



## Evaluation of Heavy Metals In Abandoned Mine Sites Of Jos-South, Plateau State, Nigeria

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Abstract	Article History
<p>Soil forms an integral part of our agricultural resources and plays an important role in the production of foods and its security. Agricultural lands have become increasingly contaminated by organic, inorganic and metallic pollutants. Metals are introduced into the environment through weathering of rock, mining activities and waste from industries. Phytoremediation is the use of plant species mainly in the remediation of environmental contamination. It is an emerging technology that is non-invasive, cost-effective and it is environmentally friendly. The study aimed to evaluate heavy metals concentrations in abandoned mine sites of Jos-South, Plateau State, Nigeria. Soil samples from among the native plant species surrounding the abandoned mine areas were collected and analyzed for total concentrations of lead, arsenic, cadmium, chromium and copper using an Atomic Absorption Spectrophotometer. The result indicated that the lead, arsenic, cadmium, chromium and copper contents in the soil samples were 1050-11570, 50-5160, 30-3165, 1120-46293.33 and 3506.67-38376.67mg/kg, with average contents of 5148.75, 2072.25, 1300.29, 16522.58 and 15114.12mg/kg respectively. The variation indexes of lead, arsenic, cadmium, chromium and copper were 58.49%, 65.25%, 68.44%, 57.84% and 54.99% respectively. Various other concentrations were also identified in the samples. Therefore, the study recommends the use of phytoremediation plants in areas of Jos- South Plateau, Nigeria to remove and stabilize heavy metals in the mining area.</p> <p><b>Keywords:</b> Heavy Metals; Pollution monitoring; Mine Sites; Metallic pollutants; Technological innovation; Cadmium; Chromium</p>	<p>Received: 30 Sep 2025 Accepted: 10 Nov 2025 Published: 20 Nov 2025</p>  <p>Scan QR code to view*</p> <p>License: CC BY 4.0*</p>  <p>Open Access article</p>
<p><b>How to cite this paper:</b> Oyewole Ba<sup>1</sup>, Dabak J<sup>1</sup> and Johnson TO<sup>1</sup> (2025). Evaluation of Heavy Metals In Abandoned Mine Sites Of Jos-South, Plateau State, Nigeria. <i>Journal of Pollution Monitoring, Evaluation Studies and Control</i>, 4(2), 139–146. <a href="https://doi.org/10.54117/72gmd845">https://doi.org/10.54117/72gmd845</a></p>	

### 1. Introduction

Phytoremediation is the use of plant species mainly in the remediation of environmental contaminants such as heavy metals, petroleum hydrocarbons, effluent from industries among others (Sharma *et al.*, 2023). These plants bind and extract toxic elements including heavy metals from the soil and water and accumulate in its biomass. Various metal-binding proteins in the plants are involved in the absorption, accumulation, translocation, and detoxification of heavy metals and hence provide tolerance to the plants (Feki *et al.*, 2021; Sharma *et al.*, 2021). The metal-binding proteins include phytochelatins, metallothioneins and transporter proteins, which are known as heavy-metal ATPases (Chaudhary *et al.*, 2018; Mathur & Chauhan, 2020). The phytoremediation mechanisms mainly involved phytoextraction, phytostabilization, phytovolatilization, and rhizofiltration. It is an emerging technology that is non-invasive, cost effective and it is environmentally friendly (Shi *et al.*, 2023).

Heavy metals are associated with toxicity effects to human, animal and plant systems. Heavy metals are obtained from natural and anthropogenic sources. The metals from the natural sources cause less harm to environment, whereas the metals from anthropogenic sources such as smelters, thermal power plants, mines, foundries pose a threat to mankind (Alsafran *et al.*, 2022). Soil microorganisms can degrade organic contaminants, while metals need immobilization or physical removal.

Some heavy metals such as Cobalt (Co), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Vanadium (V), Copper (Cu) and Zinc (Zn), though consider as a group of inorganic chemical hazards, are beneficial microelements required in minute quantities by organisms for proper growth and wellbeing, while other metals, particularly cadmium, arsenic, mercury and lead are toxic and considered as cumulative poison because they do not have any known beneficial effect in humans (Negahdari *et al.*, 2021). Chromium (Cr), cadmium (Cd), mercury (Hg), lead (Pb), arsenic (As), copper (Cu) and zinc (Zn) are the

most common heavy metal pollutants of soils. Chromium (IV) compounds are known as human carcinogens, whilst chromium (III) is considered as an essential element.

The maximum permissible limit of chromium in agricultural soils established by World Health Organization is 100 mg/kg (Ajani *et al.*, 2022). Metals are essential, but all metals are toxic at higher concentrations, because they cause oxidative stress by formation of free radicals. However, heavy metals bind to protein-binding sites by displacing original metals from their natural binding sites and result in distortion of cells (Varshney *et al.*, 2021; Janeena *et al.*, 2023). Due to their existence in the environment for very long period, they negatively impact human and animal health (Alengebawy *et al.*, 2021). This causes toxic effect to human, animals and plant which disrupt the whole ecosystem. A typical example was acute widespread lead poisoning in Zamfara state, Nigeria (Bartrem, 2017). The rising price of gold in the international market sent villagers prospecting. Unfortunately, what the local miners found was gold ore laced with high concentrations of lead (concentration as high as 10% in most cases). Consequently, thousands of villagers were exposed to mass lead poisoning. Over 735 children died and thousands were sickened by the neurotoxin in what is believed to be the worst lead poisoning epidemic in modern history (Bartrem, 2017). The aim of the study is to evaluate heavy metals concentrations in abandoned mine sites of Jos-South, Plateau State, Nigeria.

## 2. Materials and Methods

### 3.1 Description of Study Area

In Plateau State, Jos has high bounding scarp, by bare grassland and its Africa's chief tin-mining region. Its central area covers about 3,000 square meters and has an average elevation of 4,200 fts (1,280m). The Plateau has a cool rainy climate and its source of numerous rivers include the Kaduna, Krami, and N'gell. Average temperature of plateau range from 15.5°C to 18.5°C in the coolest months to 27.5°C to 30.5°C during the hottest months. Plateau share border with Kaduna state to the North, Kaduna and Nassarawa state to the East, Benue state to the South and Taraba state to the East. Jos –South is a local government area in Plateau state, Nigeria. It houses the Governor's office in Rayfield and can thus be described as the de facto capital of plateau state. Its headquarters are in the town of Bukuru at 9°48'00"N 8°52'00"E. Jos-South local government area consists of three main districts; Du, Kuru and Vwang, and has approximately 510km making it the second – largest in plateau state with a population of about 306,716 persons as of 2006 census.

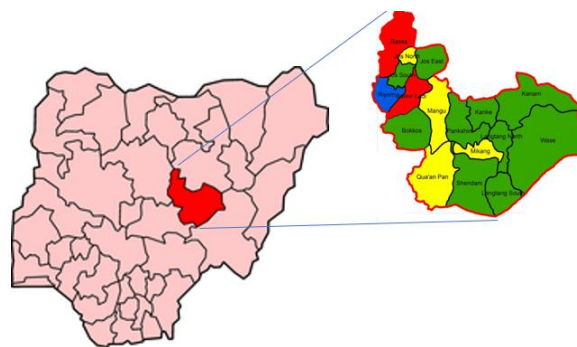


Figure 1: Map of Plateau State showing the study area and other Local Government

Source: <https://soluap.com>; <https://www.nigeriagallery.com>

## 3.3 METHODS

### Collection of samples

The natural plants around the abandoned mine site of Jos -South were investigated and sampled. Soil samples from around the plant roots were collected at the same time as the plant samples. The soil sampling depth was 0–20 cm.

### 3.4 Sample processing and determination

The soil samples were dried after removing impurities, such as stones and animal and plant residues. These samples were then ground with mortar through a 200 mesh nylon sieve, and bagged until needed. Then, 1.0g subsamples of the soil were digested in a microwave digester under a H<sub>2</sub>SO<sub>4</sub>- HNO<sub>3</sub>-HClO<sub>4</sub> digestion system (H<sub>2</sub>SO<sub>4</sub>; HNO<sub>3</sub>; HClO<sub>4</sub>) = 3:1:1, volume ratio) until the liquid clarified. The resultant solution were allowed to cool and filtered through the filter paper, the solution were made up to 100ml with deionized water. The content of five heavy metals (Arsenic, Lead, Cadmium, Chromium and Copper) were determined by Absorption Spectrophotometer.

## 3. Results and Discussion

The range of the concentrations of lead, arsenic, cadmium, chromium and copper in the soil samples were at different concentrations. Results indicated that the range of the concentrations of lead, arsenic, cadmium, chromium and copper were 1050-11570, 50-5160, 30-3165, 1120-46293.33 and 3506.67-38376.67mg/kg respectively. The mean concentrations were 5148.75, 2072.25, 1300.29, 16522.58 and 15114.12mg/kg respectively. The variation indexes of lead, arsenic, cadmium, chromium and copper were 58.49%, 65.25%, 68.44%, 57.84% and 54.99% respectively (Table 1).

According to the results, lead, arsenic, cadmium, chromium and copper contents in the soil samples were very high which could be of great threat to living organism around abandoned sites. The maximum permissible limit of chromium in agricultural soils established by World Health Organization is 100 mg/kg (Ajani *et al.*, 2022). The release of large amount of chromium into soil, ground water, and air can cause health issues in humans, animals, and marine life (Fang *et al.*, 2014). Chromium can cause a variety of diseases through bioaccumulation in human body. This ranges from dermal, renal, neurological, and GI diseases to the development of several cancers including lungs, larynx, bladder, kidneys, testicles, bone, and thyroid (Fang *et al.* 2014). Both Cr (VI) and Cr (III) are capable of producing Reactive oxygen species (Pavesi & Moreira, 2020). Cr carcinogenicity is followed by DNA damage as disruption of transcription regulation. Cr-induced DNA damage includes DNA–Cr–protein crosslinks, DNA inter/intra-strand crosslinks, single- and double-strand breaks (SSBs and DSBs, respectively), and p53 point mutations (Urbano *et al.*, 2012; Thompson *et al.*, 2013).

The international level of lead poisoning is 10ug/dl in the blood (Burki, 2012; Kianoush *et al.*, 2013). Anemia may develop with lead poisoning, this is because lead is capable of inhibiting ferrochelatase and  $\delta$ -aminolevulinic acid dehydratase (ALAD), the two of many enzymes involved in heme biosynthesis the inhibition of ferrochelatase and ALAD by lead decreases heme synthesis can leads to anemia (Mense & Zhang, 2006). Arsenic can inhibit sulfhydryl group containing enzymes which leads to their dysfunction. Moreover, Arsenic inhibits the pyruvate dehydrogenase by binding to the lipoic acid moiety of the enzyme. Pyruvate dehydrogenase inactivation can block the Krebs cycle and inhibits oxidative phosphorylation. As a result, ATP production decreases, resulting in cell damage

(Shen *et al.*, 2013). Human studies on the association between As-contaminated drinking water and adverse pregnancy outcomes have shown that arsenic can easily cross the placenta, particularly during early gestation, leading to spontaneous abortion, stillbirth, preterm birth, and low birth weight (Balali *et. al.* 2021).

The lead concentration in the soil, in which soil sample 27 and 26 had very high concentration of lead which were sampled from Bar Gaida Doi and soil 37 was high, which was sampled from Latya Doi. From this research, Bar Gaida and Latya have high concentration of lead in the soil. Arsenic concentration in the soil in which soil sampled of 6 and 37 had very high concentration of arsenic, they were sampled from Behind Rafied Resort and Latya, Du, these locations have high concentration of arsenic in the soil. Cadmium concentration in the soil, in which soil sampled 40, 37, 38 and 27 have high concentration of cadmium which were sampled from Dumpa Doi, Latya Du and Bar Gaida respectively. Dumpa Doi, Latya and Bar Gaida have high concentration of Cadmium in the soil. Concentration of Chromium in the soil in which soil sampled 32, 31,29, 30 and 27 have high concentration of chromium in the soil which were sampled at Behind Rafied Resort and 27 was Bar Gaida. Therefore, Behind Rafied Resort and Bar Gaida have high concentration of chromium. The concentration of copper in the soil in which soil sampled 3, 4,5 and 33 have high concentration of copper in the soil which were sampled from Behind Rafied Resort and 33 was sampled from Shen Doi.

Table 1: Mean concentrations of Pb, As, Cd, Cr and Cu in the soil around the abandoned mine site of Jos –south Plateau, Nigeria.

Parameters		Lead	Arsenic	Cadmium	Chromium	Copper
SOIL	Mean $\pm$ SD	5148.75	2072.25	1300.29	16522.58	15114.12
	(mg/kg)	$\pm$ 3011.47	$\pm$ 1352.18	$\pm$ 889.91	$\pm$ 9556.56	$\pm$ 8310.73
	SEM	476.50	213.95	140.81	1512.11	1314.99
	Max					
	(mg/kg)	11570.00	5160.00	3165.00	46293.33	38376.67
	Min					
(mg/kg)	1050.00	50.00	30.00	1120.00	3506.67	
%						
Coeff.Var		58.49	65.25	68.44	57.84	54.99

SD = Standard Deviation, SEM = Standard Error of Mean

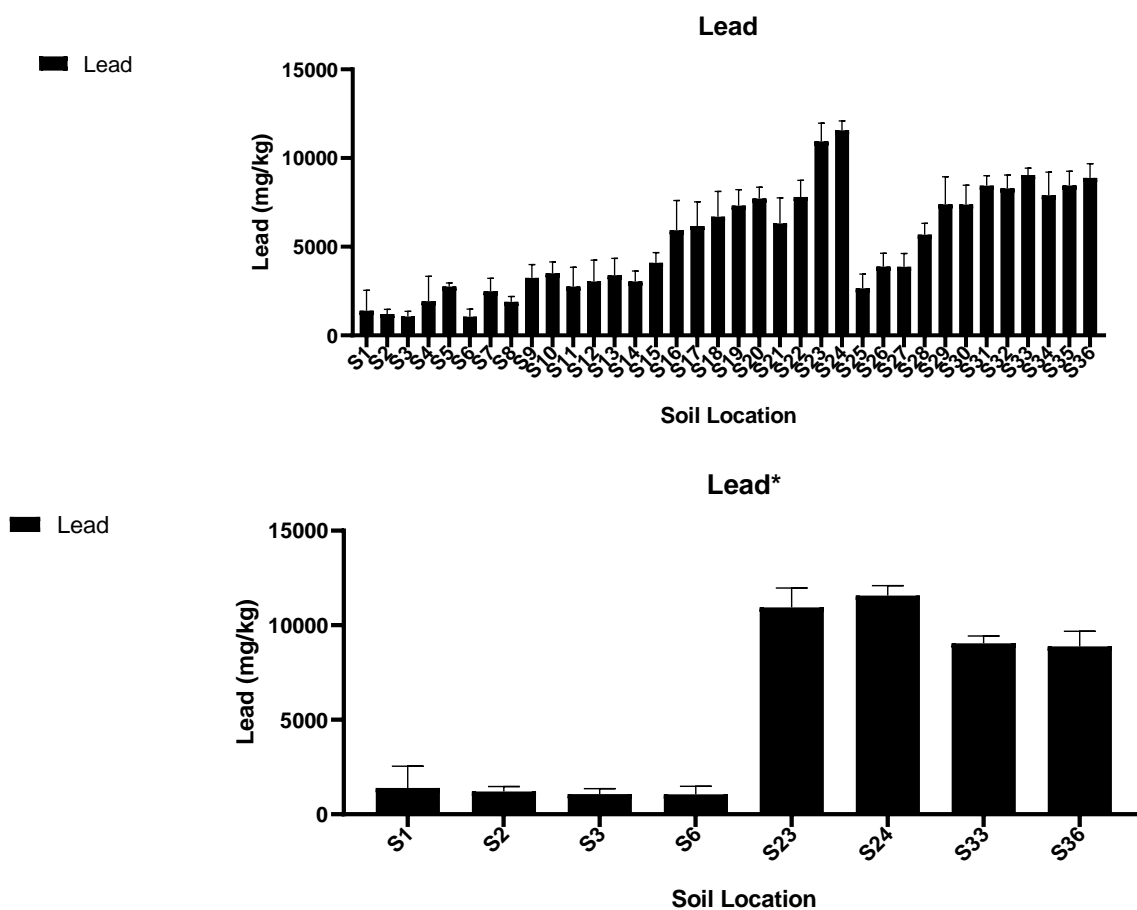
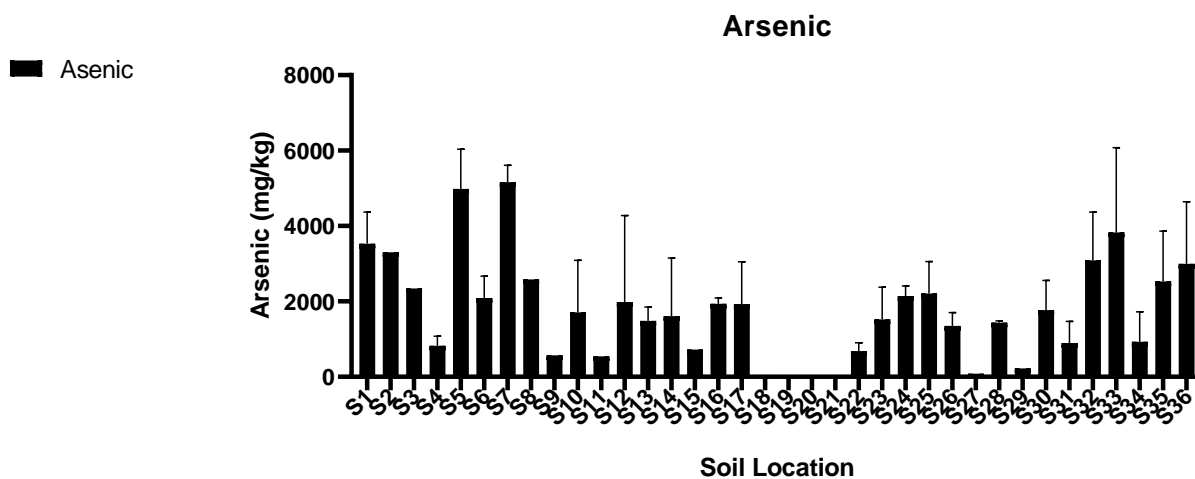


Figure 2: Lead concentration in the soil



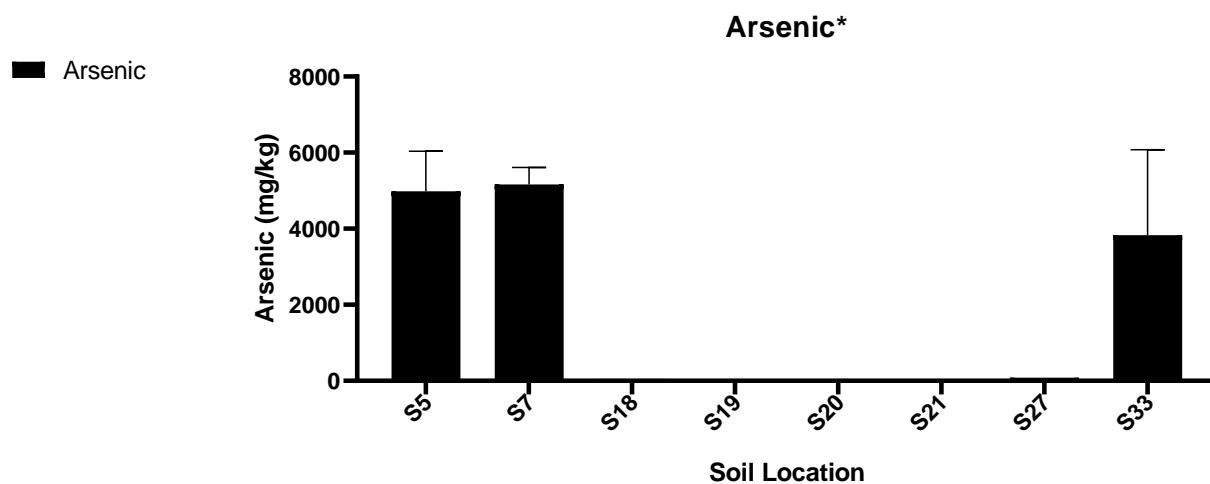


Figure 3: Arsenic concentration in the soil

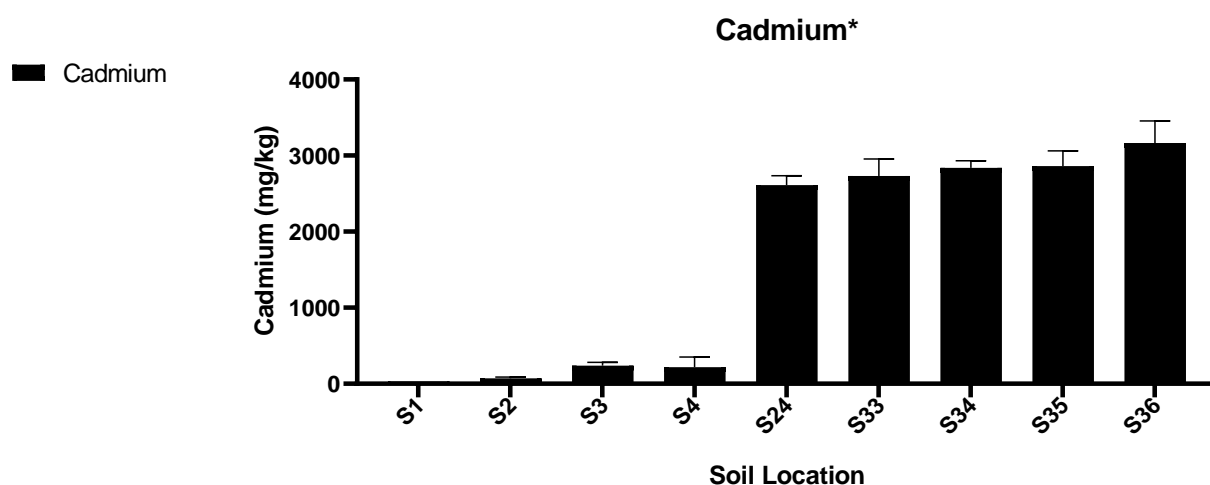
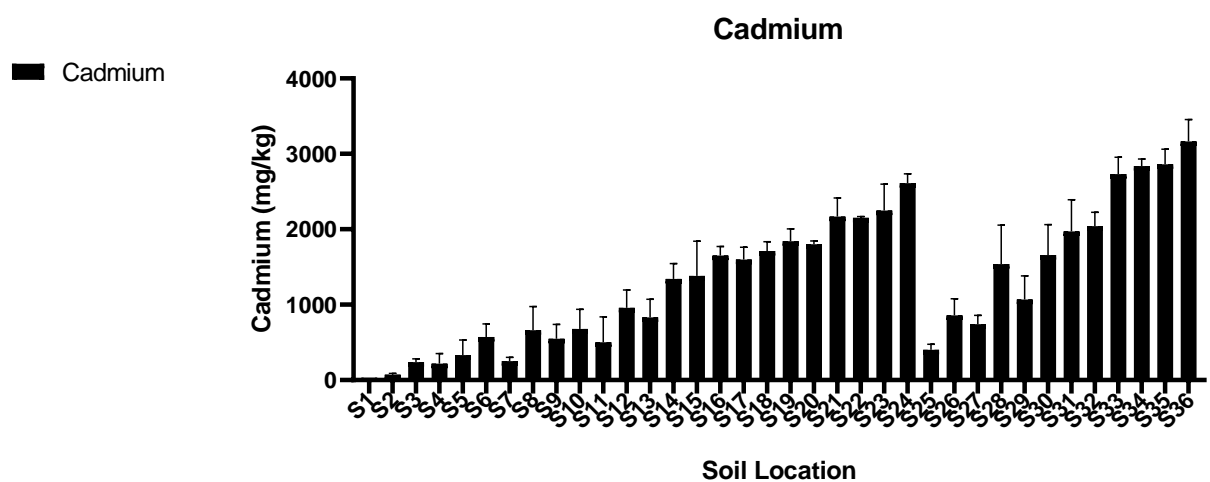


Figure 4: Cadmium concentration in the soil

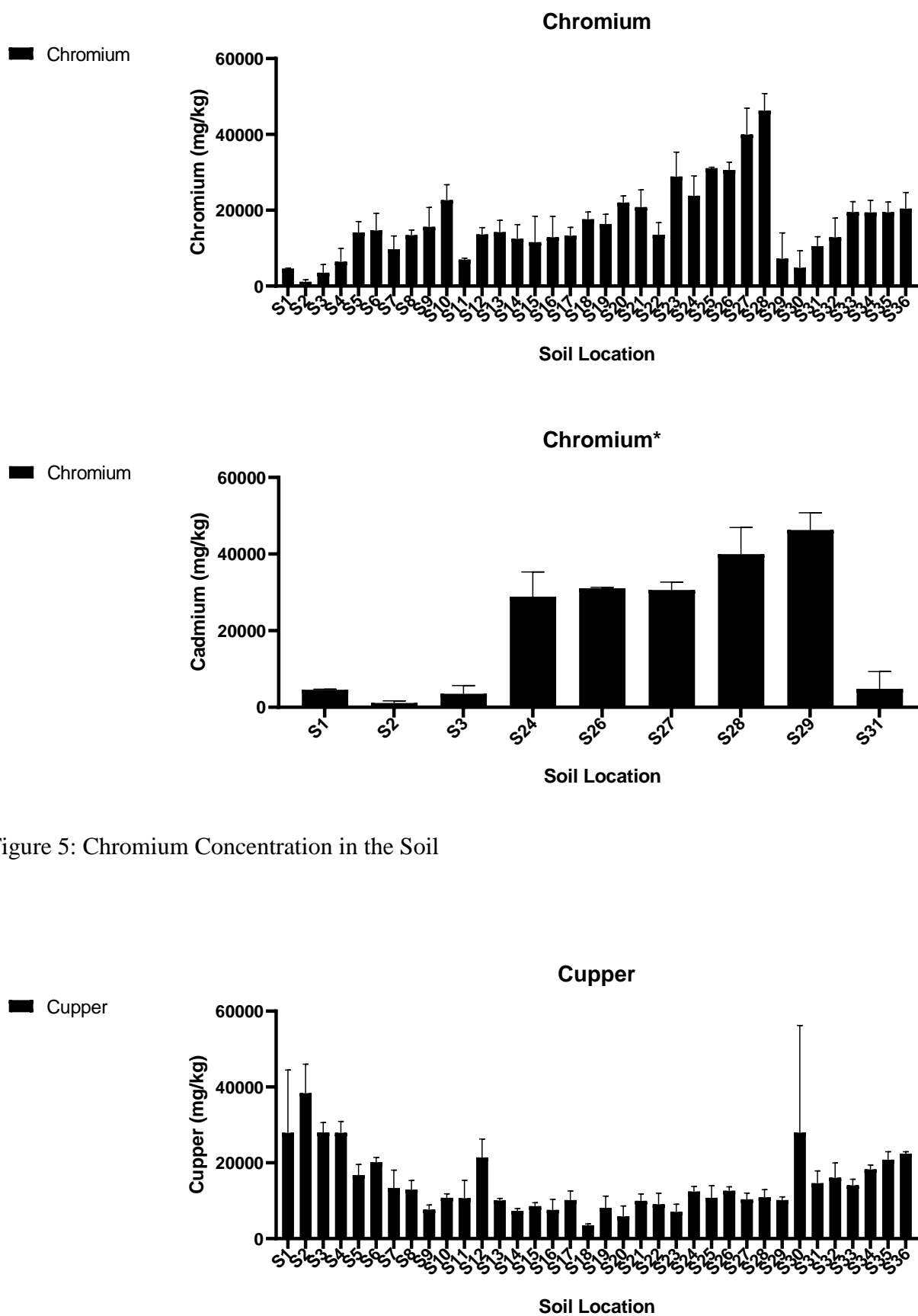


Figure 5: Chromium Concentration in the Soil

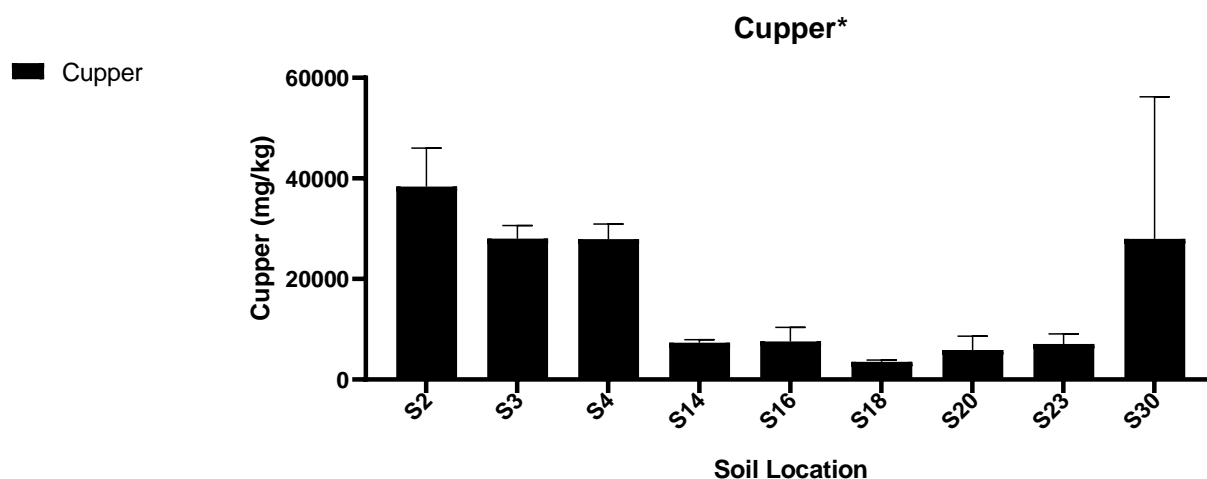


Figure 6: Copper Concentration in the Soil

**Key:**

S1 <i>Kusteletzkyia virginica</i> (L.)	S12 <i>Solanum erianthum</i>	S22 <i>Mangifera indica</i> L.	S31 <i>Carissa spinarum</i> L.
S3 <i>Urena lobata</i>	S13 <i>Lantana camara</i>	S23 <i>Sclerotinia sclerotiorum</i> (Lib.)de.Bary.	S32 <i>Catha edulis</i>
S4 <i>Vernonia amygdalina</i> Del.	S14 <i>Baccharis salicifolia</i>	S24 <i>Ipomoea pescaprae</i> (L.)R.Br.	S33 <i>Volkameria inermis</i>
S5 <i>Psidium guajava</i> L.	S15 <i>Persea Americana</i>	S25 <i>Mimosa borealis</i>	S34 <i>Acacia catechu</i> (L.F.)wild
S6 <i>Acacia xanthophloea</i> Benth	S17 <i>Mitracarpus villosus</i>	S26 <i>Ficus religiosa</i> L.	S35 <i>Terminalis mollis</i> M.A.Lawson
S7 <i>Sida rhombi folia</i>	S18 <i>Woriona saharae</i> Benth & Coss	S27 <i>Adansonia digitata</i> L.	S37 <i>Colocasia esculenta</i>
S9 <i>Oclemena nemoralis</i> (Aiton)Greene	S19 <i>Arctium minus</i>	S28 <i>Ziziphus oenoplia</i> (L.) Mill	S38 <i>Hibiscus sabdariffa</i>
S10 <i>Crotalaria spectabilis</i> Roth.	S20 <i>Broussonetia papyrifera</i>	S29 <i>Eucalyptus robusta</i>	S39 <i>Ipomoea batatas</i>
S11 <i>Dodonaea viscosa</i>	S21 <i>Eucalyptus camaldulensis</i>	S30 <i>Ipomoea aquatica</i>	S41 <i>Artemisia californica</i>

These locations have high concentration of copper in the soil. High concentration of metal in the soil may be attributed to anthropogenic activities, this is because mining tailings are scattered in this area, increased industrialization, industrial wastes and automobile wastes may be released into the environment. Research conducted in the vegetables from Jos-South revealed that all the vegetables were contaminated with metals (Dabak, 2013). Jos-South is an environment where mining tailing activities is carried out day by day which may be contributing factor of high concentration of metals in the soil. From the foregoing, this studied revealed that the soil in Jos –South were highly contaminated with heavy metals which is in agreement with the work of Dabak in 2013 who reported that the vegetables in Jos-South were highly contaminated with heavy metals due to anthropogenic activities carried out in the environment.

**4. Conclusion**

The findings of this study demonstrate that soils across multiple locations in Jos-South are significantly contaminated with heavy metals, posing substantial ecological and public-health risks. Lead, arsenic, cadmium, chromium, and copper exceeded permissible limits in several sampled sites, particularly Bar Gaida, Latya, Dumpa Doi, Behind Rafied Resort, and Shen Doi. The elevated concentrations of these metals are consistent with

the intense anthropogenic activities in the region, especially mining, industrial operations, and improper waste disposal. The toxicological implications of these contaminants are profound: chromium exposure can lead to oxidative stress, DNA damage, and increased cancer risk; lead disrupts heme synthesis and contributes to anemia; arsenic impairs key metabolic enzymes and crosses the placenta, causing adverse pregnancy outcomes; while cadmium and copper also contribute to organ toxicity and environmental degradation. The distribution pattern observed in the soil samples aligns with earlier reports, including Dabak (2013), which documented heavy metal accumulation in vegetables cultivated in Jos-South. This correlation underscores that contamination is persistent and bioavailable, entering the food chain and endangering both humans and animals. Overall, the study reaffirms the urgent need for environmental monitoring, remediation strategies, and stricter regulation of mining and industrial activities to protect communities within the region.

**Declarations**

**Ethics approval and consent to participate**

Not Applicable

**Consent for publication**

All authors have read and consented to the submission of the manuscript.

**Availability of data and material**

Not Applicable.

### Competing interests

All authors declare no competing interests.

### Funding

There was no funding for the current report.

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### FEATURED PUBLICATIONS

#### Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour

This study found that adding banana peel flour to wheat flour can improve the nutritional value of noodles, such as increasing dietary fiber and antioxidant content, while reducing glycemic index.

DOI: <https://doi.org/10.54117/72gmd845>

Cite as: Oguntuyinbo, O. O., Olumurewa, J. A. V., & Omoba, O. S. (2023). Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour. *IPS Journal of Nutrition and Food Science*, 2(2), 46–51.

#### Impact of Pre-Sowing Physical Treatments on The Seed Germination Behaviour of Sorghum (*Sorghum bicolor*)

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