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Assessment of Heavy Metals from Soil and Plants of Maiganaga Mining Site Gombe, Nigeria

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ABSTRACT

Environmental contaminants such as heavy metals released by activities related to mining deserves attention. The purpose of this study was to assess the level of heavy metal concentration in soil and plants of Maiganga coal mining site Gombe, Nigeria. Six leaves samples of Trees (*Mangifera indica*, *Azadirachta indica*, *Eucalyptus globulus*, *Anacardium occidentale*, *Cassia javanica* and *Jatropha curcas*) were collected at the reclaimed site and twelve soil samples were collected at both Mining and the Reclaimed sites at three different spots and at two different depths (15 & 30cm). Each soil and plant samples were dried, crushed and then sieved. Using aqua regia (hydrochloric acid by nitric acid, in a 3:1 volume ratio). Chromium (Cr), Cadmium (Cd), Arsenic (As), Iron (Fe), and Lead (Pb) concentrations were measured from the samples using Atomic Absorption Spectrometry. The results revealed that the concentrations of heavy metals (Cd, Cr, Fe, As, and Pb) in the soil from mining and reclaimed site are generally low and thus found to be within the World Health Organization (WHO) standard. At both 15 and 30cm iron (Fe) indicates high concentration in mining site than the reclaimed site. *M. indica, E. globulus, J. curcas* indicate high concentration of cadmium (Cd) and is higher than the WHO standard. The value obtained for cadmium (Cd) in *A. indica* is within the WHO maximum permissible limit. *A. occidentale and C. javanica* indicate low concentration of the heavy metals (Cd, Cr, Fe, As, and Pb). Arsenic (As) is the lowest concentrated heavy metal in both plant and soil samples. The low levels of As obtained in this study could be attributed to the less release of the heavy metals from the mining activity.

Keywords: Heavy Metals, Soil, Plant, Coal, Mining, Assessment, Maigang.

INTRODUCTION

Mining is the minerals extraction and other geological materials from deposits of the earth of economic value (Ali *et al*., 2021). Large amounts of metal rich waste materials are generated by mining activities and are considered as a major cause of soil contamination (Hernandez, 2020). Spoils, effluents and dust are also generated by mining activities with metal elements concentrations (Zn, Pb, Cd, Cu), which biological receptors and ecosystems might have adverse effects (Farid *et al*., 2019). Global attention of researchers has been focus on heavy metals, more especially those on generative and vegetative plant parts.

Contamination of soil due to heavy metals pose risks and hazards to humans and the ecosystem through contact with contaminated soil, reduction in food quality via phytotoxicity, reduction in land usability for agricultural production causing food insecurity and drinking of contaminated ground water, (Slavik *et al*., 2016). The cultivation of edible plants in contaminated soil, represents a potential risk since the heavy metals can be accumulated in the vegetal tissue (Jongea *et al*., 2019). The adequate restoration and protection of soil ecosystems contaminated by heavy

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metals require their characterization and remediation. In the world, including U.S.A several studies have been focused on this issue (Jablonska & Siedlecka, 2015; Woch *et al*., 2015), Asia (Pavlu *et al.,* 2007; Soudek *et al.,* 2015), Africa (Szabo *et al.,* 2015) and Nigeria (Mayanna *et al.,* 2015). Mining Activities in Maiganga coalmine at Gombe Nigeria could introduce heavy metals in the environment which affect plants, soil organism and the entire ecosystem. There is little or no information on heavy metals contamination in the soil and plants of Maiganga mining site hence, the need for this research.

MATERIALS AND METHODS

Study Area

The study was conducted in Maiganga coal mining site in kumo, Gombe State. The site is located between latitude 10^o 02 0 to 10^o 05^o and longitude10^o 06 0 to 11^o 08 0 at kumo of Akko local government in Gombe state.

Collection of Soil Samples

Soil samples were collected at Maiganga coalmine site. Using soil Auger and meter rule, three (3) soil samples were collected at the surface (0-15cm) and subsurface (15-30cm) of both the active and reclaimed site (twelve soil samples). The soil samples were labelled, bagged and taken to the laboratory for analysis. Prior to analysis, each soil sample was dried for 7 days and sieved to <2 mm according to the method of Abiya *et al.,* (2023).

Soil sample Digestion

The samples were digested using aqua regia (hydrochloric acid: nitric acid, in a 3:1 volume ratio) before being analysed for the heavy metals. One gram (1g) of the sieved soil sample was weighed into a beaker. Aliquots of 30 ml hydrochloric acid and 10 ml nitric acid were added and covered so as to allow for any reaction to subside. The mixture was then placed on a hot plate and heated at 100ºC for about one hour until it become pale yellow. After digestion, the solution was allowed to cool and then filtered using 2mm filter paper. The filtrate was then made up to the 50 ml volume and transferred to 60 ml plastic bottles. The sample bottles were labelled as Aa15, Aa30, Ab15, Ab30, Ac15 and Ac30 for the active Mining site at 15 cm and 30 cm for 3 different spots and Ra15, Ra30, Rb15, Rb30, Rc15 and Rc30 for the reclaimed site at 15cm and 30cm for 3 different spots. Heavy metals in the samples were determined with BUCK SCIENTIFIC 210/211VGPAtomic Absorption Spectrophotometer (Okoro, 2017: Estifanos and Aynalem 2022)

Collection of Plant samples and Preparation

Six (6) different Plant samples (*Mangifera indica*, *Azadirachta indica*, *Eucalyptus globulus*, *Anacardium occidentale*, *Cassia javanica* and *Jatropha curcas*) leaves of the reclaimed site were carefully collected, labelled and pressed before taking to Department of botany herbarium (Gombe State university) for identification. The plant samples were then dried in oven for three days under temperature of 40 ^{0}C as described by Radulescu *et al.,* (2021). Each dried sample was then crushed and sieved to <2 mm to become powdered prior to analysis according to the method of Gebeyehu & Bayissa (2020).

Plant sample Digestion

One gram (1g) of each powdered plant sample was weighed into a beaker. Aliquots of 30 ml hydrochloric acid and 10 ml nitric acid were added and covered so as to allow for any reaction to subside. The mixture was then placed on a hot plate and heated at 100ºC for about forty minutes until the digest become pale yellow. After digestion, the solution was allowed to cool and then filtered using 2mm filter paper. The filtrate was then made up to the 50 ml volume and transferred to 60 ml plastic bottles (Abiya *et al.,* 2023). The sample

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bottles were labelled as *M. indica, A. indica, E globulus, A. occidentale, C. javanica* and *J. curcas* for *Mangifera indica*, *Azadirachta indica*, *Eucalyptus globulus*, *Anacardium occidentale*, *Cassia javanica* and *Jatropha curcas,* respectively.

Heavy Metals Determination Using AAS

Five major toxic heavy metals (cadmium (Cd), chromium (Cr), iron (Fe), arsenic (As) and lead (Pb)) in the samples were determined with BUCK SCIENTIFIC 210/211VGP Atomic Absorption Spectrophotometer (AAS) under standard method as described by Tang *et al.,* (2020).

Data Analysis

One-way ANOVA was adopted to analyze the result obtained by using software version 2022.

RESULTS

Heavy metals concentration in the soil of Maiganga Mining Site (Active site)

Soil and plants of Maiganga coalmine were examined for five heavy metals (Cd, Cr, Fe, As and Pb). Concentrations of heavy metals in the mining site (Table 1). Iron (Fe) showed highest concentration in all sampling spots (‘Aa’, ‘Ab’ and ‘Ac’) at both 15 and 30cm among the heavy metals. Chromium (Cr) was indicate high concentration in spot ‘Aa’ at 30cm and indicate low concentration in spot ‘Ab’ at 15cm among the spots. Cadmium (Cd) concentration level become higher at spot ‘Aa’ at 15cm while ‘Ab’ at 30cm indicate lowest concentration among the spots. ‘Ab’ at 30 cm showed high concentration of lead than other sampling spots while ‘Ac’ at 15cm showed low concentration. Arsenic (As) was found low concentration in all the three sampling spots among all the heavy metals.

Table 1: Heavy metals concentration in the soil of the Maiganga Mining Site (Active site)

Samples	Cd (mg/kg)	Cr (mg/kg)	Fe (mg/kg)	As (mg/kg)	Pb (mg/kg)
Aa 15	0.598 ± 0.010^{a}	0.379 ± 0.002^{c}	1.450 ± 0.012^{b}	0.019 ± 0.005^{b}	0.048 ± 0.000^{c}
Aa 30	0.284 ± 0.001^{c}	1.100 ± 0.230^{a}	1.678 ± 0.004^{a}	0.000 ± 0.000^{d}	0.048 ± 0.001^{c}
Ab 15	0.400 ± 0.005^{b}	0.252 ± 0.003^{d}	1.265 ± 0.010^{c}	0.000 ± 0.000^{d}	0.060 ± 0.001^{b}
Ab 30	0.249 ± 0.002^{c}	0.831 ± 0.009^{a}	1.359 ± 0.006^{b}	0.000 ± 0.000^{d}	0.175 ± 0.002^{a}
Ac 15	0.399 ± 0.010^{b}	0.341 ± 0.005^{c}	1.277 ± 0.003^{c}	0.028 ± 0.000^{a}	0.013 ± 0.001^{d}
Ac 30	0.319 ± 0.002^{b}	0.533 ± 0.005^{b}	1.043 ± 0.365^{d}	0.000 ± 0.000^{d}	0.053 ± 0.001^{b}

Aa 15 = Active site spot ‘a’ at 15cm, Aa 30 = Active site spot ‘a’ at 30cm, Ab 15 = Active site spot ‘b’ at 15cm, Ab 30 = active site spot ‘b’ at 30cm, Ac 15 = Active site spot ‘c’ at 15cm, Ac 30 = Active site spot ‘c’ at 30cm. Mg/kg = Milligrams per kilogram. Mean ± standard error of mean. Values with the same super script in the same Column indicate no significant difference

Heavy Metals Concentration in the Soil of Maiganga Reclaimed Site

Heavy metals concentration of the reclaimed site is (Table 2). Iron (Fe) shown highest concentration in spot ‘Ra’ at 15 and 30cm, ‘Rb’ at 30cm among the heavy metals. Chromium (Cr) indicate high concentration in spot ‘Rb’ at 15cm and ‘Rc’ at both 15 and 30cm among the heavy metals. Cadmium (Cd) indicate low concentration in all the spots when compare with Fe and Cr. lead (Pb) showed high concentration than arsenic (As) in the samples among the spots at both a1a5 and 30cm. Arsenic (As) shown the least concentration in the soil samples of the Reclaimed site at 15 and 30cm.

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Table 2: Heavy metals concentration in the soil of Maiganga reclaimed Site

Samples	Cd (mg/kg)	Cr (mg/kg)	Fe (mg/kg)	As (mg/kg)	Pb (mg/kg)
Ra 15	0.266 ± 0.008^{c}	0.464 ± 0.004^{c}	0.728 ± 0.002^{c}	0.259 ± 0.001^{a}	0.076 ± 0.001^{b}
Ra 30	0.219 ± 0.003^{d}	0.266 ± 0.012^{c}	0.852 ± 0.001^{b}	0.013 ± 0.001^{d}	0.131 ± 0.001^{a}
Rb 15	0.436 ± 0.007^{a}	0.746 ± 0.003^{b}	0.589 ± 0.003^{c}	0.020 ± 0.007^{d}	0.044 ± 0.001^{c}
Rb 30	0.164 ± 0.002^{d}	0.608 ± 0.006^{b}	0.813 ± 0.002^{b}	0.000 ± 0.000^{e}	0.051 ± 0.001^{b}
Rc 15	0.265 ± 0.005^{c}	0.860 ± 0.004^{b}	0.627 ± 0.001^{c}	0.000 ± 0.000^{e}	0.057 ± 0.000^{b}
Rc 30	0.319 ± 0.003^{b}	1.383 ± 0.004^{a}	1.046 ± 0.011^{a}	0.000 ± 0.000^{e}	0.125 ± 0.001^{a}

Ra 15 = Reclaimed site spot ‘a’ at 15cm, Ra 30 = Reclaimed site spot ‘a’ at 30cm, Rb 15 = Reclaimed site spot ‘b’ at 15cm, Rb 30 = Reclaimed site spot ‘b’ at 30cm, Rc 15 = Reclaimed site spot ‘c’ at 15cm, Rc 30 = Reclaimed site spot ‘c’ at 30cm. Mg/kg = Milligrams per kilogram. Mean ± standard error of mean. Values with the same super script in the same Column indicate no significant difference.

Heavy Metals Concentration in Plants of the Reclaimed Site

The concentration of the heavy metals in the plant leaves of the reclaimed site is presented in Table 3. Among the five heavy metals tested in the samples iron (Fe) shown highest concentration in the plants followed by chromium (Cr), cadmium (Cd) and lead (Pb). Arsenic (As) shown low concentration of the heavy metals. *J. curcas* has the highest concentration of chromium (Cr), arsenic (As) and lead (Pb) among the samples, *M. indica* has the highest concentration of cadmium (Cd) among the samples, *E. globulus* shown the highest concentration of iron (Fe) among all the plant samples. *A. occidentale* shown the least concentration of cadmium (Cd) and lead (Pb) among all the samples.

Table 3: Heavy metals concentration in the plants of Maiganga reclaimed site.

Samples	Cd (mg/kg)	Cr (mg/kg)	Fe (mg/kg)	As (mg/kg)	Pb (mg/kg)
Mangifera indica	0.053 ± 0.002^{a}	0.109 ± 0.002^{c}	0.221 ± 0.002^{d}	0.000 ± 0.000^{d}	0.005 ± 0.000^{b}
Azadirachta indica	0.021 ± 0.000^{c}	0.182 ± 0.002^{b}	0.440 ± 0.008^{b}	0.000 ± 0.000^{d}	0.000 ± 0.000^{d}
Eucalyptus globulus	0.035 ± 0.000^{b}	0.086 ± 0.001^{d}	0.540 ± 0.001^{a}	0.000 ± 0.000^{d}	0.002 ± 0.000^{c}
Anacardium occidentale	0.011 ± 0.001^{c}	0.131 ± 0.002^{c}	0.283 ± 0.002^{c}	0.000 ± 0.000^{d}	0.000 ± 0.000^{d}
Cassia javanica	0.014 ± 0.001^{c}	0.144 ± 0.002^{c}	0.371 ± 0.004^{b}	0.000 ± 0.000^{d}	0.000 ± 0.000^{d}
Jatropha curcas	0.025 ± 0.001^{c}	0.248 ± 0.003^{a}	0.331 ± 0.003^{c}	0.122 ± 0.000^{a}	0.016 ± 0.001^{a}

Mean ± standard error of mean.
Mg/kg = Milligrams per kilogram
Values with the same super script in the same Column indicate no significant difference.

Comparison Between Concentrations of Heavy Metals of Mining Site (Active site) with Reclaimed Site at 15cm

Active site at spot ‘a’ (Aa 15) showed high concentration of iron (Fe) and cadmium (Cd) than reclaimed site spot ‘a’ (Ra 15) while reclaimed site spot ‘a’ (Ra 15) indicate high concentration of arsenic (As), chromium (Cr) and lead (Pb) than Active site spot ‘a’ (Aa 15). Active site spot ‘b’ (Ab 15) showed high concentration of iron (Fe) and lead (Pb) than reclaimed site spot ‘b’ (Rb 15) while reclaimed site spot ‘b’ (Rb 15) shown high concentration of chromium (Cr), cadmium (Cd) and arsenic (As). Active site spot ‘c’ (Ac 15) showed high concentration of iron (Fe), cadmium (Cd) and arsenic (As) than reclaimed site spot ‘c’ (Rc 15) while reclaimed site spot ‘c’ (Rc 15) indicate high concentration of chromium (Cr) and lead (Pb) than Active site spot ‘c’ (Ac 15) as described in figure 1

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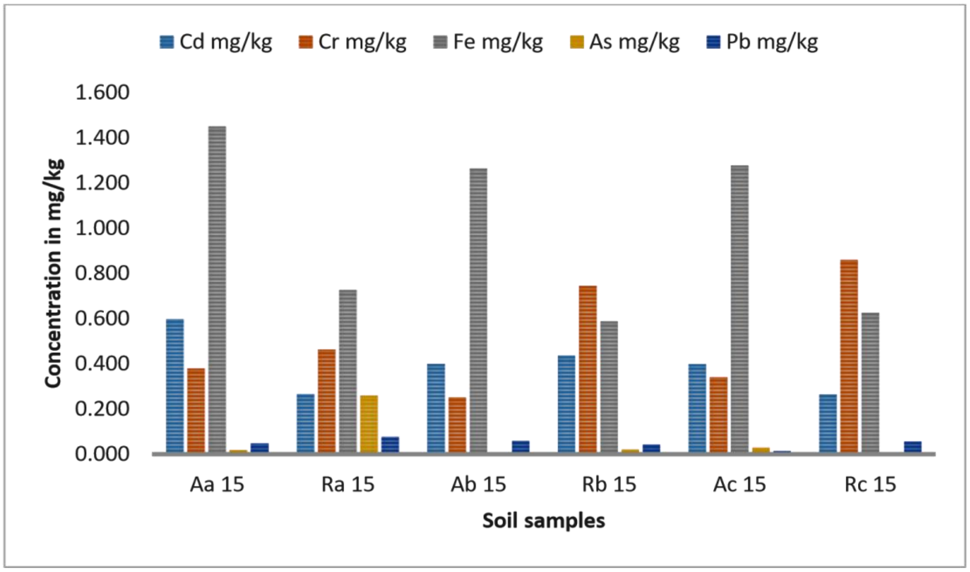

Figure 1: Comparison of heavy metals concentration of Maiganga mining site (Active site) with reclaimed site at 15cm.

Aa 15 = Active site spot 'a' at 15cm, Ra 15 = Reclaimed site spot 'a' at 15cm, Ab 15 = Active site spot 'b' at 15cm, Rb 15 = Reclaimed site spot 'b' at 15cm, Ac 15 = Active site spot 'c' at 15cm, Rc 15 = Reclaimed site spot 'c' at 15cm. Mg/kg = Milligrams per kilogram.

Comparison Between Heavy Metals Concentration of Mining Site (Active site) with reclaimed Site at 30cm

Active site at spot 'a' (Aa 30) showed high concentration of iron (Fe) chromium (Cr) and cadmium (Cd) than reclaimed site spot 'a' (Ra 30) while reclaimed site spot 'a' (Ra 30) indicate high concentration of lead (Pb) and arsenic (As) than Active site spot 'a' (Aa 30). Active site spot 'b' (Ab 30) showed high concentration of iron (Fe), chromium (Cr), cadmium (Cd) and lead (Pb) than reclaimed site spot 'b' (Rb 30) as presented in figure 2. Active site spot 'b' (Ab 30) and reclaimed site spot 'b' (Rb 30) shown equal concentration of arsenic (As). Active site spot 'c' (Ac 30) indicate low concentration of chromium (Cr) and lead (Pb) than reclaimed site spot 'c' (Rc 30). Active site spot 'c' (Ac 30) and reclaimed site spot 'c' (Rc 30) indicate equal concentration of cadmium (Cd), iron (Fe) and arsenic (As).

Comparison Between Heavy Metals Concentration of Mining Site with Permissible Limit

Comparison between concentrations of heavy metals of mining site with permissible limit is presented in Table 4. The concentration of cadmium (Cd), range 0.249 – 0.598 mg/kg in the samples shown a little significance difference from the permissible limit of 0.8 mg/kg. Chromium (Cr) concentration range from 0.252 – 1.100 mg/kg in the samples shown significance difference from the permissible limit of 100 mg/kg. Arsenic (As) ranging from 0.000 – 0.019 mg/kg shown significance difference from the permissible limit of 2 mg/kg. Lead (Pb) among the heavy metals range 0.013 – 0.019 mg/kg also shown significance difference from the permissible limit of 2 mg/kg.

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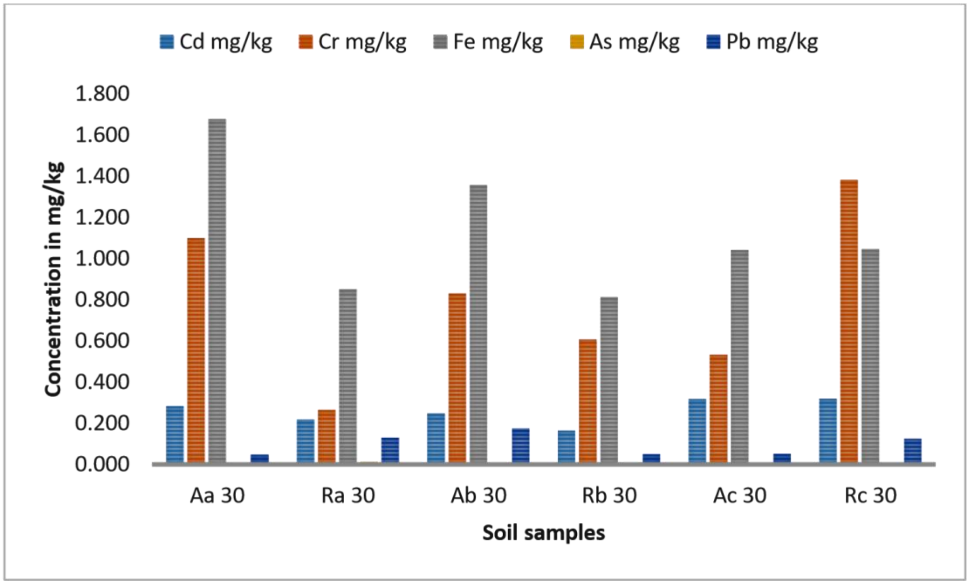

Figure 2: Comparison of heavy metals concentration of Maiganga mining site (Active site) with reclaimed site at 30cm.

Aa 30 = Active site spot 'a' at 30cm, Ra 30 = Reclaimed site spot 'a' at 30cm, Ab 30 = Active site spot 'b' at 30cm, Rb 30 = Reclaimed site spot 'b' at 30cm, Ac 30 = Active site spot 'c' at 15cm, Rc 30 = Reclaimed site spot 'c' at 30cm. Mg/kg = Milligrams per kilogram.

Table 4: Comparison between concentrations of heavy metals of Maiganaga mining site with permissible limit.

Elements	**Samples (Soil)**	**Mining Site**		**WHO Permissible Limit** (Mg/Kg)
		0–15CM (mg/kg)	**15–30CM** (mg/kg)	
Cd	Aa	0.598	0.284	
	Ab	0.400	0.249	**0.8**
	Ac	0.399	0.319	
Cr	Aa	0.379	1.100	
	Ab	0.252	0.831	**100**
	Ac	0.341	0.533	
Fe	Aa	1.450	1.678	
	Ab	1.265	1.359	------
	Ac	1.277	1.043	
As	Aa	0.019	0.000	
	Ab	0.000	0.000	**2**
	Ac	0.028	0.000	
Pb	Aa	0.048	0.048	
	Ab	0.060	0.175	**2**
	Ac	0.013	0.053	

Aa = Active site spot 'a', Ab = Active site spot 'b', Ac = Active site spot 'c'

Mg/kg = Milligrams per kilogram

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Comparison Between Heavy Metals Concentration of reclaimed Site with Permissible Limit

Comparison between heavy metals concentration of reclaimed site at 15cm and 30cm with permissible limit is presented in Table 5. The concentration of cadmium (Cd), range 0.164 – 0.436 mg/kg in the samples showed a significance difference from the permissible limit of 0.8 mg/kg. Chromium (Cr) concentration range from 0.266 – 1.383 mg/kg in the samples showed significance difference from the permissible limit of 100 mg/kg. Arsenic (As) concentration ranging from 0.000 – 0.259 mg/kg showed significance difference from the permissible limit of 2 mg/kg. The concentration of Lead (Pb) with a range between 0.044 – 0.131 mg/kg also showed significance difference from the permissible limit of 2 mg/kg. The permissible limit of iron (Fe) was not available during the study.

Table 5: Comparison between concentrations of heavy metals of Maiganga reclaimed site with permissible limit.

Elements	Samples (Soil)	Reclaimed Site		WHO Permissible Limit (Mg/kg)
		0–15CM (mg/kg)	**15–30CM** (mg/kg)	
	Ra	0.266	0.219	
Cd	Rb	0.436	0.164	**0.8**
	Rc	0.265	0.319	
	Ra	0.464	0.266	
	Rb	0.746	0.608	**100**
Cr	Rc	0.860	1.383	
	Ra	0.728	0.852	
	Rb Rc	0.589	0.813	-----
Fe		0.627	1.046	
	Ra	0.259	0.013	
As	Rb	0.020	0.000	**2**
	Rc	0.000	0.000	
	Ra	0.076	0.131	
Pb	Rb	0.044	0.051	**2**
	Rc	0.057	0.125	

Ra = Reclaimed site spot ‘a’, Rb = Reclaimed site spot ‘b’, Rc = Reclaimed site spot ‘c’ Mg/kg = Milligrams per kilogram.

Comparison Between Heavy Metals Concentration in Plants with Permissible Limit

Comparison between concentrations of heavy metals in plants samples with permissible limit is presented in Table 6. For chromium (Cd), the *M. indica, E. globulus* and *A. occidentale* with 0.053, 0.035 and 0.011 mean respectively shown a significance difference with the permissible limit (0.02), while *A. indica, C. javanica* and *J. curcas* with 0.21, 0.014 and 0.025 mean showed no significance difference with the permissible limit (0.02). For chromium (Cr), *M. indica, A. indica, E. globulus*, *A. occidentale, C. javanica* and *J. curcas* with 0.109, 0.182, 0.086, 0.131, 0.144 and 0.248 mean respectively shown a significance difference with the WHO permissible limit (1.30). For iron (Fe), *M. indica, A. indica, E. globulus, A. occidentale, C. javanica* and *J. curcas* with 0.221, 0.440, 0.540, 0.283, 0.371 and 0.331 mean respectively shown a significance difference with the WHO permissible limit (20.0). For arsenic (As), *M. indica, A. indica, E. globulus, A. occidentale, C. javanica* and *J. curcas* with 0.000, 0.000, 0.000, 0.000, 0.000 and 0.122 mean respectively shown a significance difference with the WHO permissible limit

(1.0). For lead (Pb) *M. indica, A. indica, E. globulus, A. occidentale, C. javanica* and *J. curcas* with 0.005, 0.000, 0.002, 0.000, 0.000 and 0.016 mean respectively shown a significance difference with the WHO permissible limit (2.0).

Table 6: Comparison between concentration of heavy metals in plants samples with permissible limit

Elements	Samples (Plants)	Mg/kg	WHO Permissible Limit (Mg/kg)
	M. indica	0.053	
Cd	*A. indica*	0.021	
	E. globulus	0.035	**0.02**
	A. occidentale	0.011	
	C. javanica	0.014	
	J. curcas	0.025	
	M. indica	0.109	
Cr	*A. indica*	0.182	
	E. globulus	0.086	**1.30**
	A. occidentale	0.131	
	C. javanica	0.144	
	J. curcas	0.248	
	M. indica	0.221	
Fe	*A. indica*	0.440	
	E. globulus	0.540	**20.0**
	A. occidentale	0.283	
	C. javanica	0.371	
	J. curcas	0.331	
	M. indica	0.000	
As	*A. indica*	0.000	
	E. globulus	0.000	**1.0**
	A. occidentale	0.000	
	C. javanica	0.000	
	J. curcas	0.122	
	M. indica	0.005	
Pb	*A. indica*	0.000	
	E. globulus	0.002	**2.0**
	A. occidentale	0.000	
	C. javanica	0.000	
	J. curcas	0.016	

Mg/kg = Milligrams per kilogram.

DISCUSSION

Concentration of some heavy metals in soil and plant of maiganga coalmine was studied. All the soil and plant samples tested in this study were found positive for all the heavy metals analyzed. The heavy metals analyzed are cadmium (Cd), chromium (Cr), iron (Fe), Arsenic (As) and Lead (Pb). The heavy metals were tested at two different depth of the mining site and reclaimed site (15 – 30cm). The concentration of Heavy metals in the soil of the Mining and reclaimed Site at 15 and 30cm indicate that iron (Fe) showed the highest concentration in all the samples. This indicate that iron (Fe) become more abandon in the mining site due to the mining activity. This result is contrary with the findings of Abiya *et al*., (2023) in ijana goldmine Osun State. For both 15 and 30cm in the mining and reclaimed site, arsenic (As) was found to be the metal with the low concentration. This result is in line with the findings of Tahar & Keltoum (2019).

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In this study mining site indicate high concentration of iron (Fe) and cadmium (Cd) while reclaimed site indicates high concentration of chromium (Cr) and arsenic (As), both at 15cm depth. The mining and the reclaimed site indicate no difference in the concentration of lead (Pb). This could be due to the similarity of the soil of both site and there is no any alteration or activity occur in the reclaimed site, this finding conforms to the result of Klaudia & Marian (2015). Comparison between concentration of heavy metals of mining site with permissible limit in this study demonstrate that concentration of Cadmium (Cd), Chromium (Cr) Arsenic (As) and lead (Pb) range 0.249 – 0.598 mg/kg, 0.252 to 1.100 mg/kg, 0.000 to 0.019 mg/kg and 0.013 to 0.019 mg/kg respectively in the samples is below the permissible limit of 0.8 mg/kg, 100 mg/kg 2 mg/kg and 2mg/kg respectively this could be attributed to the less release of the metals from the mining activity. This result is in line with the findings of Ahmad & Erum (2010) and Shrivastava *et al.,* (2017).

The plant absorption of the iron (Fe) in the reclaimed site conforms to the result of Gebeyehu and Bayissa, (2020). Arsenic showed least concentration in the reclaimed site among all the heavy metals. The little concentration recorded might be due to the presence of arsenic (As) in minerals which can be released only by very slow disintegration processes. This finding is in line with the study of Radulescu *et al.,* (2021). This result is in agreement with the finding of Chen *et al.,* (2017) from Xiamen, China. The overall levels of heavy metals accumulation in *J. curcas* sample has followed the order of Cr > Cd > Fe > Pb > As. This is due to their level of absorption in the leaf of the plant.

Relatively high contents of cadmium (Cd) were detected in Haizhou and Xihe areas in china (klays *et al.,* 2019). Ahmad & Erum (2023) found that when compared with the other metals cadmium is found to leach more in soil, with increased availability in plant. Asenic (As), lead (Pb), Chromium (Cr) and iron (Fe) indicate low concentration in *M. indica*. This finding is in line with the result of Liz *et al.,* (2014). The high iron (Fe) concentration in plant was also observed in Chang'ombe Mchicha area Dar es

Salaam by Sharma *et al*., (2016). This result is in agreement with the finding of Gebeyehu and Bayissa, (2020). Concentration of heavy metals in *E. globulus* in this study followed the order of Fe > Cd > Pb > As > Cr. The less concentration of Arsenic (As) and Lead (Pb) in *A indica*, *A. occidentatle* and *C. javanica* in this study is in agreement with the study of Wang *et al*., (2021). He reported less concentration of arsenic (As) in plant and soil sample of gold mining area. This reveal that the concentration of the heavy metals in the plant is negligible, hence no effect can be access from the plant. This results are similar to those found by Akintola, (2022). This finding is in agreement with the result of Abiya *et al.,* (2023). They reported low concentration of arsenic (As), chromium (Cr) and lead (Pb) in plant of Ijana gold mining site, southwestern Nigeria and is contrary to the finding of Ideriah *et al.,* (2010).

The high concentration of Cadmium in *M. indica* higher than the permissible limit may be due to the polluted air generated by the mining activities. This is because the soil where the plant grow has low concentration of cadmium (Cd) when compare with the permissible limit. This finding agree with the result of Al-Busaidi *et al.,* (2018) and Sobha *et al.,* (2014). Who reported high concentration of cadmium (Cd) than the permissible limit. Comparatively, lead (Pb) and cadmium (Cd) have no recognized favorable effects in plants and are solely lethal (Sardar *et al*., 2013). However, the overall content of this element is decisively influenced by the mining activity, which was pointed out in the work of Sun *et al.,* (2018). This reveal that the concentration of the heavy metals in the plant is negligible, hence no effect can be access from the plant. This results are similar to those found by Akintola, (2022).

CONCLUSION

The concentration levels of heavy of metals (Cd, Cr, Fe, As, and Pb) in the soil samples from Maiganga mining and reclaimed site are generally low and thus found to be within the World Health Organization (WHO) permissible level. At both 15 and 30cm iron (Fe) indicates high concentration in mining site than the reclaimed site. Plants like *M. indica, E. globulus, J. curcas* revealed high concentration of cadmium (Cd) and found to be higher than the WHO permissible levels, and they indicate low concentration of chromium (Cr), iron (Fe), arsenic (As) and lead (Pb) and are within WHO permissible level. *A. indica* indicate that the value obtained for cadmium (Cd) is the same with the WHO maximum permissible limit and the value obtain from chromium (Cr), iron (Fe), arsenic (As) and lead (Pb) are within WHO permissible level. *A. occidentale and C. javanica* indicate low concentration of all the tested heavy metals (Cd, Cr, Fe, As, and Pb). Therefore, the soils and plant of Maiganga mining site at the time of this study doesn't present significant contaminations of most of the heavy metals, thus they are yet to be impacted negatively by the mining activity. Increased mine expansion would also necessitate continued assessment for possible pollution around the mine site.

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