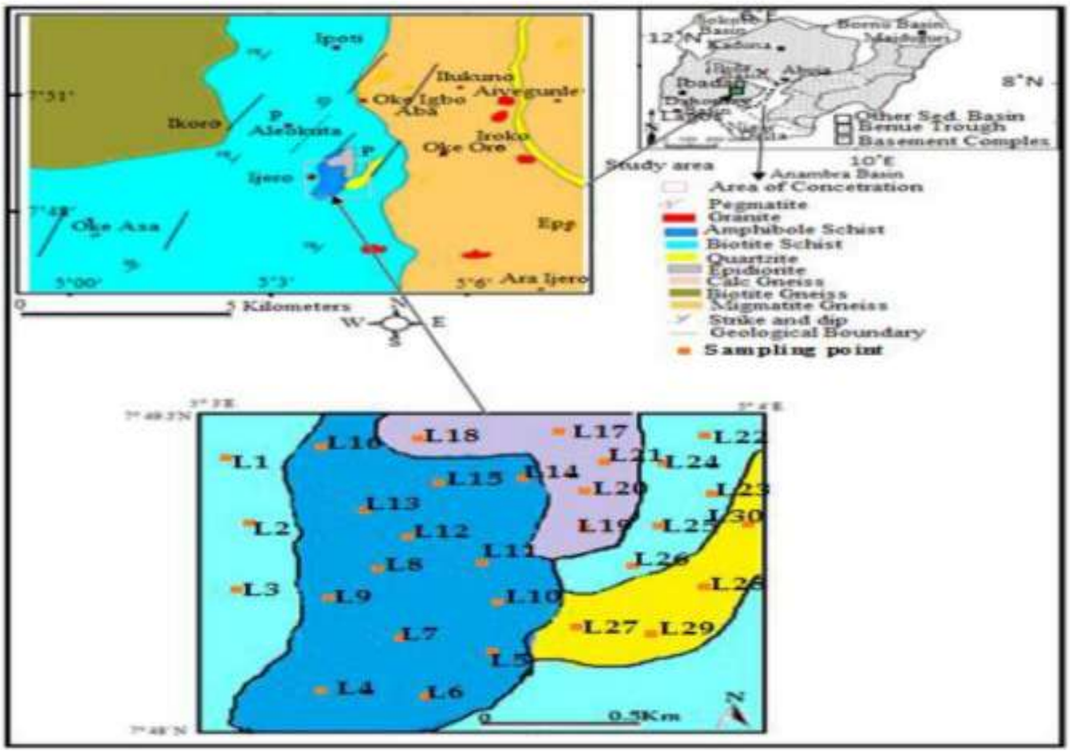

Fig.1Geological and location map of IjeroEkiti area (Talabiet al., 2015)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

Field Sampling

Four different locations were sampled in this project. Three of the locations were within the mine perimeter while the fourth 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 a hand trowel and were rigorously mixed together in a polythene bag. At the end of the samples collection, fours set of samples were available for laboratory analysis.

Sample Preparation

The 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 labeled accordingly prior to analysis, and the residue samples were discarded.

Physicochemical Analysis

All the soil samples were subjected to tests at the College of science, research and extension unit, Afebabalo University Ado-Ekiti. The pH of each sample was determined with a pH meter in a 1:1 ratio suspension of the sample in distilled water in accordance with ASTM D4972.Soil organic carbon is a measureable component of soil organic matter content and was determined by theWalkley and Black procedure (Neson and Sommers,1982). Electrical conductivity was measured in a 1:5 soil to water suspension using an HI 9828 Multi-parameter portable (HANNA instruments). Chloride was determined using Morh's method by adding potassium chromate to the water extract from the soil sample, and was titrated with silver nitrate.Sulphide was determined from soil extract by turbidimetry method (NCHRP, 2009). Nitrate was determined from the mixture of the water extract from the soil samples, salicylic acid and 4M sodium hydroxide then absorbance of the resulting solution was read at 410nm on vis spectrometer.

To determine the concentration of heavy metals in the samples, one gram of pulverized and oven dried 50^0C soil sample was weighed into a 100ml conical flask and moistened with distilled water. 10ml aqua regia HNO_3: HCl (3:1) was added then boiled with steady heat to almost dryness. It was allowed to cool and leached with 5ml of 6M H_2SO_4. 5ml of distilled water was added and allowed to boil for 10mins. It was cooled and filtered; the filtrate was made up to 100ml and was subjected for metal analysis. As, Cd, Cu, Pb, Fe & Zn will be determined using Atomic Absorption Spectrophotometer (AAS) buck scientific 211 AAS VGP.

Soil Quality Assessment

To assess trace element pollution risk, series indices were being calculated.

I. Contamination Factor Index

The contamination factor which was proposed by Håkanson (1980) was used and its expression is:

$$C_f^i = \frac{C_i}{C_n^i} \quad (1)$$

Where; Ci is the measured value of trace element I in the soil sample (mg/kg) and it is the geo-chemical background value of trace element i.

This factor was used to determine the level of contaminant in the soil. The C_f value was divided into four categories: $C_f < 1$ as low contamination; $C_f < 3$ as moderate contamination; $C_f < 6$ considerable contamination; and $C_f > 6$ as very high contamination (Cheng et al., 2018).

II. Potential Ecological Risk Index

The potential ecological risk index assesses the risk behaviour of an element in the environment comprehensively (Håkanson 1980). This index was used to assess the potential ecological risk of trace metal in the studied area. Håkanson (1980) determined the toxicity coefficients for As, Cd, Cr, Cu, Hg, Pb, and Zn to be 1, 2, 5, 5, 10, 30 and 40 respectively. The degree of E_r was classified as follows: $E_r < 40$ low risk; $40 <= E_r < 80$, moderate risk; $80 <= E_r < 160$, considerable risk; $160 <= E_r < 320$, high risk; and $E_r <= 320$, very high risk (Håkanson 1980).

Mathematically, potential ecological risk index (E_r) was calculated as follows:

$$E_r^i = C_f^i \text{ X } T_r^i \quad (2)$$

Where; E_r is the potential ecological risk associated with element I, C_f is the contamination factor of trace element I, and T_r is the toxicity coefficient of element i.

III. Nemerow Comprehensive Index

Soil pollution according to Nemerow index was used to analyze the soil quality. Nemerow index has been widely used to assess soils (Li et al., 2015 and Cheng et al., 2018), stream sediments (Singovszkaet al., 2016) and waters (Cheng et al., 2016).

Mathematically, Nemerow comprehensive index P_i was calculated as follows:

$$P_i = \sqrt{\frac{(mC_d)^2 + (C_{fmax}^i)^2}{2}} \quad (3)$$

Where; mC_d is the modified contamination degree from Equation (4) and Cf_{max} is the maximum value of the contamination factor calculated from

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

Equation (1) (Li et al., 2008). Soil pollution according to the Nemerow index can be classified into five groups: Pi <=0.7 as clean; 0.7 < Pi <=1 as warning limit; 1 <Pi <=2 as slight pollution; 2 < Pi <=3 as moderate pollution; and Pi > 3, heavy pollution (Hong-Guiet al., 2012).

IV. Degree of Contamination Index

The degree of contamination mC_d is defined as the sum of all contamination factors for various heavy metals over the number of analyzed element. The degree of contamination was calculated based on Abrahim's modification of the Håkanson contamination degree C_d. mC_d represents a generalized form of the overall degree of contamination at a sampling point (Håkanson, 1980 and Abrahim, 2005). Mathematically, degree of contamination index mC_d was calculated as follow:

$$mC_d = \frac{\sum_{i=1}^{N} C_f^i}{N} \quad (4)$$

Where; N is the number of elements analyzed and C_f is the contamination factor. Brady et al. (2015) grades' classifications of mC_d were used to analyze the degree of contamination of the soil in the studied area. The classifications were in seven grades: mC_d< 1.5, unpolluted; 1.5 <= mC_d < 2, slightly polluted; 2 <= mC_d< 4, moderately polluted; 4 <= mC_d< 8, considerably polluted; 8 <= mC_d< 16, highly polluted; 16 <= mC_d< 32, strongly polluted; and mC_d>= 32, extremely polluted.

V. Potential Ecological Risk Index for Combined Factors

Potential ecological risk index for combined factors RI for trace metals was analyzed using the formula proposed by (Håkanson, 1980).

$$RI = \sum_{i=1}^{n} E_r^i \quad (5)$$

Where; E_r is the monomial potential ecological risk associated with element i.

The modified grades for the RI of seven trace elements are as follows: RI < 105 as low risk; 105 <= RI < 210, moderate risk; 210 <= RI < 420, considerable risk; and RI <= 420, very high risk (Lin et al., 2016).

III. RESULTS AND DISCUSSION

Physico-chemical Analysis of the Samples

In this study, four samples were collected within the mine perimeter at 100meter interval while a control sample was collected at 500m away from the mine perimeter. The samples were labeled sample A, B, C and D with the control sample being labeled sample D. In order to understand the soil capability to retain heavy metals, geochemical soil characteristics such as soil pH, carbon content, Electric conductivity were performed on the samples. Table 1 shows the results of the Physicochemical analysis of the samples

The results of the pH showed that all the sample were acidic with their values ranging from 6.46 to 6.92, with the control sample being close to neutral as shown in Table 1. Sample B has the highest acidic value of 6.46. The mineral deposits being extracted within the mine region could have contributed to the acidic level of the soil.

The results of the Electricity conductivity ranged from 177.4 to 362.15µs/cm. The EC was observed to be higher in the sample within the mine perimeter (sample A, B and C) while it was observed to be low in the control sample (sample D) which value was 177.4µs/cm. 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).

The soil organic carbon ranged from 1.58% to 2.08% as shown in Table 1.From the results, it could be seen that all the samples within the mine perimeter have high carbon content than the 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, water holding capacity, and stability of aggregates (Silva and Sá- Mendonça, 2007). In addition, the soil organic carbon also affects microbial activity. Hence, a key component of soil fertility, especially in tropical conditions, which interacts with chemical, physical, and biological soil properties and must be considered in assessments of soil health.

The content of chlorine in the samples ranged from 0.65 to 0.18with the control sample having the lowest Cl content. This implies that the mining activities could have contributed to the increment. Increase in chlorine content in the soil indicated high rate of Cl in take by immediate plants which could reduce the crop yields (Onipedeet al., 2020).

The results of the sulphide content ranged from 2.41 to 6.05 while the control sample has a mean value of 3.15. 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.

Nitrite content in the soil samples was observed to be between 0.013 and 0.09 with the control sample possessing the lowest nitrite content. This indicated

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

that the mining activities contributed to the presence of nitrite in the samples which is essential for proper plant growth.

Table 1: Results of Physicochemical analysis of the samples

SAMPLE CODES	pH	EC (µS/cm)	TOC (%)	Cl^- (mg/kg)	S_2 (mg/kg)	NO^{2-} (mg/kg)
A	6.73± 0.7	290.85 ± 31	2.08± 0.3	0.176	5.50± 0.5	0.0665
B	6.68± 0.6	195.81 ± 20	1.725± 0.2	0.091	2.41± 0.2	0.0395
C	6.74± 0.7	302.15± 33	1.95± 0.3	0.1465	6.05± 0.6	0.0685
D	6.92± 0.9	177.38± 12	1.585± 0.2	0.0655	3.15± 0.4	0.0125

Heavy Metal Concentration of the Samples

The results of the heavy metal concentration of the samples are shown in Table 2. The concentration of As present in the sample ranged from 0.33 to 0.120. The content of "As" was observed to be high in all the samples within the mine perimeter in comparison to the control sample. This could also be observed in other heavy metals such as Cd, Cu, Pb and Zn with results ranging from 0.014 to 0.069; 0.417 to 1.318; 0.417 to 1.318; and 0.172 to 0.328 respectively. It could be observed that heavy metals concentration was high in all the samples within the mine perimeter than that of the control samples as shown in Figure 2 and 3 respectively. It could be connoted that that the mining activities have influences in the accumulation of heavy metals in the soil.

Table 2: Result of heavy metals concentration in samples (mg/kg)

SAMPLE CODES	As (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
A	0.115	0.067	1.326	0.296	3.636
B	0.05	0.026	0.627	0.211	2.797
C	0.122	0.0615	1.30	0.328	3.59
D	0.0325	0.0145	0.415	0.169	2.265

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

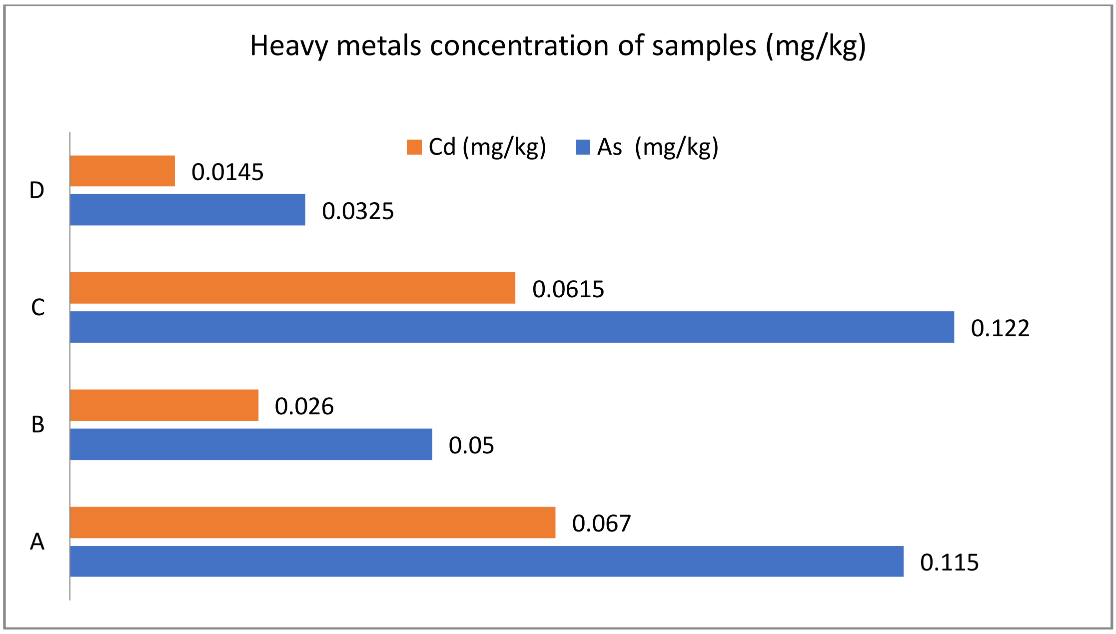

Figure 2: Heavy metals concentration of the samples (mg/kg)

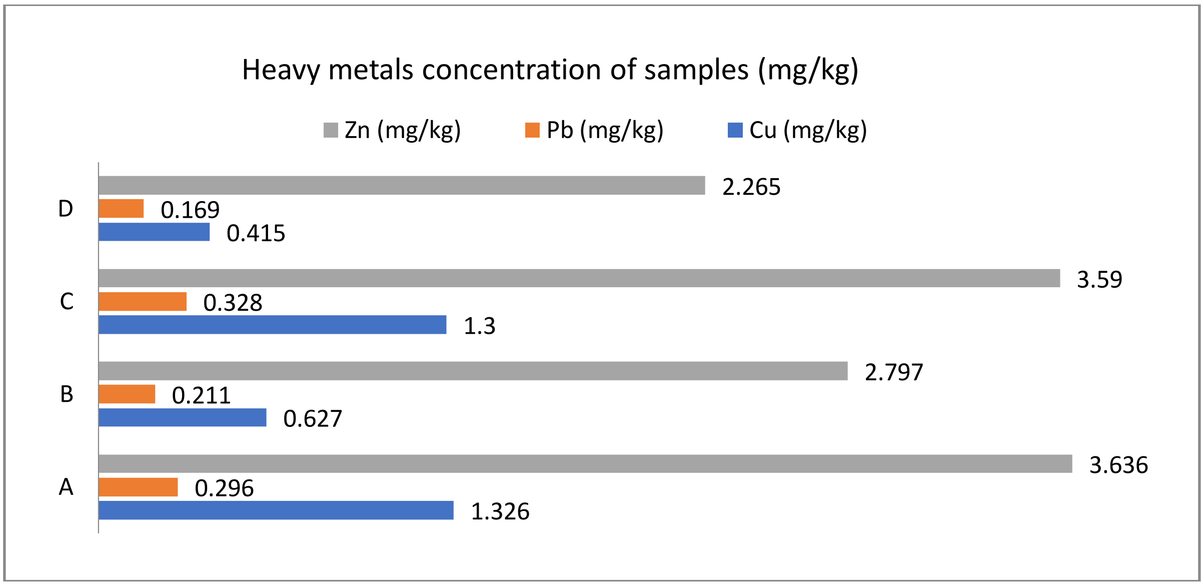

Figure 3: Heavy metals concentration of samples (mg/kg)

Results of Soil Quality Assessment

The contamination index (C_f)of the heavy metals in the soil samples was analyzed. Sample A has C_f value of 3.5 for Arsenic, 4.6 for Cd, and 3.2 for Cu, which indicated a considerable contamination for the heavy metals. The C_f value for Zn was 1.6, which indicated a moderate contamination. Sample B has C_f values of 0.15 and 0.18 for As and Cd respectively which indicated a low contamination. The C_f value of Cu, Pb and Zn were 1.0, 1.25 and 1.2 respectively, which indicated a moderate contamination. Sample C has C_f value ranging from 1.6 to 3.7, which indicated a considerable contamination of the soil as shown in Table 3 and Figure 4 respectively.

The potential Ecological risk index (E_r) was analyzed. The E_r values of the sample ranged from 0.15 to 48. Sample B and C showed z E_r<40 which indicated a low risk for all the analyzed heavy metals. Sample A showed a moderate risk for Zn (Hakanson, 1980). The results of the E_r were showed in Table 4 and Figure 5 respectively.

Soil Pollution according to Nemerow index (PI) was used to analyzed the soil quality. The PI value for As, Cd, Cu, Pb and Zn were 2.75, 3.86, 3.01, 2.4 and 2.4 respectively for sample A, which could

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

be considered as moderate to heavy pollution with respect to the control sample. For sample B, the heavy metals As, Cd, Cu, Pb, and Zn were O.55, 0.55, 0.89, 1.03 and 1.0 respectively, which could be considered as clean to warning limit. The PI values of As, Cd, Cu, Pb and Zn for sample C were 3.22, 3.51, 2.31, 2.31 and 2.19 respectively, which could be considered as moderate to heavy pollution with respect to the control sample as shown in Table 5 and Figure 6 respectively.

The degree of contamination index (mC_d) was analyzed. mC_d value of sample A and C was highly polluted while that of sample B was moderately polluted as shown in Table 6 and Figure 7 respectively.

The potential ecological risk index (RI) for combined factors RI for trace metal was analyzed. RI values for sample A, B and C were 94.2, 54.01 and 89.1 respectively as shown in Table 7 and Figure 8 which could be considered as low risk (Hakanson, 1980).

Table 3: Results of contamination factor index (C^i_f) of the samples

SAMPLES	As	Cd	Cu	Pd	Zn
A	3.5	4.6	3.2	1.75	1.6
B	0.15	0.18	1.0	1.25	1.2
C	3.7	4.2	1.9	1.9	1.6

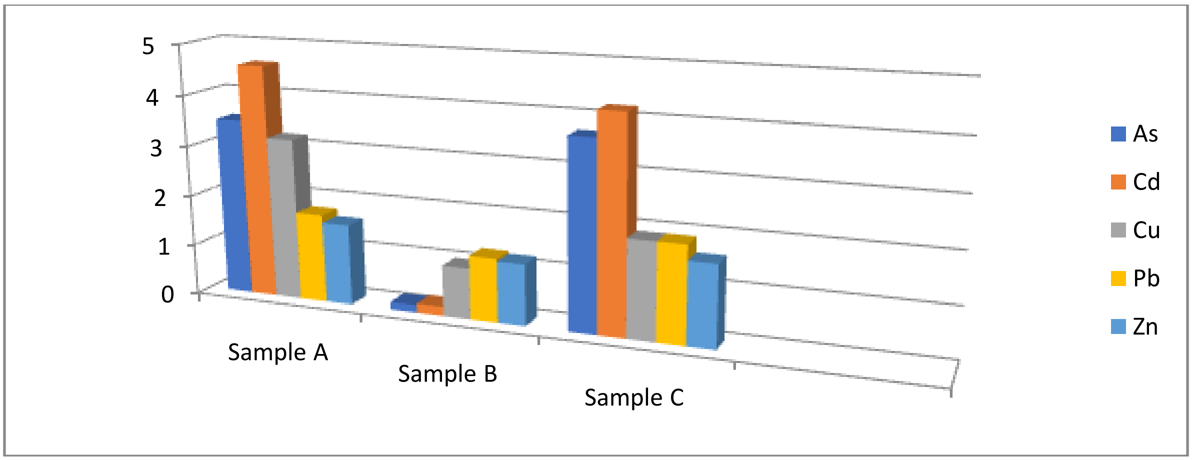

Figure 4: Contamination factor index of the samples

Table 4: Results of potential ecological risk index (E_r) of the samples

SAMPLES	As	Cd	Cu	Pd	Zn
A	3.5	9.2	16	17.5	48
B	0.15	0.36	5	12.5	36
C	3.7	8.4	9.5	19.0	1.6

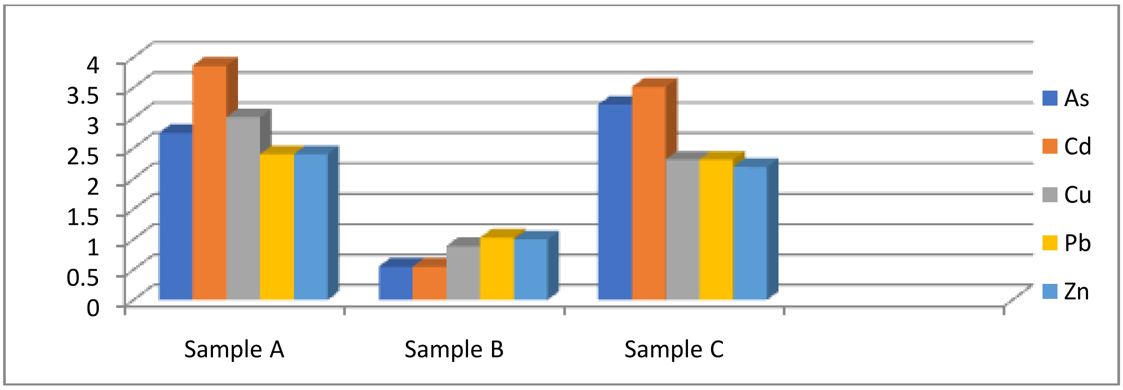

Figure 5: Potential ecological risk index (E_r) of the samples

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 773-783 www.ijaem.net ISSN: 2395-5252

Table 5: Results of Nemerow comprehensive index (P_i) of the samples

SAMPLES	As	Cd	Cu	Pd	Zn
A	2.75	3.86	3.01	2.4	2.4
B	0.55	0.55	0.89	1.03	1
C	3.22	3.51	2.31	2.31	2.19

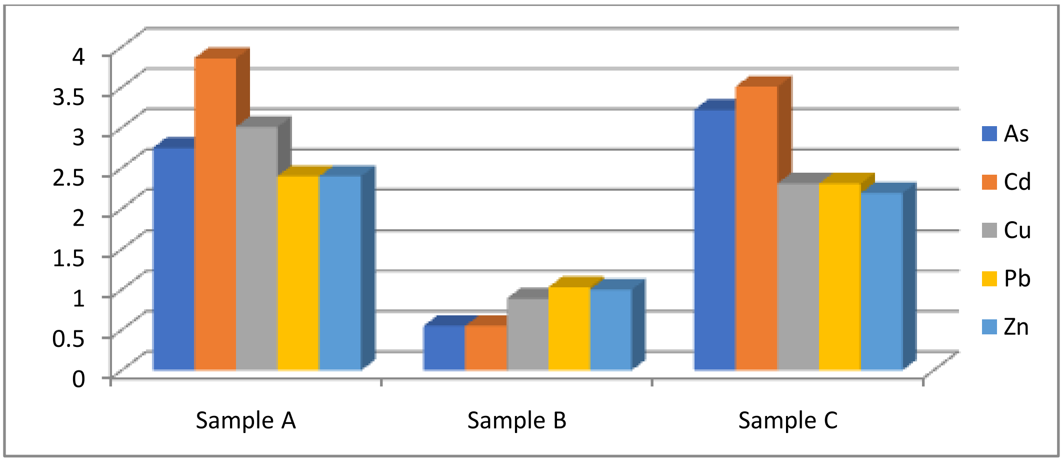

Figure 6: Nemerow comprehensive index (P_i) of the samples

Table 6: Results of degree of contamination index (mC_d) of the samples

Samples	(mC_d)
A	14.65
B	3.78
C	13.3

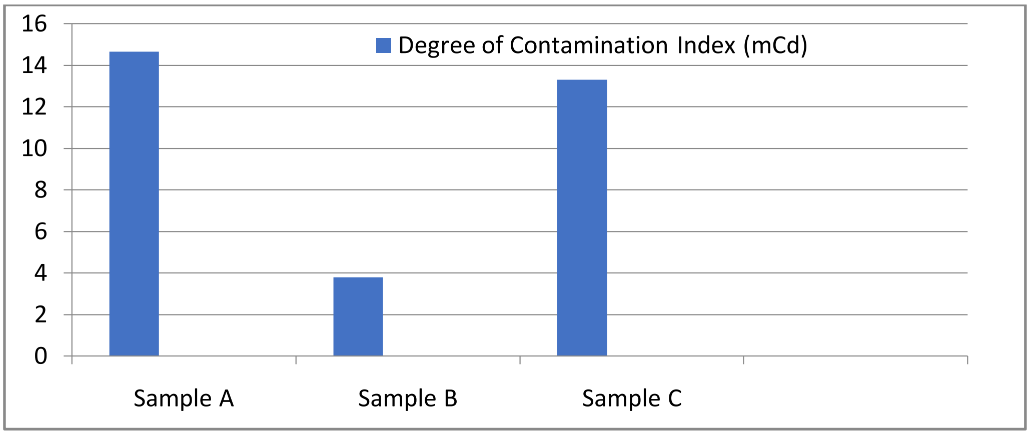

Figure 7: Degree of contamination index (mC_d) of the samples

Table 7: Results of potential ecological risk index for combined factors (RI) of the samples

Samples	**(RI)**
A	94.2
B	54.01
C	89.1

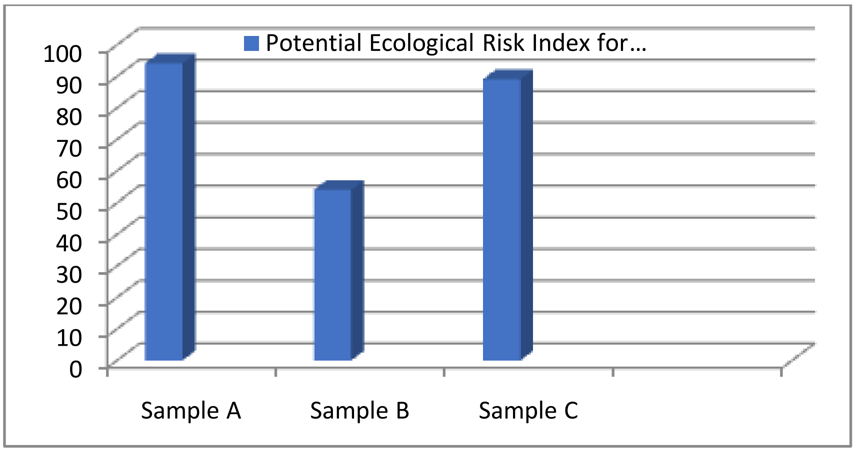

Figure 8: Potential ecological risk index for combined factors (RI) of the samples

IV. CONCLUSION

The effects of mining activities on soil qualities have been assessed through physico-chemical analysis and heavy metal contamination of soil in Ijero-Ekiti mining area. This provides important information about the distribution and the contamination levels of the heavy metals in the mine area with respect to the undisturbed area. Understanding the scale, sources and degree of heavy metal contamination is essential for environmental management. It is also important in reducing risks to human health, ensuring food safety, and managing contaminated soil.

The soils around Ijero-Ekiti mining area contain high concentrations of As, Cd, Zn and Cu when compared to their concentrations in the control soil, indicating that the mining activities has contributed to the increase in level of heavy metals observed in the area, though the concentration do not exceeded the standard concentration that should be present in the soil. The pH value of the samples varied between 6.68 and 6.92, which indicates moderate acidity in all the soil samples.

The results of the Contamination factor index, Potential ecological risk index (E_r) and Nemerow comprehensive index (P_i) show that Cadmium is the major pollutant followed by Arsenic and Copper while the results of degree of contamination index (mC_d) and potential ecological risk index for combined factors (RI) show that Sample A is the most polluted region, followed by Sample C and B respectively. The contamination by Cd represents a serious threat to the environment and human health, because Cd is considered one of the most toxic and carcinogenic heavy metals and its main source could be from intensive mining and processing activities. The contamination of the soils by heavy metals in the area is increasing and such a situation requires effective measures to prevent further pollution of the ecosystem.

Further research should focus on the assessment, monitoring and control of the heavy metals contamination of the air-borne dust, stream waters and sediments.

REFERENCES

[1]. Abrahim, G.M.S. Holocene sediments of Tamaki Estuary (2005): Characterization and impact of recent human activity on an urban estuary in Auckland. Ph.D. Thesis, University of Auckland, Ajakaiye D. E. (1985): Environmental problems associated with mineral exploitation in Nigeria. Paper presented at the 21st Annual Conference of the Nigeria Mining and Geosciences Society; Jos. pp. 140–148.

[2]. Akinola, Oluwatoyin O, Okunlola, Olugbenga A, Obasi , Romanus A. (2014): Physico-Chemical Characteristics And Industrial Potentials Of Lepidolite From Ijero-Aramoko Pegmatite Field, Southwestern Nigeria International journal of scientific & technology research volume 3, issue 3, issn 2277-8616

[3]. Bennett, L.T., Mele, P.M., Annett, S., Kasel, S. (2010): Examining links between soil management, soil health, and public benefits in agricultural landscapes: an Australian perspective. Agriculture, Ecosystemsand Environment 139, 1-12.

[4]. Brady, J.P.; Ayoko, G.A.; Martens, W.N.; Goonetilleke, A. (2015) Development of a hybrid pollution index for heavy metals in marine and estuarine sediments. Environ. Monit. Assess. 2015, 187, 306.

[5]. Cheng, X.; Danek, T.; Drozdova, J.; Huang, Q.; Qi, W.; Zou, L.; Yang, S.; Zhao, X.; Xiang, Y. (2018): Soil heavy metal pollution and risk assessment associated with the Zn-Pb mining region in Yunnan, Southwest China. Environ. Monit. Assess. 190, 194.

[6]. Cheng, X.; Qi, W.; Danek, T.; Matysek, D.; Huang, Q.; Zhao, X.; Zhou, Z.; Fang, R.; Zou, L.; Xu, J. (2016) Heavy metal contamination of surface water and groundwater in and around GejiuTin Mine, Southwest China. In˙zynieriaMineralna 17, 93–98.

[7]. Chukwuma E. C., Chukwuma D. M. and Adio A. F. (2020). Flora diversity of Ijero Local Area of Ekiti State, South-Western Nigeria. The Journal of the Society for Tropical Plant Research 7(1): 55–64,.

[8]. Figueroa F, Castro-Larragoitia J, Aragón A, García-Meza J (2010): Grass cover density and metal speciation in profiles of a tailings-pile from a mining zones in Zacatecas, North-Central Mexico. Environ. Earth Sci. 60(2):395-407.

[9]. Håkanson, L. (1980): An ecological risk index for aquatic pollution control. A sedimentological approach. Water Res., 14, 975–1001.

[10]. Hong-Gui, D.; Teng-Feng, G.; Ming-Hui, L.; Xu, D. (2012): Comprehensive assessment model on heavy metal pollution in soil. Int. J. Electrochem. Sci. 7, 5286–5296.

[11]. Kanmony, C. (2009): Human right and health care. New Delphi, India: Mittal Publication. Khan, A and Gbouri, A. (2011): Environmental pollution; its effects on life and its remedies. Journal of Arts, Science and Commerce; 2: 276-285.

[12]. Li, H.; Xiao, T.F.; Shuang, Y.; He, L.B.; Ning, Z.P.; Li, D.H.; Zhu, C.S. (2008) Geochemical distribution and Environmental quality of cadmium in river sediment around the JindingPb- Zn mine area in Yunnan. Environ. Sci. 2894–2898.

[13]. Li, J.G.; Pu, L.J.; Liao, Q.L.; Zhu, M.; Dai, X.Q.; Xu, Y.; Zhang, L.F.; Hua, M.; Jin, Y. (2015): How anthropogenic activities affect soil heavy metal concentration on a broad scale: A geochemistry survey in Yangtze River Delta, Eastern China. Environ. Earth Sci. 73, 1823–1835.

[14]. Lin, Q.; Liu, E.; Zhang, E.; Li, K.; Shen, J. (2016): Spatial distribution, contamination and ecological risk assessment of heavy metals in surface sediments of Erhai Lake, a large

[15]. eutrophic plateau lake in southwest China. CATENA 145, 193–203.

[16]. Muhammad S, Tahir Shah M, Khan S (2011): Heavy metal concentrations in soil and wild plants growing around Pb-Zn sulfide terrain in the Kohistan region, northern Pakistan. Microchem. J. 99:67-75.

[17]. Nelson DW, Sommers LE (1982).Total carbon, organic carbon and Agronomy 9 American SocietyOf Agronomy, Madison, WIpp 279- Organic matterIn Page, L. (Ed.) Methods of Soil Anaysis. Part 2. 539.

[18]. Okunlola, O. A and Akinola, O. O. (2010): Petrochemical characteristics of the Precambrian rare metal pegmatite of OkeAsa area, southwestern Nigeria: implication for Ta-Nb mineralization RMZ Materials and Geo-environment, vol. 57(4): 525-538,

[19]. Onipede A. E., Oyelade, W. A., Omosebi J. G. and Obabire A. A. (2020). Physicochemical and Heavy metals Analysis of Soil around Palm oil producing Area in IllutitunOsoore, Nigeria.

[20]. International Research Journal, 6 (1).

[21]. Papafilippaki, A; Kotti, M. and Stavroulakis, G. (2008): Seasonal variations in dissolved heavy metals in the Keritis River Chania, Greece. Global Nest Journal; 3:320-325.

[22]. Pierzynski, G.M., Sims, J.T. and Vance, G.F. (2000): Soils and Environmental Quality, CRC press, London, UK, 2nd edition.

[23]. Qishlaqi, A. and Moore, F. (2007): Statistical analysis of accumulation and sources of heavy metals occurrence in agricultural soils of Khoshk River Banks, Shiraz, Iran. American –Eurasian Journal of Agriculture and Environment Science; 2:565-573.

[24]. Sharma RK, Agrawal M, Marshall F (2007): Heavy metal contamination of soil and vegetables in suburban areas of Varanasi, India. Ecotoxico. Environ. Safety. 66 (2): 258-266

[25]. Silva, I.R., Sa Mendonca, E. (2007). Materiaorganicado solo = Soil organic matter. p. 275-374.

[26]. Singovszka, E.; Balintova, M.; Holub, M. (2016): Heavy metal contamination and its indexing approach for sediment in Smolnik creek (Slovakia). Clean Technol. Environ. Policy 18, 305–313.

[27]. Song Y, Ji J, Mao C, Yang Z, Yuan X, Ayoko GA, Fros RL (2010): Heavy metal contamination in suspended soils of Changjiang River – environmental implications. Geoderma. 159:286-295.

[28]. Talabi A. O., Afolagboye L. O,Aladejana, J. A., Akinola, O. O., and Aturamu, A. O. (2015): Of Impacts of Artisanal and Groundwater Quality of Ijero-Ekiti, South Small-Scale Mining Activities on Western Nigeria. International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 4,

[29]. Yassir, Barkouch and Alain, Pineau (2016) Evaluation of the impact of mine activity on surrounding soils of DraaLasfar mine in Marrakech- Morocco. African Journal of Environmental Science and Technology Vol. 10(1), pp. 44-49.