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Original Article

Heavy metal contamination and pollution assessment of dumpsite soils at Federal University Oye-Ekiti (Oye campus), Ekiti State, Nigeria

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ABSTRACT

Solid waste accumulation continues to increase in many developing environments, posing potential risks to soil quality and public health, particularly in densely populated university communities. This study assessed heavy metal contamination and evaluated associated pollution indices in dumpsite soils within the Federal University Oye-Ekiti (Oye Campus), Ekiti State, Nigeria. Soil samples were collected from a depth of 0–15 cm at two impacted locations (residential halls and academic buildings), while an undisturbed soil sample served as the control. The concentrations of selected heavy metals (cadmium, copper, chromium, lead, and zinc) were determined using Atomic Absorption Spectroscopy (AAS). To further assess the level of contamination, pollution indices including the contamination factor (CF), geo-accumulation index (Igeo), contamination degree (CD), and pollution load index (PLI) were applied. The results showed that soils from the residential hall area recorded relatively higher concentrations of Cd, Cu, and Pb (0.1040 ± 0.0014 mg/kg, 9.1865 ± 0.0021 mg/kg, and 0.3145 ± 0.0050 mg/kg, respectively) compared to the academic environment and control site. Across all sampling locations, the pollution indices generally indicated low levels of contamination, with CF and PLI values below threshold limits and negative Igeo values suggesting unpolluted conditions. However, slightly elevated index values in the residential area compared to the control site reflect localized anthropogenic influence, likely arising from improper waste disposal and routine campus activities. While the soils are not currently at pollution risk levels, the observed variations highlight early-stage enrichment of heavy metals due to human activities, emphasizing the need for continued monitoring and improved waste management practices.

Keywords: Dumpsites; Heavy metals; Soil contamination; Pollution indices

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INTRODUCTION

In many developing nations, including Nigeria, open dumping still serves as the most widely used method to dispose of solid waste. These unmanaged dumpsites receive mixed waste streams that include municipal refuse, metals, discarded electronics, batteries, and industrial residues. Over time, heavy metals like chromium (Cr), lead (Pb), zinc (Zn), cadmium (Cd), nickel (Ni), iron (Fe) and copper (Cu) accumulate in dump soils because they are not degradable and persist in the environment for a long time after the original waste has decomposed. This accumulation can elevate soil metal concentrations above natural background levels, especially near active dump zones [1-2]. Unlike organic waste, heavy metals do not break down and can migrate through soil profiles, potentially entering groundwater or nearby agricultural soils. The existence of high concentrations of heavy metals in soil can indicate long-term pollution and increased ecological risk, particularly where dumpsites are close to human activities or land cultivation [3].

Quantitative pollution indices are extensively utilized in environmental research to evaluate the level of contamination of soils affected by human activities. The Contamination Factor (CF) compares each metal's concentration in the soil to a reference or baseline value, showing whether levels are low, moderate, or high. The Geo-accumulation Index (Igeo) assesses how much soil metal concentrations have increased relative to pre-industrial conditions, while the Pollution Load Index (PLI) offers an integrated measurement of the total soil metal contamination. These indices enable researchers to classify the severity of metal pollution and compare different sites or dumpsites systematically [1].

Studies across Nigeria have consistently shown that dumpsite soils contain elevated heavy metal levels and that pollution indices often indicate significant contamination [1,4]. For example, in Ado-Ekiti, southwestern Nigeria, the application of Igeo and PLI revealed significant contamination of soils near active dumpsites, with elevated levels of metals like chromium, lead and manganese relative to control locations [2]. Such findings highlight the long-term effects of inappropriate waste disposal methods on soil quality in urban and peri-urban environments.

Despite these findings in urban and regional dumpsites, there remains a lack of focused research on heavy metal contamination of soils at institutional dumpsites, such as those found within university campuses. Institutional dumpsites can receive similar waste streams, especially electronic waste, batteries, and metal-bearing materials, but are often overlooked in broader studies. Understanding their contamination status using established pollution indices can provide valuable baseline data for environmental management and community health planning.

This study therefore aims to evaluate the concentrations of selected heavy metals in soil from the main dumpsite on the Oye campus of the Federal University Oye-Ekiti and to assess the level of contamination in the soil using established pollution indices including CF, Igeo, and PLI.

MATERIALS AND METHODS

Study Area

The Federal Government of Nigeria founded Federal University Oye-Ekiti (FUOYE) in 2011 as part of a plan to increase access to high-quality postsecondary education. It is situated in the southwest part of Nigeria in Oye-Ekiti, Ekiti State. The university operates two main campuses: Oye (main campus) and Ikole. Geographically, the main campus of Federal University Oye-Ekiti is located at roughly latitude 7.7915° N and longitude 5.3245° E (Figure 2.1). The institution is situated within a semi-urban area, providing a mix of rural tranquillity and access to urban infrastructure. The surrounding environment supports agricultural, educational, and socio-economic activities that contribute to student learning and research.

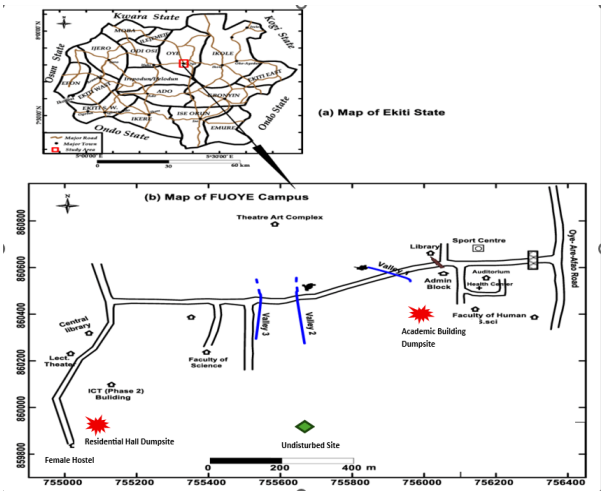

Figure 2.1: Map of Federal University Oye-Ekiti, (Oye-campus), Ekiti State, Nigeria.

Collection and Preparation of Soil Sample

Soil samples were collected from two main dumpsites on the Oye campus of the Federal University Oye-Ekiti (FUOYE). The first site was near the student residential halls along Phase 2 and Phase 3 roads (Latitude 7°6′28″N, Longitude 5°18′55″E), and the second was in the academic area along Phase 1 road (Latitude 7°6′45″N, Longitude 5°19′16″E). An undisturbed part of the campus, away from any waste disposal activities (Latitude 7°6′32″N, Longitude 5°18′50″E), was used as a control. At each dumpsite, soil was collected randomly from areas containing a mix of waste, including organic residues, plastics, metals, paper, and decomposed materials. Three separate samples were taken from each site with a soil auger at a depth of 0–15 cm and then combined to form a single representative sample for that location. The control soil was collected in the same way to provide a baseline for comparison. All samples were placed in clean, labelled bags and transported to the Environmental Management and Toxicology Laboratory at FUOYE for analysis.

Sample Preparation and Digestion of Soil

Samples of soil were air-dried at room temperature and manually cleared of stones, roots, and other extraneous materials. The samples that had been dried were then gently ground and passed through a 2 mm sieve to obtain a uniform fraction suitable for analysis Freshly made aqua regia, a 3:1 mixture of strong hydrochloric acid and nitric acid, was used to acid digest 2.5 g of each processed soil sample to extract metals. Aqua regia digestion is widely applied for the determination of pseudo-total concentrations of heavy metals in soils due to its ability to dissolve most environmentally available metal fractions. The digestion mixtures were heated to about 95 °C on a hot plate for one hour to facilitate metal extraction. After cooling, the digests were diluted with deionised

distilled water to a volume of 50 mL and allowed to stand overnight to ensure proper settling of suspended particles prior to analysis [5-6].

Heavy Metal Analysis

The concentrations of cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu) and chromium (Cr) in the samples of the digested soil were determined using a PG AA500 Atomic Absorption Spectrophotometer (AAS). Before analysis, the equipment was calibrated with standard solutions prepared from certified stock solutions of each metal. A series of working standards was used to generate calibration curves, which were then used to determine the concentrations of the metals in the samples. Each digested sample was introduced into the instrument, and absorbance readings were taken at the appropriate wavelengths for each element.

To guarantee the degree of accuracy of the results, reagent blanks were analysed alongside the samples to check for any contamination, and selected samples were analysed in duplicate to confirm consistency. The instrument was also recalibrated at intervals during the analysis to maintain stability.

All measurements were reported in milligrams per kilogram (mg/kg) in accordance with the soil samples' dry weight, following standard procedures for heavy metal determination in environmental studies [7-9].

Heavy Metal Pollution Assessment Indices

Geo-accumulation Index (Igeo)

The Geo-accumulation Index (Igeo) was originally developed by Müller [10] and has since become a common tool for evaluating trace metal pollution in sediments and soils, particularly in European environmental studies [11]. The Igeo is used to compare current concentrations of heavy metals in soil against their natural background levels, allowing researchers to determine how much contamination has occurred relative to geochemical baselines. This approach classifies pollution into seven categories, from unpolluted to very contaminated (i.e., classes 0–6) based on how enriched a metal is compared to its background value [10,12].

Following the method outlined by Lar *et al* [12], the Geo-accumulation Index was computed using the standard formula to quantify the degree of metal enrichment in the soil samples.

$$Igeo = log2\ C_n/1.5B_n$$

…… (1)

Where:

- C_n is the measured metal concentration.
- B_n is the metal's background value in reference environment.
- 1.5 is the correction factor for natural variation

The average global concentrations of the following elements in soils, expressed in mg/kg, were used as reference values in this study: Fe = 47,200; Cr = 90; Zn = 95; Ni = 68; Cd = 0.30; Pb = 20; Cu = 45; and Mn = 850, as published by Turekian and Wedepohl [13].

To assess soil contamination, the geo-accumulation index (Igeo) was applied, following the method introduced by Müller [10] and adapted by Huu *et al.* [14]. The Igeo divides contamination levels into seven classes, which range from unpolluted to extremely polluted.

Igeo Classification:

- Igeo ≤ 0 means Unpolluted
- $0 <$ Igeo ≤ 1 means Unpolluted to moderately polluted
- $1 <$ Igeo ≤ 2 means Moderately polluted
- $2 <$ Igeo ≤ 3 means Moderately to heavily polluted

- 3 < Igeo ≤ 4 means Heavily polluted
- 4 < Igeo ≤ 5 means Heavily to extremely polluted
- Igeo > 5 means Extremely polluted.

Contamination Factor (CF)

The contamination factor was employed to quantify the extent of heavy metal pollution in the soil samples. CF expresses the ratio between the concentration of a specific metal in the soil and its natural background value [15]. The average crustal shale values published by Turekian and Wedepohl [13] were used as the background values for heavy metals in this study. The formula for CF is shown in Equation 2:

$$CF = \frac{C_{sample}}{C_{background}}$$

……(2)

Where:

• C_{sample} = measured concentration of a specific heavy metal in the dumpsite soil in mg/kg, and

• $C_{background}$ = corresponding background concentration of that metal in shale in mg/kg as reported by Turekian and Wedepohl [13].

CF levels are interpreted as follows in accordance with Hakanson's classification [15]:

contamination

- 1 ≤ CF < 3 = Moderate contamination
- 3 ≤ CF < 6 = Considerable contamination
- CF ≥ 6 = Very high contamination

Contamination Degree (Cd)

The contamination degree for each sampling location represents the total of individual CF values for the metals assessed. This cumulative index provides an overall measure of contamination pressure at a site [16]. Degree of contamination was calculated as:

$$Cd = \sum CF_i$$ ..... (3)

Where CF_i represents the ith metal's contamination factor.

In addition to shale reference values, this study also compared results with Nigerian regulatory target values for soil established by the Department of Petroleum Resources (DPR, 2002). These permissible limits (in mg/kg) include Cu = 36, Cd = 0.8, Zn = 140, Cr = 100 and Pb = 85.

The following scale was used to interpret the overall contamination degree [16]:

- Cd < 8 = Low degree of contamination
- 8 ≤ Cd < 16 = Moderate degree of contamination
- 16 ≤ Cd < 32 = Considerable degree of contamination
- Cd ≥ 32 = Very high degree of contamination

Pollution Load Index (PLI)

The Pollution Load Index is a composite measure used to determine the overall level of contamination by heavy metals at a study site. The PLI is helpful for evaluating the intensity of pollution across areas since it offers a single value that represents the combined influence of several metals [18]. For every metal examined, the index is computed by taking the nth root of the product of contamination factors (CF):

$$PLI = (CF_1 \times CF_2 \times CF_3 \times CF_n)^{1/n}$$ ……(4)

Where:

- **CF_i** is the contamination factor for the *i*-th heavy metal,
- **n** is the total number of metals included in the calculation [18-19].

Interpretation of PLI values follows established criteria: a PLI of 1 indicates baseline (unpolluted) conditions, values below 1 suggest no significant pollution, and values above 1 signal a deterioration of environmental quality as a result of heavy metal pollution [20].

Data Analysis

The concentrations of heavy metals in soil samples were processed and analysed using IBM SPSS Statistics software. Summary statistics were presented as mean values with standard deviations (mean ± SD). To compare the metal levels between dumpsite and control soils, one-way analysis of variance (ANOVA) was carried out. Duncan's Multiple Range Test (DMRT) was used to differentiate between group means when ANOVA revealed significant differences. At $p < 0.05$, differences were deemed statistically significant.

RESULTS

Heavy Metal Concentrations in Soil Samples

Heavy metal concentrations across the sampling sites are presented in Table 3.1. The results show that concentrations of copper (Cu), zinc (Zn) chromium (Cr), cadmium (Cd) and lead (Pb) were higher in soils from the residential halls and academic building environment compared to the control site. The overall distribution pattern of the heavy metals conformed to the sequence: Cu > Zn > Cr > Cd > Pb. The school residential halls recorded the highest concentrations of cadmium (0.1040 ± 0.0014 mg/kg), copper (9.1865 ± 0.0021 mg/kg), and zinc (8.4070 ± 0.0028 mg/kg). The academic building environment showed slightly lower concentrations, while the control site recorded the lowest values for all metals. All measured concentrations were lower than the permissible limits set by regulatory bodies such as WHO and DP

R.

Table 3.1: Heavy Metal Concentrations of Selected Soil Samples in Federal University Oye-Ekiti (Oye-Campus)

Sampling Sites	Cadmium (Cd) (mg/kg)	Copper (Cu) (mg/kg)	Chromium (Cr) (mg/kg)	Lead (Pb) (mg/kg)	Zinc (Zn) (mg/kg)
School Residential Halls	0.1040 ± 0.0014[c]	9.1865 ± 0.0021[c]	0.9505 ± 0.0050[b]	0.3145 ± 0.0050[c]	8.4070 ± 0.0028[c]
Academic Building Environment	0.0820 ± 0.0028[b]	7.5290 ± 0.0042[b]	1.0725 ± 0.0106[c]	0.2550 ± 0.0071[b]	5.1940 ± 0.00 28[b]
Control	0.0240 ± 0.0028[a]	2.5470 ± 0.0028[a]	0.3730 ± 0.0042[a]	0.0940 ± 0.0028[a]	3.4480 ± 0.0028[a]
DPR Limit (mg/kg)	0.8	36	100	85	140

Sampling Sites	Cadmium (Cd) (mg/kg)	Copper (Cu) (mg/kg)	Chromium (Cr) (mg/kg)	Lead (Pb) (mg/kg)	Zinc (Zn) (mg/kg)
WHO Limit (mg/kg)	0.3	100	100	85	300

KEY:
Results are means of duplicate treatments ± standard deviation.
Means followed by the same superscript within a column are not significantly different ($p < 0.05$) based on Duncan's post hoc test.

Contamination Factor (CF) and Contamination Degree (CD)

The contamination factor (CF) values for the selected heavy metals across the sampling sites are shown in Table 3.2. In this study, all calculated CF values were less than 1, indicating low contamination levels for all metals across all sites. The contamination factor (CF) values of heavy metals followed the order Cd > Cu > Zn > Pb > Cr in both the residential halls and academic environment. Cadmium recorded the highest CF values, ranging from 0.080 (control) to 0.347 (residential halls), while chromium showed the lowest values (0.004–0.012). The calculated contamination degree (CD) values were 0.667 for the residential area, 0.520 for the academic environment, and 0.182 for the control site. These values are all below the threshold of 6, indicating low levels of cumulative heavy metal contamination across the study area.

Table 3.2: Contamination Factor (CF) and Contamination Degree (CD) of Heavy Metals

Metal	Residential Hall CF	Academic Environment CF	Control CF
Cd	0.347	0.273	0.080
Cu	0.204	0.167	0.057
Cr	0.011	0.012	0.004
Pb	0.016	0.013	0.005
Zn	0.089	0.055	0.036
Contamination Degree of Heavy Metals			
CD (ΣCF)	0.667	0.520	0.182

KEY: CF < 1 → Low; 1–3 → Moderate; 3–6 → Considerable; 6 → Very high

Geo-accumulation Index (Igeo)

The Geo-accumulation Index (Igeo) values calculated for the heavy metals are presented in Table 3.3. All Igeo values across the sampling sites were negative, indicating that the soils are unpolluted (Class 0). The distribution pattern followed: Cd > Cu > Zn > Pb > Cr for both the residential halls and the academic environment. Cadmium recorded the highest Igeo values (−2.11 in residential

halls), while chromium had the lowest (−7.15).

Table 3.3: Geo-accumulation Index (Igeo) of Heavy Metals

Metal	Residential Hall Igeo	Academic Environment Igeo	Control
Cd	-2.11	-2.39	-4.21
			-5.12
Cu	-2.88	-3.05	
			-8.82
Cr	-7.15	-7.09	
			-7.98
Pb	-6.57	-6.71	-5.61
Zn	-4.08	-4.52	

KEY: Igeo ≤ 0 → Unpolluted; 0–1 → Unpolluted to moderately polluted
1–2 → Moderately polluted
2–3 → Moderately to heavily polluted
3–4 → Heavily polluted
5 → Extremely polluted

Pollution Load Index (PLI)

The Pollution Load Index (PLI) values for the sampling sites are presented in Table 3.4.

The PLI values obtained for the residential hall, academic environment, and control site were 0.064, 0.052, and 0.020, respectively. All values were less than 1, indicating that the soils across the study area are unpolluted.

Table 3.4: Pollution Load Index (PLI) of Sampling Sites

Sampling Site	PLI
Residential Hall	0.064
Academic Environment	0.052
Control	0.020

KEY: PLI > 1 indicates pollution

DISCUSSION

Heavy metal concentrations were higher in soils from the residential halls and academic building environments relative to the control site. The school residential halls showed the highest levels of cadmium (0.1040 ± 0.0014 mg/kg), copper ($9.1865 \pm 0.00\,21$ mg/kg), and zinc (8.4070 ± 0.0028 mg/kg), indicating notable anthropogenic input, likely from domestic waste such as batteries, plastics, corroded pipes, and metal scraps. These materials are known to release trace metals into surrounding soils over time. The academic

building environment also recorded elevated levels of these metals, though slightly lower than those in the school residential halls. In contrast, the control site presented significantly lower values across all measured metals, suggesting minimal exposure to anthropogenic inputs.

Despite these variations, the heavy metal concentrations recorded in this study were generally below the permissible limits recommended by regulatory bodies like Department of Petroleum Resources (DPR) and the World Health Organization (WHO). For instance, WHO-recommended soil limits for key metals such as cadmium (0.8 mg/kg), chromium (100 mg/kg), copper (36 mg/kg), zinc (300 mg/kg) and lead (85 mg/kg) are considerably greater than the concentrations obtained in all sampled locations [21]. This suggests that the soils within the study area are not currently exposed to critical levels of heavy metal pollution that could pose immediate environmental or health concerns [22].

Although the heavy metal concentrations recorded in this research were within acceptable limits, the relatively higher concentrations observed in the residential and academic areas compared to the control location highlight the role of localized human activities in influencing soil quality. Activities such as improper waste disposal, accumulation of domestic refuse, and routine campus operations contribute to the gradual introduction of heavy metals into the soil. Materials like plastics, food waste, metal scraps, and electronic components can gradually release heavy metals into the soil through decomposition and leaching processes [23]. Similar trends have been reported in several Nigerian studies, where soils around dumpsites consistently exhibit higher heavy metal concentrations than nearby control sites. For example, elevated levels of zinc, cadmium and lead have been seen in dumpsite soils in Uyo due to continuous deposition of mixed wastes such as batteries, electronic materials, and household refuse [24]. In addition, studies conducted in Ibadan have shown that dumpsite soils contain significantly higher concentrations of heavy metals due to prolonged waste accumulation and decomposition processes, which enhance metal release and retention in the soil matrix [25]. Similarly, research in Bauchi, Nigeria demonstrated that soils influenced by solid waste disposal contained higher levels of heavy metals compared to uncontaminated areas, highlighting the role of waste type and composition in determining the extent of metal contamination [26]. These studies collectively show that continuous input and breakdown of waste materials lead to gradual enrichment of heavy metals in soils surrounding dumpsites.

The relatively elevated levels of zinc and copper detected in the residential areas may be associated with common household wastes such as metal scraps, batteries, plastics, and discarded electronic materials. Although the concentrations measured in this study remain within acceptable limits, the continuous input of such materials may lead to gradual accumulation over time. This is particularly important because of the persistence and the non- biodegradability of heavy metals in soils, increasing the likelihood of long-term environmental build-up [22].

Furthermore, even low concentrations of heavy metals can pose risks over time due to their potential for bioaccumulation, resulting in environmental build-up and potential entry into the food chain, which may eventually pose risks to human health [22]. These metals can be taken up by plants and transferred through the food chain or enter the human body through direct contact with contaminated soil. Studies have shown that crops grown in contaminated soils can accumulate heavy

metals, thereby increasing the risk of human exposure [27]. In addition, proximity to pollution sources has been linked to increasing metal concentrations in soils, further emphasizing the cumulative effect of continuous anthropogenic inputs [28].

Although the levels of heavy metals recorded in this research are low and within acceptable safety limits, the observed differences between impacted sites and the control indicate ongoing human influence. The concentrations are also considerably lower than those reported in heavily impacted dumpsite soils across Nigeria, including Minna, Ibadan, Osogbo, and Uyo [24-25, 29-30]. This suggests that although human activities within the university environment contribute to slight enrichment of metals in residential and academic areas, the intensity of contamination is significantly lower than that observed in typical municipal dumpsites. This may also be attributed to the relatively recent establishment of the Federal University Oye-Ekiti in 2011 [31], indicating that waste generation and accumulation within the study area have occurred over a shorter period compared to older urban environments. As a result, there has been less time for prolonged deposition, transformation, and accumulation of heavy metals in the soil. This temporal factor helps to explain the generally low levels of contamination observed in the study area.

The contamination factor (CF) values for the selected heavy metals across the sampling sites further support these observations. All calculated CF values were less than 1, which is indicative of low contamination levels for the heavy metals across all sites. The CF values followed the order Cd > Cu > Zn > Pb > Cr in both the residential halls and academic environment, indicating that cadmium contributed most significantly to soil contamination across the sampling sites. The relatively higher CF values observed in the residential halls and academic environment compared to the control site suggest the influence of anthropogenic activities such as waste disposal, domestic emissions, and general campus operations. However, the consistently low CF values indicate that these inputs have not yet resulted in concerning levels of contamination, in agreement with the classification proposed by Hakanson [15].

The contamination degree (CD), which represents the cumulative effect of all metals at each sampling site, further supports this observation. The calculated CD values for the residential area, academic environment, and control site were all below the threshold value of 6, indicating low levels of cumulative contamination of heavy metals across the study locations. Although the residential area recorded the highest CD value, reflecting greater human influence, the results suggest that the overall level of heavy metal accumulation in the study area remains minimal.

The values of the Geo-accumulation Index (Igeo) provide additional confirmation of the low contamination status of the soils. The distribution of Igeo values was in the sequence Cd > Cu > Zn > Pb > Cr, with all values being negative across the sampling sites. This indicates that the soils fall within Class 0 (unpolluted) according to Müller's classification [10], indicating that the levels of heavy metals are within natural background levels and have not been significantly influenced by contamination. The consistently low Igeo values support the CF and CD results, confirming that although there is some variation across locations, the soils remain environmentally safe.

When compared with findings from other studies, the Igeo values obtained in this study are considerably lower. For instance, studies conducted in Nigeria have reported higher

levels of contamination in dumpsite soils. Onyedika [26] reported moderate to strong pollution with cadmium in soils from dumpsites in Bauchi, while Ihedioha *et al*. [24] observed very high to extreme contamination levels for cadmium in soils from Uyo. Similarly, Odat [32] reported relatively higher Igeo values for cadmium in roadside soils in Jordan, attributing the enrichment to anthropogenic sources such as vehicular emissions. The much lower Igeo values recorded in the present study suggest that, although human activities contribute to the occurence of heavy metals, the extent of accumulation is minimal compared to heavily impacted environments such as municipal dumpsites and high-traffic areas.

Cadmium, however, remains the most prominent metal in terms of relative enrichment, which is consistent with its known environmental behaviour. It is a widely distributed pollutant often associated with anthropogenic sources such as waste disposal, industrial materials, and electronic components. Although the concentrations recorded in this study are low, cadmium is of particular concern because of its environmental persistence and its potential to accumulate in the ecosystem over time. Prolonged exposure to cadmium through soil, water, or food pathways has been associated with adverse health effects, including damage to the kidneys, bones, and other organ systems [33].

The Pollution Load Index (PLI) values further show that the study area is not polluted, as all values were less than 1. The slightly higher PLI value in the residential halls further reflects the influence of human activities in this area, although the impact remains minimal. These findings suggest that, while anthropogenic inputs are present, they have not accumulated to levels that would degrade soil quality significantly.

The observed variation in pollution indices across the sampling sites highlights the role of human activities in influencing soil chemistry within the study area. The higher CF, Igeo, and PLI values recorded in residential and academic environments suggest localized enrichment of heavy metals, most likely resulting from improper waste disposal practices and routine campus activities. Metals such as cadmium, copper, and lead showed relatively higher enrichment compared to other elements, which may be associated with common sources including discarded batteries, electronic waste, and metallic household materials typically found in campus environments.

Spatial differences were also evident, with residential hall soils consistently recording higher pollution indices than the academic environment. This pattern may be attributed to increased human density, higher waste generation, and closer proximity to informal disposal points around residential areas. In contrast, the academic environment, while still influenced by anthropogenic inputs, exhibited slightly lower levels of enrichment, while the control site remained least affected due to minimal human disturbance. Although the absolute concentrations of heavy metals remain low, the pollution indices indicate that continuous anthropogenic inputs are gradually altering the geochemical composition of soils within the study area. If such inputs persist over time without proper management, there is a possibility of gradual accumulation, which may elevate contamination levels in the future.

From the standpoint of public health and the environment, the current levels of contamination do not pose immediate toxicity risks. However, the potential for long-term exposure through dust inhalation, surface runoff, and plant uptake cannot be ignored. This underscores the importance of

implementing effective waste management strategies and establishing routine environmental monitoring systems within the campus to prevent future accumulation and ensure sustainable soil quality.

CONCLUSION

The investigation of dumpsite soils at Federal University Oye-Ekiti (Oye-Campus), Ekiti State, Nigeria, assessed the concentration of heavy metals (Cu, Cr, Cd, Zn, and Pb) in soils from different locations within the Federal University Oye-Ekiti, Oye Campus. The findings demonstrated that metal concentrations were generally higher in the residential halls and academic environments in contrast to the control location, indicating the impact of human activities.

Despite this variation, all measured concentrations were below the permissible limits established by regulatory bodies such as the World Health Organization and Department of Petroleum Resources. All the contamination factor (CF) values were below 1, suggesting low levels of contamination, while the geo-accumulation index (Igeo) categorised the soils as uncontaminated. Similarly, the pollution load index (PLI) values were less than 1 throughout the sampling locations, confirming that the soils are not polluted. Overall, the results show that the soils in the study locations are currently within acceptable environmental quality standards, although localized increases in metal concentrations suggest ongoing anthropogenic inputs.

According to the results of this study, it is important to carry out regular checks on soil quality to ensure that heavy metal levels do not increase over time, especially in areas with more human activity such as residential zones. There is also a need to improve how waste is handled on campus by ensuring proper disposal and reducing practices that can introduce harmful substances into the soil. Creating awareness among students and staff is equally important, as better understanding of environmental issues can help reduce careless waste disposal. Activities like indiscriminate dumping and burning of refuse should be discouraged and properly controlled to prevent soil contamination. In addition, further studies should be conducted to examine whether these metals are accumulating in plants or entering groundwater, as this could have implications for human health through the food chain.

DECLARATIONS

Authors' Contributions

AIO conceptualized the study. AIO, AAA and OJO designed the study. AIO and NPC conducted fieldwork and data collection. AAA performed the data analysis. NPC and AIO interpreted the results. AIO prepared the first draft of the manuscript, which was reviewed by AAA, OJO and FBA. All authors contributed to the development of the final manuscript and approved its submission.

Disclosure of Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Ethics Approval and Informed Consent

This study did not involve human or animal subjects. Therefore, ethical approval was not required. All soil samples were collected from environmental sites without any direct interaction with human participants or biological organisms.

Disclosure of Funding

The authors declare that this study did not receive any external funding.

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