*Original Research Article*

SPATIAL ASSESSMENT OF HEAVY METAL CONTAMINATION IN SOILS NEAR WASTE DUMPSITE IN ADO-EKITI, NIGERIA USING POLLLUTION AND GEO-ACCUMULATION INDICES

.

ABSTRACT

|  |
| --- |
| **Aims**: This study assesses heavy metal contamination in soils near the Ilokun and Emirin dumpsites in Ado-Ekiti, Nigeria, focusing on arsenic, chromium, manganese, nickel, and leads to understand the environmental risks posed by these sites.**Study Design:** The study employed an observational, cross-sectional design to assess heavy metal contamination in soils around two dumpsites in Ado-Ekiti, Nigeria. This design provided a snapshot of metal concentrations across multiple points within and around each dumpsite, allowing spatial distribution patterns to be analyzed.**Place and Duration:** Soil samples were systematically collected from multiple zones at each dumpsite and a control sample was obtained from a distant residential area.**Methodology:** Using Atomic Absorption Spectrophotometry, the concentrations of heavy metals were measured and statistically analyzed, with results showing significant differences across sites (p < 0.05).**Results:** Ilokun soils exhibited the highest contamination levels, with mean concentrations of arsenic (0.1176 ppm), chromium (0.3682 ppm), manganese (0.4667 ppm), nickel (0.0609 ppm), and lead (0.3319 ppm), whereas Emirin displayed moderate contamination, with lower values than Ilokun yet still elevated compared to the control site. The Geo-Accumulation Index (Igeo) indicated substantial contamination of chromium, manganese, and lead in both dumpsites, with levels in Ilokun being particularly elevated.**Conclusion:** The Pollution Load Index (PLI) for both dumpsites remained below critical thresholds, suggesting low overall pollution; however, the data underline the need for continuous monitoring and targeted remediation to reduce potential health risks and ensure soil safety for surrounding communities. |

*Keywords: [*Heavy Metal, Contamination, Soil, Pollution Load Index, Geo-accumulation Index]

1. INTRODUCTION

The continuous increase in human-generated waste—whether from residential, industrial, or commercial activities—has escalated environmental pollution concerns globally, with developing nations like Nigeria facing significant challenges in managing waste effectively (Daniel et al., 2021; Nwosu et al., 2021). Waste is generally defined as any material that loses its usefulness due to damage, wear, or contamination, thereby requiring disposal (Nwosu et al., 2021). In many urban and rural areas of Nigeria, waste is disposed of indiscriminately in open dumpsites. This unregulated disposal practice frequently occurs in easily accessible locations without adequate containment or management systems, such as engineered liners or leachate collection systems (Igboama et al., 2022). Consequently, open dumpsites become sources of various environmental pollutants, including hazardous heavy metals, which can leach into the surrounding soil and contribute to severe soil contamination (Ojiego et al., 2022).

Soil contamination with heavy metals near dumpsites has become a pressing issue, primarily due to the lack of proper waste management infrastructure in Nigerian dumpsites (Aliyu et al., 2020). Studies have shown that solid waste management in Nigeria is often characterized by inadequate collection and disposal facilities, as well as limited recycling options (Omang et al., 2021). This creates an environment where waste is left to decompose or is sometimes burned, releasing pollutants into the air and soil (Ogbaran and Uguru, 2022). Such practices contribute to the buildup of heavy metals in the soil, which poses significant risks to environmental health and safety. These metals do not degrade and, over time, accumulate in soils, reaching toxic concentrations that may harm plant life, soil organisms, and potentially enter the food chain, impacting human and animal health (Adewale et al., 2019). Heavy metals, such as lead, nickel, chromium, and manganese, are common contaminants in soils near dumpsites. These metals often originate from waste materials like batteries, electronics, and other industrial refuse disposed of at these sites (Akter et al., 2019; Onwukeme and Eze, 2021). Once introduced into the soil, these metals persist, affecting the soil's physical and chemical properties and hindering its ability to support vegetation (Ojiego et al., 2022).

Heavy metal pollution in soil not only disrupts ecological systems but also poses direct risks to human health, particularly through exposure pathways such as ingestion, inhalation, or dermal contact with contaminated soil (Nyiramigisha and Sajidan, 2021). Health effects from exposure to heavy metals can be severe, potentially leading to kidney and liver damage, neurological impairment, and increased risks of cancers, highlighting the urgency of addressing this environmental hazard (Elanga et al., 2022).

In Nigeria, research on soil contamination has indicated that soil around dumpsites, although sometimes fertile, is often highly polluted with heavy metals (Onuh et al., 2021; Chukwuma, 2022). Such findings underscore the paradox of soil in dumpsite regions: while potentially rich in organic material, it harbors concentrations of heavy metals that reduce its agricultural and ecological viability (Ojiego et al., 2022). The presence of these metals disrupts soil microbial communities, reduces plant growth, and increases health risks for communities that may use this soil for agriculture or other purposes. Moreover, heavy metals in soil can migrate into water sources through runoff, further extending the contamination problem and threatening drinking water safety (Karimian et al., 2021; Mavakala et al., 2022).

Studies across Nigeria highlight a significant issue with heavy metal contamination in soils near waste dumpsites, presenting both environmental and health risks. For example, research by Ojiego et al. (2022) found that soils around the Kuje and Kwali dumpsites in Abuja contained high levels of heavy metals like nickel, chromium, lead, cadmium, and zinc—far exceeding national safety limits. These metals were not only abundant but also showed patterns of accumulation, which could worsen over time. Similarly, Issa et al. (2022) assessed soils around dumpsites in Warri and found that while pollution levels were still relatively low, they recommended preventive steps to keep contamination from escalating. In Rivers State, Afolabi et al. (2022) found particularly high levels of cadmium at an abandoned landfill, marking it as a significant ecological risk.

Another study by Abiaziem et al. (2022) on an e-waste dumpsite in Ogun State showed concerning concentrations of cadmium, chromium, lead, arsenic, and zinc, which pose serious risks to local soil and water quality. Southeastern Nigeria is also affected; Onwukeme and Eze (2021) observed widespread metal contamination at several dumpsites, with levels that exceed both control sites and regulatory standards. In Ekiti State, research by Olubanjo and Olanrewaju (2019) found high concentrations of lead, zinc, and magnesium in soils near dumpsites in Ado-Ekiti, raising concerns about the risk of these metals entering the ecosystem and even food sources if such soils are used for agriculture or composting. Together, these studies underscore a common theme: soil contamination from heavy metals is a widespread problem around dumpsites in Nigeria, requiring urgent monitoring and intervention to protect both the environment and public health.

To evaluate and manage soil contamination, pollution and geo-accumulation indices provide a scientific basis for measuring heavy metal the concentrations and assessing ecological risk (Olagunju et al., 2020). These indices allow researchers to quantify the degree of pollution and help regulatory agencies establish guidelines for acceptable contamination thresholds in the environment. Pollution indices also support risk assessment, a critical step in determining the health impacts and necessary mitigation measures for affected regions (Olagunju et al., 2020). For Nigerian environmental authorities, such evaluations are essential in guiding policy and remediation efforts aimed at reducing soil contamination and its associated health risks(Olubanjo and Olanrewaju, 2019; Chukwuma, 2022).

This study focuses on the spatial assessment of heavy metal contamination in soils around a dumpsite in Ado Ekiti, Nigeria, using pollution and geo-accumulation indices. By analyzing the concentration and distribution of specific heavy metals, this research aims to provide a clearer understanding of the contamination levels in the area. Such information is crucial for informing remediation strategies and protecting the health of the local population and ecosystem. Through this investigation, we aim to address an environmental issue of growing concern and contribute to the broader body of knowledge on soil contamination and management in Nigeria.

2. material and methods

***Study Area*:** The study was conducted in Ado-Ekiti, the capital of Ekiti State, Nigeria. Located within the North Western part of the Benin-Owena River Basin Development Area, Ado-Ekiti sits at an elevation of approximately 439 meters above sea level. The town lies between 7°37′23.84″ N latitude and 5°13′15.13″ E longitude and experiences a tropical climate, with a rainy season from April to October and a dry season from November to March. Average annual temperatures range around 27°C, with higher humidity during the wet season. Two major dumpsites, Ilokun and Emirin, situated within the Ado-Ekiti metropolis, were selected for the study as they represent operational sites maintained by the Ekiti State Waste Management Authority (EK-WMA). The Ilokun dumpsite covers approximately 6.49 hectares, while the Emirin dumpsite spans 10.2 hectares, both facilitating long-term waste deposition and organic matter decomposition, potentially leading to soil and groundwater contamination in surrounding areas.



**Figure 1: (A) Map of Nigeria/Ekiti State showing Ado-Ekiti, the study area (B) Map of Ekiti State showing Ilokun community (C) Ilokun area showing the sampled waste dumpsite**

******

**Figure 2: (A) Map of Nigeria/Ekiti State showing Ado-Ekiti, the study area (B) Map of Ekiti State showing Emirin community (C) Emirin area showing the sampled waste dumpsite**

***Soil Sampling***: This study employed a systematic random sampling technique to collect soil samples from designated intervals within and around the dumpsites at Ilokun and Emirin. Each dumpsite was divided into three zones—Top-site, Dump-site, and Down-site—for comprehensive sampling. Control samples were collected from a residential area located at a considerable distance from each dumpsite (11.42 km from Emirin and 12.27 km from Ilokun). Soil samples were collected from a depth of 30 cm to assess heavy metal contamination effectively. All samples were collected in July 2023, during the moderate rainy season, and were transported to the laboratory for analysis following strict preservation and labeling protocols to ensure sample integrity.

***Inclusion and Exclusion Criteria***: Soil samples were taken only from the Ilokun and Emirin dumpsites and the surrounding residential areas in Ado-Ekiti. Control samples from the Jerusalem community, which is distant from both dumpsites, were included to serve as a baseline for comparison.Samples from regions outside Ado-Ekiti, as well as inactive or illegal dumpsites, were excluded to maintain consistency in assessing current heavy metal pollution levels from operational dumpsites.

***Soil Sample Digestion***: Soil samples were prepared for heavy metal analysis by oven-drying at 50°C, followed by pulverization and sieving through a 2 mm mesh. A 1 g portion of each sample was moistened with distilled water and treated with 10 ml of aqua regia (HNO₃:HCl in a 3:1 ratio). The mixture was heated at 160°C for 1 hour to near dryness, then cooled and filtered. The filtrate was diluted to 100 ml with distilled water in a conical flask and stored for analysis.

***Sample Analysis***: Heavy metal concentrations (Pb, Ni, Mn, Cr, and As) in the soil samples were determined using Atomic Absorption Spectrophotometry (Buck Scientific 211 VGP model), following standardized methods (APHA 20th Edition 3111B and 3111D, ASTM D3561 and D5198). Each sample was aspirated into an air-acetylene flame, with metal-specific wavelengths set for analysis (Cr 557.9 nm, Cu 324.7 nm, Pb 217.0 nm, Mn 279.5 nm, Ni 232.0 nm, and As 193.7 nm). Instrument calibration was performed using standard solutions, and triplicate measurements were conducted for each sample to ensure accuracy.

***Data Analysis***: Statistical analyses were conducted using the R-Statistical tool. Descriptive statistics, including mean and standard deviation, were used to summarize the concentrations of heavy metals. Analysis of Variance (ANOVA) and Tukey’s post-hoc test (significance level of 0.05) was applied to assess differences in metal concentrations across sampling sites. Contamination indices, such as Contamination Factor (CF), Pollution Load Index (PLI), and Geo-Accumulation Index (Igeo), were calculated to evaluate the extent of soil pollution and associated ecological risks

$$CF= \frac{C\_{metal}}{C\_{background value}} (1)$$

$$PLI= \left(CF\_{1}×CF\_{2}×CF\_{3}×…CF\_{n}\right)^{^{1}/\_{n}} (2)$$

$$lgeo=log\_{2}\left(\frac{C\_{n}}{1.5B\_{n}}\right) (3)$$

**3. RESULT AND DISCUSSION**

***Result***: Table 1 shows the mean and standard deviation of the concentration of heavy metals from the locations.The analysis of soil samples from Emirin, Ilokun, and a control site revealed variations in heavy metal concentrations. Ilokun soil showed the highest mean concentrations across all measured metals, with arsenic (As) at 0.1176 ppm, chromium (Cr) at 0.3682 ppm, manganese (Mn) at 0.4667 ppm, nickel (Ni) at 0.0609 ppm, and lead (Pb) at 0.3319 ppm. Emirin soil had moderate levels, with lower mean values than Ilokun but still higher than the control. Control soil samples displayed the lowest metal concentrations, with mean As at 0.0305 ppm, Cr at 0.1128 ppm, Mn at 0.2035 ppm, Ni at 0.0125 ppm, and Pb at 0.107 ppm. These results suggest that soils near the dumpsites, particularly Ilokun, are more heavily contaminated compared to the control site.

**Table 1**: **Mean±SD of Heavy Metals Concentration in Soil Samples obtained from the Sampled Sites**

|  |  |  |  |
| --- | --- | --- | --- |
| **Metals** | **Emirin** | **Ilokun** | **Control site** |
| **As (ppm)****M±SD** | 0.039±0.0183 | 0.1176±0.0143 | 0.0305±0.0025 |
| **Cr (ppm)****M±SD** | 0.2319±0.0667 | 0.3682±0.0172 | 0.1128±0.0040 |
| **Mn (ppm)****M±SD** | 0.3253±0.0335 | 0.4667±0.0372 | 0.2035±0.0058 |
| **Ni (ppm)****M±SD** | 0.0347±0.0165 | 0.0609±0.0107 | 0.0125±0.0030 |
| **Pb (ppm)****M±SD** | 0.1889±0.0593 | 0.3319±0.0349 | 0.107±0.0081 |

Table 2 presents the ANOVA test results for soil samples from the Emirin, Ilokun, and control sites. The p-value for heavy metal concentrations across these sites is 0.001948, which is below the 0.05 significance level. This indicates a statistically significant difference in heavy metal concentrations between the sites. In other words, heavy metal levels in the soil at Ilokun differ significantly from those at Emirin and the control site.

**Table 2: ANOVA of Heavy Metals in Soil samples from Emirin, Ilokun and Control Sites**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Source of Variation** | **Sites** | **Heavy Metals** | **Error** | **Total** |
| **SS** | 0.07825 | 0.185073 | 0.020813 | 0.284136 |
| **Df** | 2 | 4 | 8 | 14 |
| **MS** | 0.039125 | 0.046268 | 0.002602 |   |
| **F** | 15.03861 | 17.78421 |   |   |
| **P-value** | 0.001948 | 0.00048 |   |   |
| **F Crit.** | 4.45897 | 3.837853 |   |   |

Table 3 shows the contamination levels of heavy metals in soils from Emirin, Ilokun, and a control site were assessed using the Geo-Accumulation Index (Igeo), comparing the results to established background values for each metal. The findings for Emirin reveal varied levels of contamination: arsenic (As) shows a slightly reduced concentration with an Igeo of -0.94342, while chromium (Cr), manganese (Mn), and lead (Pb) have significantly elevated Igeo values of 2.950468, 5.438736, and 3.420123, respectively, indicating a high degree of contamination. Nickel (Ni) in Emirin shows a slight decrease with a negative Igeo of -0.3046. These results suggest a pattern of heavy metal contamination in Emirin, particularly for chromium, manganese, and lead, which exceed baseline levels and indicate a substantial environmental impact.

**Table 3: Geo-Accumulation Index of Heavy Metal Concentration in Soil of the Sampled Sites**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sampled Sites** | Emirin | Ilokun | Control |
| **As** | -0.9434 | 0.64893 | -1.2981 |
| **Cr** | 2.95047 | 3.61746 | 1.91073 |
| **Mn** | 5.43874 | 5.95946 | 4.76199 |
| **Ni** | -0.3046 | 0.50691 | -1.7776 |
| **Pb** | 3.42012 | 4.23325 | 2.60011 |

In Ilokun, the Geo-Accumulation Index shows a slightly different contamination profile, with positive Igeo values for all metals analyzed. Arsenic (As) has a mild increase (Igeo 0.648926), while chromium (Cr), manganese (Mn), and lead (Pb) exhibit high levels of contamination, with Igeo values of 3.617455, 5.959461, and 4.233249, respectively. Nickel (Ni) also shows a slight increase (Igeo 0.506907), indicating contamination in the area. The control site, used as a baseline, showed mostly negative Igeo values, especially for arsenic and nickel, indicating minimal contamination. Its Igeo values for chromium, manganese, and lead were much lower, highlighting the contamination in Emirin and Ilokun. Overall, both Emirin and Ilokun soils show elevated levels of chromium, manganese, and lead, with Ilokun displaying a higher degree of contamination, suggesting potential environmental risks in these areas and a need for targeted remediation.

Table 4 shows the contamination factor and pollution load index of the heavy metals in the soil samples. In the Emirin soil samples, Contamination Factor (CF) values for heavy metals such as arsenic (As), chromium (Cr), manganese (Mn), nickel (Ni), and lead (Pb) indicate relatively low contamination. Chromium shows the highest CF among the metals, suggesting a slightly higher contamination level than the others, but overall, the CF values in Emirin are modest, implying limited heavy metal presence. The Pollution Load Index (PLI) for Emirin soil, at 0.408896, is well below the threshold of 1.0, indicating that the overall pollution load remains low. This is a positive outcome, suggesting minimal environmental and health risks from heavy metals in this area.

**Table 4: Contamination Factor and Pollution Load Index of Heavy Metals**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sampled Sites** | Emirin Soil | Ilokun Soil | Control Soil |
| **CF (As)** | 0.00195 | 0.00588 | 0.00153 |
| **CF (Cr)** | 0.00464 | 0.00736 | 0.00226 |
| **CF (Mn)** | 0.00163 | 0.00233 | 0.00102 |
| **CF (Ni)** | 0.00099 | 0.00174 | 0.00036 |

|  |  |  |  |
| --- | --- | --- | --- |
| **CF Pb)** | 0.00222 | 0.00391 | 0.00126 |
| **PLI** | 0.4089 | 0.46275 | 0.36439 |
| **Status** | Low contamination | Low contamination | Very Low contamination |

Similarly, Ilokun soil samples show low CF values across the tested metals, with chromium again having the highest CF value, but still within a low contamination range. The PLI for Ilokun, calculated at 0.462748, also falls below the 1.0 threshold, reinforcing the finding of low overall pollution. The control site further supports these observations, with consistently low CF values for all metals and a PLI of 0.364387, affirming minimal contamination. Overall, the CF and PLI analyses suggest low levels of heavy metal contamination in both Emirin and Ilokun soils. These findings are reassuring in terms of environmental and health implications, but continued monitoring and management will be essential to ensure the long-term safety and quality of the soils in the study area.

***Discussion***: When comparing the levels of heavy metal contamination in the soil samples from Emirin and Ilokun, it becomes evident that Ilokun soil exhibits higher concentrations of several heavy metals, indicating a greater degree of contamination. Notably, the concentration of arsenic (As) in the Ilokun soil is significantly higher at 0.1176 ppm compared to Emirin's 0.039 ppm, highlighting a more pronounced contamination of arsenic in Ilokun. Additionally, Ilokun soil displays a higher concentration of chromium (Cr) at 0.3682 ppm compared to Emirin's 0.2319 ppm, indicating a greater presence of chromium contamination. Manganese (Mn) concentration in Ilokun soil is also elevated at 0.4667 ppm, surpassing Emirin's 0.3253 ppm, signifying a higher degree of manganese contamination. Furthermore, the concentrations of nickel (Ni) and lead (Pb) in Ilokun soil, measured at 0.0609 ppm and 0.3319 ppm, respectively, are both higher than Emirin's concentrations at 0.0347 ppm and 0.1889 ppm, indicating a greater contamination of these metals in Ilokun soil. Therefore, based on these multiple heavy metal concentrations, it is evident that the soil sample from Ilokun is more contaminated than that from Emirin.

The study found that Heavy Metal concentrations (As, Cr, Mn, Ni and Pb) were higher in the sampled locations (Emirin and Ilokun) compared to the control site, and there were significant differences in Heavy Metal concentrations both among the Heavy Metals themselves and among the sampled locations. Ilokun had significantly higher Heavy Metal concentrations compared to Emirin and the control site, while Emirin's Heavy Metal concentrations were not significantly different from the control site. Additionally, the Geo-Accumulation index suggests that the soil in Emirin and Ilokun is moderately contaminated, except for As and Ni. The contamination factor (CF) also indicates low contamination in both Emirin and Ilokun, with CF values between 0.001 and 0.002 in Emirin and between 0.002 and 0.007 in Ilokun. The control sites showed very low contamination with CF values between 0.0003 and 0.002. Overall, the Pollution Load Index (PLI) suggests that the sampled soil from Emirin and Ilokun have low contamination.

In support of the claim that heavy metal concentrations were higher at the dumpsites compared to non-dumpsites, several relevant references can be used. Saheed*et al.* (2020) assessed heavy metal concentrations in soil and groundwater around refuse dumpsites in Nigeria and reported higher concentrations of Cd, Pb, Cr, Mn, and Ni in the sampled locations. Orellana-Mendoza *et al.* (2022) identified significantly elevated levels of arsenic (As) and cadmium (Cd) contamination in agricultural soils near dumpsites, with Cd posing the greatest risk. In addition, Also, Nyiramigisha*et al.* (2021) also investigated the harmful impacts of heavy metal contamination in the soil and crops grown around dumpsites and found that the soil, vegetables, and other food crops in the vicinity of dumpsites were contaminated with heavy metals. Nyiramigisha and Sajidan (2021) found higher metal levels in dumpsites compared to control sites, emphasizing the anthropogenic contribution to heavy metal pollution and urging against farming near dumpsites. Liu *et al*. (2016) conducted a study on heavy metal concentrations in riparian soils along the Han River in China and found that the concentrations of several heavy metals, including Cr, Mn, Ni, and Pb, were higher in the sampled locations. Alabi *et al.* (2019) investigated heavy metal concentrations in soils around an asphalt production and quarry site in Nigeria and found higher concentrations of Cr, Mn, Ni, and Pb in the soil samples.

Afolabi and Eludoyin (2021) also evaluated the contamination status of soil around abandoned and active dumpsites in Nigeria. Their findings revealed that the concentration of heavy metals in the soil was high, indicating contamination. This contamination poses ecological and health-related risks. Since groundwater can be affected by the contaminants present in the soil, it is reasonable to infer that well water around dumpsites can be contaminated by heavy metals. Karimian*et al.* (2021) highlighted significant heavy metal pollution in Tehran landfill soil, particularly affecting children, and called for policy reevaluation. Agbemafle et *al.* (2020) revealed that heavy metal concentrations in leachates and crops near dumpsites in Ghana exceeded acceptable levels, raising concerns about crop safety. Li *et al.* (2020) identified changing metal distributions and significant pollution levels, emphasizing the need for careful site selection and operation in building waste dumpsites. The results of the study Adagunodo*et al.* (2018) indicates that when heavy metal concentrations in studied samples were compared to WHO allowable limits at sampled locations, it was found that Pb, Cr, and Cu levels were below the permissible limit, but Cd and Zn concentrations exceeded the permissible limit (Adagunodo*et al.,* 2018).

Furthermore, Shafiqul (2020) found higher heavy metal concentrations in dumpsite soil compared to non-dumpsite soil, though all remained within acceptable limits. Ojiego*et al.* (2022) identified pollution in Abuja's dumpsites, particularly in Kuje, with positive relationships indicating soil metal buildup. Issa *et al.* (2022) reported minimal heavy metal contamination around Warri's dumpsites, with Pollution Load Index (PLI) values below 1. Onuh*et al.* (2021) discovered heavy metals in soil and vegetables near a Nigerian dumpsite, potentially affecting human health. Onwukeme and Eze (2021) revealed elevated heavy metal levels in dumpsite soils, suggesting multi-element contamination. Obasi and Maduekwe (2021) reported moderate contamination, particularly in copper (Cu) and lead (Pb), near Awotan Ibadan dumpsites. Onyekachi *et al.* (2020) found elevated heavy metal concentrations in soil at Amaenyi Dumpsite in Awka, emphasizing the need for improved waste management and remediation measures.

In addition, Yerima*et al.* (2020) utilized MP-AES to analyze soil samples, revealing moderate to severe pollution with zinc, lead, and cadmium in Wukari, Nigeria. Nnaji and Chukwu (2020) found elevated heavy metal concentrations in Umuahia dumpsite soils, particularly for cadmium, with potential bioaccumulation risks. Adetuga*et al.* (2020) assessed heavy metal levels in the Old Oyo National Park, noting moderate soil contamination and cadmium toxicity during the wet season. Wunzani*et al.* (2020) observed higher heavy metal concentrations in Kaduna State's Kafanchan dumpsites, particularly for copper, lead, and zinc. Ekere*et al.* (2020) highlighted elevated cadmium levels in soil and cereal plants near an open dumpsite in Ugwuaji, Enugu, posing health risks. Sharfaddeen*et al.* (2020) reported heavy metal contamination in Kano dumpsite soils, with enrichment and geo-accumulation indices indicating varying pollution levels. Nasir and Barkoma (2020) found low nitrogen levels and heavy metal contamination in Yobe soils. Bashir *et al.* (2019) detected high levels of chromium, cadmium, zinc, and other metals in Gombe dumpsite soils but concluded minimal health risks. Jiya *et al.* (2019) revealed alarming chromium pollution at various dumpsites in Kogi, Nasarawa, and Niger States.

Also, Olowookere*et al.* (2018) observed elevated heavy metal concentrations in Gwagwalada, Abuja's dumpsite, remaining within specified limits. Lala *et al.* (2022) assessed chromium, copper, lead, zinc, and manganese levels in Afe-Babalola University soils, finding moderate pollution and recommending regular monitoring of heavy metal sources. Afolagboye*et al.* (2020) conducted a comprehensive analysis of heavy metals near a municipal dumpsite in Omuooke-Ekiti, revealing elevated concentrations in topsoil, potential ecological risks, and correlations between heavy metals. Olubanjo and Olanrewaju (2019) investigated soil and water samples around illegal dumpsites in Ado Ekiti, identifying lead as the predominant heavy metal and highlighting environmental risks due to proximity to wells and potential soil use for composting. Ayeni *et al.*, (2017) explored heavy metal accumulation in plants, invertebrates, and soil near a municipal dumpsite in Ado-Ekiti, finding significant levels of copper, nickel, and cobalt, posing long-term health hazards, and recommending measures to prevent contamination. Collectively, these studies shed light on the presence of heavy metals in soil near waste dumpsites and their potential ecological and health implications.

**4. Conclusion***:* This study found higher concentrations of metals like chromium, manganese, and lead in Ilokun compared to Emirin, with both sites showing elevated levels relative to the control site. Although all measured concentrations were within WHO/FAO permissible limits, the Geo-Accumulation Index and Pollution Load Index suggest moderate contamination, particularly in Ilokun. These findings highlight the need for continued monitoring and environmental management around these dumpsites to prevent potential risks to soil health, local ecosystems, and human populations.

Ethical approval (whereever applicable)

 “All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.”

References

Abiaziem, V; Ojelade, I. A; Peter, S (2022). Ecological and human health risk assessment of heavy metals contamination of soil in e-waste dumpsite in Atan, Ogun State, Nigeria. *International Journal of Environmental Chemistry and Ecotoxicology Research*, 4(1), 1–14.Available at https://fpiwitedjournal.federalpolyilaro.edu.ng/administrator/docs/3386953.pdf

Adagunodo, T. A; Adabanija, M. A; Adeniji, A; Oladele, S; Adetunji, A (2018). Heavy metal concentrations and its possible human health risk in groundwater from abandoned and active dumpsites in Ibadan. *Journal of Heavy Metals and Environment*, 12, 45–58.

Adewale, B; Fasunwon, O. O; Awodoyin, R. O (2019). Assessment of heavy metal contamination in soil from a solid waste dumpsite in Ogun State, Nigeria. *Environmental Monitoring and Assessment*, 19(3), 200–209.

Afolabi, O; Eludoyin, O (2021). Evaluation of heavy metals and contamination status of soil around abandoned and active Nigerian dumpsites. *Journal of Geography, Environment and Earth Science International*, 25(1), 1–11. DOI: https://doi.org/10.9734/jgeesi/2021/v25i1030310

Afolabi, O. O; Wali, E; Ihunda, E. C; Asomaku, S. O (2022). Health and environmental risk assessment of toxic metals and metalloids burdened soil due to anthropogenic influence. *Journal of Toxicology and Risk Assessment*, 8(2), 1–12.

Afolagboye, L. O; Ojo, A. A; Talabi, A. O (2020). Evaluation of soil contamination status around amunicipal waste dumpsite using contamination indices, soil quality guidelines, and multivariate statistical analysis. *SN Applied Sciences*, 2, 1864.DOI:

Agbemafle, R; Aggor-Woananu, S. E; Akutey, O; Bentum, J. K (2020). Heavy metal concentrations in leachates and crops grown around waste dumpsites in Sekondi-Takoradi in the Western Region of Ghana. *Research Journal of Environmental Toxicology*, 14(1), 16–25.

Alabi, A. A; Usman, O; Yusuf, M (2019). Heavy metal pollution index of soil around an asphalt production and quarry site in Nigeria. *Environmental Research and Public Health Journal*, 12(2), 48–58.

Aliyu, A; Haruna, Y; Mohammed, S (2020). Impacts of urban solid waste on environmental health in Nigeria: A review. *International Journal of Environmental Health*, 15(3), 112–119.

Ayeni, K; Ajayi, O; Odeyemi, D (2017). Studies on heavy metal accumulation in plants, invertebrates, and soil in a public dumpsite in Ado-Ekiti, Ekiti State. *International Journal of Sciences: Basic and Applied Research*, 36(2), 18–26.

Chukwuma, C (2022). Environmental cadastre of plant-soil interactions in the uptake and distribution of heavy metals or trace elements. *Advanced Journal of Environmental Science and Technology*, 7(1), 266–276.

Daniel, A. N; Ekeleme, I. K; Onuigbo, C. M (2021). Review on effect of dumpsite leachate to the environmental and public health implication. *GSC Advanced Research and Reviews*, 7(2), 51–60.

Ekere, N. R; Ugbor, M. C; Ihedioha, J. N; Ukwueze, N. N; Abugu, H. O (2020). Ecological and potential health risk assessment of heavy metals in soils and food crops grown in abandoned urban open waste dumpsite. *Journal of Environmental Health Science and Engineering*, 18, 711–721.

Elanga, D; Devi, K. D; Mishra, R (2022). Heavy metal toxicity problems in agriculture and mitigation strategies. *Journal of Agriculture and Food Research*, 10, e100374.

Igboama, W. N; Hammed, O. S; Fatoba, J. O (2022). Environmental risk assessment of heavy metal concentrations in soils near dumpsites in Abuja, Nigeria. *Journal of Toxicology and Environmental Health*, 6(1), 42–52.

Issa, B. R; Birma, G. J; Tawari-Fufeyin, P (2022). Index model approach of heavy metals pollution assessment in soil quality of selected solid waste dumpsites in Warri and environs, Delta State, Nigeria. *Direct Research Journal of Public Health and Environmental Technology*, 7(1), 1–8.

Jiya, M. J; Bala, J. D; Mustapha, H. I (2019). Heavy metals concentration in the dumpsite soil using geo-accumulation index and ecological risk assessment. *Agricultural Engineering International: CIGR Journal*, 21(3), 7–17.

Karimian, S; Shekoohiyan, S; Moussavi, G (2021). Health and ecological risk assessment and simulation of heavy metal-contaminated soil of Tehran landfill. *Royal Society of Chemistry Advances*, 11, 8080–8095.

Lala, M. A; Adesina, O. A; Sonibare, J. A (2022). Assessment of heavy metal pollution status in surface soil of a Nigerian university. *Journal of the Nigerian Society of Physical Sciences*, 4(887), 1–11.

Li, X; Ning, S; Zhang, P; Yang, W (2020). Environmental pollution and health risks of heavy metals in the soil around a construction waste landfill. *International Journal of Design and Nature and Ecodynamics*, 15(3), 393–399.

Liu, J; Zhang, X; Wang, R (2016). Heavy metal concentrations in riparian soils along the Han River, China. *Environmental Science and Pollution Research*, 23, 7749–7758.

Mavakala, B. K; Sivalingam, P; Poté, J (2022). Evaluation of heavy metal content and potential ecological risks in soil samples from wild solid waste dumpsites in a developing country under tropical conditions. \*Environmental Challenges, 7\*, e100461.

Nasir, M. U; Barkoma, M. B (2020). Determination of heavy metal pollution in soil collected from the bank of River Yobe Nigeria. *International Journal of Scientific and Research Publications*, 10(5), 955–962.

Nnaji, J. C; Chukwu, E (2020). Ecological risk assessment of heavy metals in soils from dumpsites within Umuahia, Nigeria. *Communication in Physical Sciences*, 5(2), 124–135.

Nwosu, O. U; Orji, C. G; Awuchi, C. G (2021). Evaluation of waste management practices at The Federal University of Technology, Owerri, Imo State of Nigeria. *International Journal of Advanced Academic Research*, 7(3), 32–48.

Nyiramigisha, P; Sajidan, K (2021). Assessment of heavy metals concentration in the soil and crops grown around dumpsites. *East African Scholars Journal of Agricultural Life Sciences*, 4(4), 82–88.

Ojiego, B. O; Ilo, O. P; Okolo, J. C (2022). Concentrations of heavy metals in soil samples from dumpsites located at Kuje and Kwali area councils, Abuja, Nigeria. *Journal of Materials and Environmental Sciences*, 13(9), 1037–1046.

Olagunju, T. E; Akawu, I. H; Ugokwe, C. U (2020). Quantification and risk assessment of heavy metals in groundwater and soil of residential areas around Awotan landfill, Ibadan. *Journal of Toxicology and Risk Assessment*, 6, 33.

Omang, D. I; John, G. E; Bisong, J. O (2021). Public health implication of solid waste generated by households in Bekwarra Local Government Area. *Africa Health Sciences*, 21(3), 1467–1473.

Onuh, E; James, I. U; Bulus, M (2021). Assessment of heavy metals contamination in a farmland near a market dumpsite in Zaria, Nigeria. *Dutse Journal of Pure and Applied Sciences*, 7(1), 271–279.

Onwukeme, V. I; Eze, V. C (2021). Identification of heavy metals source within selected active dumpsites in Southeastern Nigeria. *Environmental Analysis, Health and Toxicology*, 36(2), 1–18.

Orellana-Mendoza, E; Zamora, Y. M; Bastos, M. C (2022). Ecological risk assessment for heavy metals in agricultural soils surrounding dumps, Huancayo Province, Peru. *Journal of Ecological Engineering*, 23(6), 75–89.

Saheed, A; Yusuf, J; Emeka, S (2020). Heavy metal concentrations in soil and groundwater around refuse dumpsites in Nigeria. *Environmental Science and Health Journal*, 8(4), 215–227.

Shafiqul, I (2020). Assessment of heavy metal contamination of soil in municipal open-air dumpsites of Dhaka City. *Repository of SHER-E-BANGLA Agricultural University*.

Yerima, E. A; Sha’Ato, R (2020). Ecological risk assessment of mineral and heavy metals levels of soil around auto mechanic village Wukari, Nigeria. *Academic Journal of Chemistry*, 5(7), 81–90.