



## EVALUATION OF HEAVY METALS POLLUTION IN SOME SOILS FROM EGBEDI DUMPSITE AND ITS SURROUNDINGS IN OSOGBO, NIGERIA

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### ABSTRACT

The study evaluates heavy metal pollution status in soils from the Egbedi dumpsite and its surrounding residential areas in Osogbo, Nigeria. Soil samples were collected at five distances (0 m, 200 m, 500 m, 1 km, and 1.5 km) from the site over three months, focusing on the concentrations of cadmium, chromium, cobalt, copper, iron, lead, manganese, and zinc. The samples were digested for their heavy metal concentration using aqua regia and analyzed through Flame Atomic Absorption Spectrophotometer. Quality assurance techniques adopted included blank determination, recovery analysis, and calibration of standards. Descriptive and inferential statistics were employed for data interpretations. Metal pollution assessment was conducted by employing mathematical models in terms of anthropogenic contamination factor, degree of contamination, element contamination index, metal contamination index, enrichment factor, geo-accumulation index, and pollution load index. The total metal concentrations for the three months varied from 0.01 mgkg<sup>-1</sup> Pb to 268.40 mgkg<sup>-1</sup> Fe. Pollution indices, including CF, ECI element, and PLI, confirmed severe anthropogenic contamination at the dumpsite, with a CF of 2.03 for Cd and an ECI of 1.03. The Cdeg and MCI were notably high, reaching 295.91 and 287.91, respectively. All the models showed that pollution statuses were in decreasing order of A>B>C>D>E across the sites. These findings underscore the urgent need for effective waste management strategies and regular monitoring to mitigate heavy metal pollution, its ecological and health impacts.

**Keywords:** Soil, Quality, Contamination, Environment, Impact, Pollution

### INTRODUCTION

Dumpsites are essential in managing municipal wastes, and are particularly common in developing countries, where recent up-to-date waste management technologies are lacking (Sabir *et al.*, 2022). Waste items in urban and rural areas are collected and taken to designated dumpsites, from where further activities take place. These activities include waste sorting and collection of waste items of interest by scavengers for re-use or recycling (Hussein *et al.*, 2021). Some other activities are direct recycling by recyclers, burning to reduce waste volume and obtain inherent materials of interest, and degradation of wastes by natural processes and human interventions (Thomas, 2015). These activities usually change the physical and chemical forms of these wastes, and result in release of heavy metals into soils at the dumpsites, and surroundings (Ogbonna *et al.*, 2020). The heavy metals released are the constituents of many everyday items, which are now wastes at these dumpsites (Shi and Wang, 2021). Aside's dumpsites, heavy metals are also released from many anthropogenic activities, including industrial processes, vehicular emissions and fossil fuel combustion (Ajah *et al.*, 2015). Heavy metals are non-biodegradable and hence, persistent in soils (Ali *et al.*, 2021). They are toxic to soil organisms, and cause an imbalance in soil elemental concentrations, thus reducing soil quality (Singh and Steinnes, 2020). For instance, plants take up metals in addition to soil elements through the roots, and transfer them to other tissues and organs.



Heavy metals are toxic to these plants and affect their physiology and growth; while they accumulate in plant tissues in other cases (Vongdala *et al.*, 2019). Soil invertebrates such as earthworms are also affected by heavy metals in soils, such that they experience population decline, and are unable to perform their ecological roles in the soil (Ogbonna *et al.*, 2020). Many vertebrates are affected by heavy metals directly at dumpsites through dermal contact, grazing or ingesting waste food items at or in the vicinity of dumpsites (Anietie and Labunmi, 2015; Bashir *et al.*, 2019). Away from the dumpsites, many organisms are exposed to heavy metals indirectly, when they feed on contaminated plants and animal products (Ali *et al.*, 2021). It is also common to find agricultural activities taking place at dumpsites, due to possible free land, and the myth that dumpsite soils are fertile (Thomas, 2015). Humans experience adverse effects when in contact with heavy metals (Ita and Anwana, 2017), more commonly as a result of bioaccumulation through the food chain (Ogunbanjo *et al.*, 2016). Both cancer and non-cancer risks have been documented from heavy metal exposure in humans (Adama *et al.*, 2016; Ogunbanjo *et al.*, 2016; Thongyuan *et al.*, 2021; Ali *et al.*, 2021). This study was conducted to evaluate the heavy metal contents in dumpsite soils at Egbedi, Osun State, Nigeria.

## **METHODOLOGY**

### **Study Area**

Egbedi dumpsite is owned and managed by Osun State Government, Nigeria (Latitude 7°47'39"N, Longitude 4°27'20"E). About half of the 50 hectare land mass currently functions for waste collection. Soil collection was done at the dumpsite and at four residential locations away from the dumpsite (200 m, 500 m, 1 km and 1.5 km); between Longitude 4.436925 – 4.444370 and Latitude 7.774155 and 7.791894, making a total of five samples. Surface soils (0 – 15 cm) were collected after the wastes were carefully parted to expose the soil surface. The samples were transported to laboratory in moisture bag for further analyses. Samples were collected once a month for a total of three months. In the laboratory, soil samples were air-dried and sieved through a 2 mm sieve, until digestion to determine the heavy metal concentrations.

### **Digestion of Soil Samples**

Environmentally, substantial fractions of all metals were leached by weighing 1.0 g of each soil sample into acid-washed beakers. About 30 ml aqua regia (HCl: HNO<sub>3</sub>; 3:1) was introduced in a Teflon beaker on a thermostat hot-plate functioning between 150 and 180°C. When the digestion was complete, as indicated by a light colour of the mixture, the beaker was removed from the hot plate, cooled to room temperature and filtered using a filter paper into a 25 ml volumetric flask. The filtrate was made up to the 25 ml mark using distilled water. Standards for the solution adopted to standardize the Flame Atomic Absorption Spectrophotometer (FAAS) were obtained as commercial (British Drug House, BDH, Chemical Ltd, Poole, England) stock metal solutions out of which working standards were made ready for proper dilution. Blank samples (samples comprising all reagents except the soil sample) were determined for all methods, analyzed and subtracted out of the sample. This was done to check reagent and ecological intrusions. Analytical technique approved for the investigation was verified by conducting a spike recovery test on soil samples. The Cd, Cr, Co, Cu, Fe, Pb, Mn, and Zn contents were determined utilising FAAS Buck Scientific Model 205 by automatic interpolation with regard to the calibration graph at the Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile-Ife, Nigeria. Soil samples were assayed for contamination with trace metals (Cd, Cr, Co, Cu, Fe, Pb, Mn, and Zn). Metal contamination state was assessed utilising average shale by Singh (2011) to determine the background values of pollution indices specifically Enrichment factor (EF), Contamination index (CI), Pollution load index (PLI) and Geo-accumulation index (I - geo).

### **Heavy Metal Analysis**

The digested soil samples were analyzed for eight heavy metals (Cd, Cr, Co, Cu, Fe, Pb, Mn, and Zn) using their respective wavelengths on the Atomic Absorption Spectrophotometer (AAS) 990 PG.



### Statistical Analysis

Descriptive statistics were used to present tables. Standard deviations were estimated and values were presented as Mean  $\pm$  standard deviation. The data were further subjected to Analysis of Variance (ANOVA) and Duncan's multiple range tests (DMRT) was used to evaluate the significant difference in the concentration of different parameters with respect to different stations. A probability level of less than 0.05 was considered significant.

### Pollution Indicators

The following indices were adopted to evaluate heavy metals contamination in the soil:

**Anthropogenic Contamination Factor (CF):** This quantifies the degree of contamination as single-metal index and gives the relative amount of metals from anthropogenic origin. It is calculated according to the formula developed by Håkanson (1980) as follows:

$$CF = \frac{\text{Conc of metal in Sample}}{\text{Background conc of metal}} \dots\dots\dots(1)$$

**Degree of Contamination (Cdeg):** This gives the overall degree of contamination of all examined metals and it is calculated according to Håkanson (1980):

$$Cdeg = \sum \left( \frac{\text{Conc of metal in Sample}}{\text{Background conc of metal}} \right)^i \dots\dots\dots(2)$$

Where *i* represents each metal i.e., Cd, Co, Cr, Cu, Fe, Pb, Mn, and Zn. Note that Hakanson (1980) categorized degree of contamination (Cdeg) of less than 8 ( $Cdeg < 8$ ) as Low while values ranging between 8 and 16 ( $8 \leq Cdeg < 16$ ) was categorized as moderate. Also, Cdeg values greater than 16 but less than 32 ( $16 \leq Cdeg < 32$ ) and values greater than 32 ( $32 \leq Cdeg$ ) indicated considerable and very high contamination respectively.

**Element Contamination Index (ECI)** is the expression of single metal contamination within a sample relative to the background values of the respective metals, and is expressed as:

$$ECI = \left( \frac{C_m - B_m}{B_m} \right) \dots\dots\dots(3)$$

**Metal Contamination Index (MCI)** is an expression of combined metal contamination in relation to the background values of the respective metals and is calculated as:

$$MCI = \sum \left( \frac{C_m - B_m}{B_m} \right)^i \dots\dots\dots(4)$$

Where, '*i*' is as defined above while  $C_m$  is the concentration in soil and  $B_m$  is the concentration of metal in background within the study area. According to Meybeck *et al.* (2004), MCI was categorized as shown in Table 1.

**Table 1:** Interpretation of Metal Contamination Index (MCI)

Range	Interpretation
$MCI < 5$	Very low
$5 \leq MCI < 25$	Low
$25 \leq MCI < 50$	High
$50 \leq MCI < 100$	Very high
$100 \leq MCI$	Extremely high

**Enrichment factor** is expressed as follows:

$$EF = \left( \frac{C_n / C_{ref}}{B_n / B_{ref}} \right) \dots\dots\dots(5)$$

Where:

$C_n$  = Content of the metal in the study area,

$C_{ref}$  = Content of the metal in the reference environment

$B_n$  = Content of the reference metal (Mn) in the study

$B_{ref}$  = Content of the reference metal (Mn) in the reference environment



A metal is regarded as a reference metal if it is of low occurrence and is present in the environment in trace amounts (Loska *et al*, 2003). Enrichment factor (EF) are categorized as minimal when  $EF < 2$  but when EF values is greater or equal to 2 but less than 5 ( $2 \leq EF < 5$ ), it is categorized as Moderate. EF is classified as significant enrichment when values range between 5 and 20 ( $5 \leq EF < 20$ ) while EF values between 20 and 40 ( $20 \leq EF < 40$ ) and above 40 ( $EF > 40$ ) are classified as Very high and Extremely high respectively.

**Index of Geoaccumulation (I-geo):** is expressed as

$$I\text{-geo} = \log_2 \left( \frac{C_n}{1.5 \times B_n} \right) \dots\dots\dots(6)$$

Where  $C_n$  is the concentration of metal 'n' in the soil and  $B_n$  is the geochemical background value of metal 'n' in the background. The constant 1.5 is a factor that permits the analysis of natural fluctuations in the content of a given substance in the environment and very small anthropogenic influences (Table 2).

**Table 2:** Categorization of Geoaccumulation Index (I-geo) according to Muller (1979)

Range	Interpretation
$I\text{-geo} \leq 0$	Practically uncontaminated
$0 < I\text{-geo} < 1$	Uncontaminated to Moderately contaminated
$1 < I\text{-geo} < 2$	Moderately contaminated
$2 < I\text{-geo} < 3$	Moderately to Heavily contaminated
$3 < I\text{-geo} < 4$	Heavily contaminated
$4 < I\text{-geo} < 5$	Heavily to Extremely contaminated
$6 \leq I\text{-geo}$	100-fold enrichment of a metal

**Pollution Load Index (PLI):** is calculated according to Tomlinson *et al*. (1980) as:

$$PLI = (CF_1 \times CF_2 \times CF_3 \dots\dots\dots)^{\frac{1}{n}} \dots\dots\dots(7)$$

Where CF is the contamination factor and 'n' is the number of metals. The contamination factor is calculated as in equation 1. According to Fagbote and Olanipekun, (2010), PLI values of 0.0 indicates perfection while a value of 1.0 reflects only baseline levels of pollutants and values above 1 ( $PLI > 1$ ) shows progressive deterioration of the station.

## RESULTS

The mean concentrations of heavy metals across different distances from the dumpsite were analyzed and are summarized in Table 3. The mean concentrations of heavy metals varied significantly with distance from the dumpsite. The highest concentration was observed at the dumpsite (7.7 mg/kg), significantly exceeding the WHO guideline of 0.002 – 0.5 mg/kg. Concentrations decreased with distance, with values of 5.8 mg/kg (200 m), 5.5 mg/kg (500 m), 5.4 mg/kg (1000 m), and 5.2 mg/kg (1500 m). Similarly, Pb concentrations were highest at the dumpsite (10 mg/kg), tapering off to 3.0 mg/kg (200 m) and 2.5 mg/kg (500 m), with lower levels noted further away. Iron concentrations were notably high, with a mean of 268.4 mg/kg at the dumpsite and decreasing to 135.8 mg/kg at 1500 m. This suggests a strong localized source of Fe, likely due to waste materials. The mean concentration at the dumpsite was extremely high at 2.0 mg/kg, whereas lower concentrations were recorded as the distance increased, suggesting significant local contamination. These results highlight a clear trend of decreasing heavy metal concentrations with increasing distance from the dumpsite, indicating a localized contamination effect.

The values of CF for each heavy metal (as presented in Table 4) indicate the degree of anthropogenic contamination. The CF for Cd was 2.03 at the dumpsite, indicating moderate contamination, which decreased to 1.37 at 1500 m. Also, for Pb, high values were noted near the dumpsite (43.48), reflecting severe contamination that diminished with distance. The extremely high CF value of 200.00 for Cu at the dumpsite suggests intense pollution from Cu sources, likely due to electronic waste. The CF indicated varying degrees of contamination, with cadmium and copper

demonstrating severe contamination levels. The CF results corroborate the findings from Table 3, reinforcing the localized impact of the dumpsite on soil contamination.

**Table 3:** Mean Concentration of Heavy Metals of Soil Samples in Egbedi Dumpsite and its Surroundings

Heavy metals (mg/kg)	Distance from dumpsite in meters					WHO (1999) Permissible Limits in Soil	F value
	A (0)	B (200)	C (500)	D (1000)	E (1500)		
<b>Cadmium</b>	7.7±0.8 <sup>a</sup>	5.8±0.7 <sup>b</sup>	5.5±0.2 <sup>c</sup>	5.4±0.6 <sup>d</sup>	5.2±0.3 <sup>e</sup>	0.002 – 0.5	2.3
<b>Cobalt</b>	0.05±0.01 <sup>a</sup>	0.25±0.06 <sup>b</sup>	0.41±0.01 <sup>c</sup>	0.22±0.01 <sup>d</sup>	0.27±0.15 <sup>e</sup>	12	0.2
<b>Chromium</b>	0.10±0.03 <sup>a</sup>	0.57±0.3 <sup>b</sup>	0.42±0.1 <sup>c</sup>	0.55±0.2 <sup>d</sup>	0.95±0.65 <sup>e</sup>	0.1	0.9
<b>Copper</b>	2.0±0.3 <sup>a</sup>	0.05±0.5 <sup>b</sup>	0.03±0.2 <sup>c</sup>	0.03±0.2 <sup>d</sup>	0.01±0.1 <sup>e</sup>	0.1	1.0
<b>Iron</b>	268.4±3.5 <sup>a</sup>	188.6±1.5 <sup>b</sup>	163.0±1.2 <sup>c</sup>	139.4±0.9 <sup>d</sup>	135.8±0.5 <sup>e</sup>	1.5	25.0
<b>Lead</b>	10±2.0 <sup>a</sup>	3.0±0.6 <sup>b</sup>	2.5±0.3 <sup>c</sup>	1.5±1.0 <sup>d</sup>	0.01±0.1 <sup>e</sup>	1.0	2.2
<b>Manganese</b>	0.40±0.1 <sup>a</sup>	1.24±0.74 <sup>b</sup>	0.91±0.53 <sup>c</sup>	0.42±0.10 <sup>d</sup>	0.74±0.15 <sup>e</sup>	0.2	0.5
<b>Zinc</b>	1.22±0.51 <sup>a</sup>	0.46±0.1 <sup>b</sup>	0.23±0.1 <sup>c</sup>	0.58±0.10 <sup>d</sup>	0.94±0.15 <sup>e</sup>	6	0.3

Mean levels with the same alphabets within the same row are statistically different at  $p < 0.05$

**Table 4:** Mean Contamination Factor (CF) of Heavy Metals of Soil Samples in Egbedi Dumpsite and its Surroundings

CF	Distance from dumpsite in meters				
	A 0	B -200	C -500	D -1000	E -1500
Cadmium	2.03	1.53	1.45	1.42	1.37
Cobalt	0.50	2.50	4.10	2.20	2.70
Chromium	0.50	2.85	2.10	2.75	4.75
Copper	200.00	5.00	3.00	3.00	1.00
Iron	40.51	28.47	24.60	21.04	20.50
Lead	43.48	13.04	10.87	6.52	0.04
Manganese	0.75	2.34	1.72	0.79	1.40
Zinc	8.13	3.07	1.53	3.87	6.27

The values of ECI (Table 5), representing single metal contamination relative to background levels, indicate high ECI values for Cd (1.03 at 0 m) which reflect significant contamination that decreases with distance. Similarly, ECI values for Pb (42.48 at the dumpsite) indicate severe contamination, which is also reflected in the CF values. The ECI values for the all the examined heavy metals highlight the environmental threat posed by these metals in soils near the dumpsite, emphasizing the need for monitoring and remediation. The Enrichment Factor for Cd was 2.68 at the dumpsite, indicating significant enrichment, which decreased to 0.98 at 1500 m (Table 6). The very high EF of 265.00 for Cu at the dumpsite suggests extreme anthropogenic enrichment, likely linked to improper disposal practices. The EF results align with the observed metal concentrations and further underline the anthropogenic influence on soil quality at the dumpsite.



**Table 5:** Mean Element Contamination Index (ECI) of Heavy Metals of Soil Samples in Egbedi Dumpsite and its Surroundings

ECI	Distance from dumpsite in meters				
	A	B	C	D	E
	0	-200	-500	-1000	-1500
Cadmium	1.03	0.53	0.45	0.42	0.37
Cobalt	-0.50	1.50	3.10	1.20	1.70
Chromium	-0.50	1.85	1.10	1.75	3.75
Copper	199.00	4.00	2.00	2.00	0.00
Iron	39.51	27.47	23.60	20.04	19.50
Lead	42.48	12.04	9.87	5.52	-0.96
Manganese	-0.25	1.34	0.72	-0.21	0.40
Zinc	7.13	2.07	0.53	2.87	5.27

**Table 6:** Mean Enrichment Factor of Heavy Metals of Soil Samples in Egbedi Dumpsite and its Surroundings

EF	Distance from dumpsite in meters				
	A	B	C	D	E
	0	-200	-500	-1000	-1500
Cadmium	2.68	0.65	0.84	1.79	0.98
Cobalt	0.66	1.07	2.39	2.78	1.93
Chromium	0.66	1.22	1.22	3.47	3.40
Copper	265.00	2.14	1.75	3.79	0.72
Iron	53.68	12.17	14.33	26.55	14.68
Lead	57.61	5.58	6.33	8.23	0.03
Zinc	10.78	1.31	0.89	4.88	4.49

### Index of Geoaccumulation (I-geo)

The Index of Geoaccumulation (I-geo) recorded an I-geo value of 0.41 for Cd at the dumpsite which suggests moderate contamination, decreasing to 0.27 at 1500 m (Table 7). I-geo values for Pb (8.73 at the dumpsite) suggest heavy contamination, reflecting significant anthropogenic input. The Igeo values for all the heavy metals indicate a concerning level of contamination that requires immediate attention and potential remediation (Table 7).

The Cdeg, MCI, and PLI are presented in Table 8 which revealed that the calculated Cdeg ranged from 295.91 at the dumpsite to 38.02 at 1500 m, categorizing the sites as highly contaminated. Similarly, the MCI values showed a significant contamination trend, peaking at 287.91 at the dumpsite. The PLI value of 5.69 at the dumpsite indicates progressive deterioration of soil quality, with values dropping to 1.85 at 1500 m, showing that distance plays a critical role in contamination levels. These indices collectively illustrate the extent of heavy metal pollution in soils around the Egbedi dumpsite, confirming severe environmental degradation.

**Table 7:** Index of Geoaccumulation (I-geo) of Heavy Metals of Soil Samples in Egbedi Dumpsite and its Surroundings

I-geo	Distance from dumpsite in meters				
	A	B	C	D	E
	0	-200	-500	-1000	-1500
Cadmium	0.41	0.31	0.29	0.29	0.27
Cobalt	0.10	0.50	0.82	0.44	0.54
Chromium	0.10	0.57	0.42	0.55	0.95
Copper	40.14	1.00	0.60	0.60	0.20
Iron	8.13	5.71	4.94	4.22	4.11
Lead	8.73	2.62	2.18	1.31	0.01
Manganese	0.15	0.47	0.34	0.16	0.28
Zinc	1.63	0.62	0.31	0.78	1.26

**Table 8:** Degree of Contamination (Cdeg), Metal Contamination index (MCI) and Pollution Load Index (PLI) of heavy metals of soil samples in Egbedi Dumpsite and its Surroundings

	A	B	C	D	E
Cdeg	295.91	58.79	49.37	41.59	38.02
MCI	287.91	50.79	41.37	33.59	30.02
PLI	5.69	4.42	3.57	3.19	1.85

**Table 9:** Relationship between Heavy Metals and their Concentration in Egbedi Dumpsite and its Surroundings from 0 m to 1500 m

	Cd	Co	Cr	Cu	Fe	Pb	Mn	Zn
Cd	1							
Cu	-0.804	1						
Cr	-0.882	0.479	1					
Cu	.980 **	-0.825	-0.770	1				
Fe	.979**	-0.719	-0.832	.926*	1			
Pb	.992**	-0.741	-.892*	.960**	.981**	1		
Mn	-0.397	0.578	0.327	-0.534	-0.205	-.365	1	
Zn	0.649	-0.845	-0.174	0.751	0.554	0.554	-.554	1

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

Table 9 shows that several heavy metals correlated significantly with soil sample measured. At  $p < 0.05$ , Cr correlated negatively with Pb ( $r = -0.892$ ), Cu correlated positively with Fe ( $r = 0.926$ ). The other heavy metals variables correlated with several others at  $p < 0.01$ , except Cd with Co, Cr, Mn, and Zn; Co with Cr, Cu, Fe, Pb, Mn, and Zn; Co with Cr, Cu, Fe, Pb, Mn, and Zn; Cr with Cu, Fe, Mn, and Zn; Cu with Mn and Zn; Fe with Mn and Zn; Pb with Mn and Zn and Mn with Zn did not show significant correlation at either  $p < 0.05$  or  $p < 0.01$ .

## DISCUSSION

The results revealed that, heavy metals in soil near the Egbedi dumpsite pose potential risks to both the environment and human health. The elevated levels of Cd, Pb, and Cu can lead to soil and water contamination, impacting agricultural productivity and food safety. The strong correlation between proximity to the dumpsite and metal concentration underscores the anthropogenic influence on soil quality. This study on heavy metal contamination around the Egbedi dumpsite highlights significant environmental concerns related to soil quality and public health. The elevated concentrations of heavy metals such as Cd, Pb, and Cu near the dumpsite can have profound ecological implications (Zhao *et al.*, 2019).

Heavy metals are persistent environmental pollutants that can accumulate in soil, leading to adverse effects on soil microorganisms, plants, and higher trophic levels. The presence of high concentrations of metals like Pb and Cd can disrupt soil biota, affecting microbial diversity and activity, which are essential for nutrient cycling and soil fertility (Huang *et al.*, 2019). This study found that Cd levels at the dumpsite were approximately 7.7 mg/kg, far exceeding the WHO guideline of 0.002 – 0.5 mg/kg. Such levels can inhibit microbial processes, potentially leading to reduced soil health and agricultural productivity (Sharma *et al.*, 2020). Plants are also adversely affected by heavy metals, as these contaminants can inhibit germination, root elongation, and overall growth. Accumulation of metals in plant tissues can lead to bioaccumulation and biomagnification within food webs, posing risks to herbivores and subsequently to higher trophic levels, including humans (Pérez *et al.*, 2019).

Similar study by Odukoya *et al.* (2020) in Lagos, Nigeria, found alarming levels of Pb and Cd in urban soils, which correlated with significant declines in microbial diversity. Sharma *et al.* (2020) in India also reported that soils near waste disposal sites exhibited heavy metal concentrations that adversely affected local flora and fauna. Huang *et al.* (2019) observed that soils in agricultural lands near industrial areas in China had elevated levels of Cd and Pb, which adversely impacted crop yield



and soil health. These findings resonate with the observations from the Egbedi dumpsite, suggesting that heavy metal pollution from anthropogenic activities is a widespread issue impacting ecosystems globally. At  $p\text{-value} < 0.05$ , some heavy metals correlated positively with one another, showing that there are significant interactions between the heavy metals in soil samples of the study area. This confirms that the presence of certain pollution indicator will influence the occurrence or increase of some other parameters in the study site.

The implications of heavy metal pollution extend beyond ecological concerns, significantly impacting human health. Prolonged exposure to contaminated soils can lead to metal uptake through crops, posing risks of heavy metal toxicity in humans (Nriagu, 2018). The increasing prevalence of food contamination in regions adjacent to dumpsites emphasizes the urgent need for monitoring and regulation of waste disposal practices to protect public health. Additionally, the findings of this study highlight the importance of comprehensive environmental impact assessment (EIA) before the establishment or expansion of waste management facilities. EIA can help identify potential contamination risks and provide recommendations for mitigating environmental impacts (Glasson *et al.*, 2012). Effective waste management strategies, such as proper segregation and treatment of hazardous waste, are crucial to reducing heavy metal contamination in soils.

## **CONCLUSION AND RECOMMENDATION**

The study on heavy metal pollution in soils surrounding the Egbedi dumpsite in Osun State, Nigeria, reveals significant contamination levels that pose serious ecological and public health risks. The analysis demonstrated elevated concentrations of heavy metals, including Cd, Pb, and Cu, particularly at the dumpsite, with levels markedly exceeding established limits. Statistical evaluations indicated a clear decline in heavy metal concentrations with increasing distance from the dumpsite, emphasizing the localized impact of waste disposal practices. The derived contamination factors, element contamination indices, and pollution load indices highlighted the severe anthropogenic influence on soil quality, categorizing the area as highly contaminated. This illustrates a pressing environmental issue with significant ecological and health implications. To address these challenges, further research should focus on developing effective remediation strategies, such as phytoremediation and bioremediation, to restore contaminated soils. Continued monitoring and public awareness campaigns can also play vital roles in mitigating the adverse effects of heavy metal pollution. The study has added to the understanding of anthropogenic influences on soil quality and emphasizes the importance of environmental impact assessments in waste management practices in our environment.

## **ETHICAL STATEMENT**

*The authors confirm that all experiments were carried out following the approval of the appropriate ethical review committee of the Central Research Laboratory, University of Ibadan, Nigeria (reference number not applicable) and were following both the national and international safety regulations and ethical principles for animal welfare. The authors also confirm that they have followed EU standards for scientific purposes.*

## **CONFLICT OF INTERESTS**

The authors declare that they have no financial or non-financial competing interests that are directly or indirectly related to this work.

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