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Concentrations of Cadmium, Copper, Zinc, Lead, Nickel and Manganese in Soil from open Dumpsite at Baralola, Ikire, Osun State, Nigeria

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ABSTRACT: Heavy metal contamination in soil is a growing environmental and public health concern, particularly in developing countries where waste disposal practices are poorly regulated. This study assessed the concentrations of selected heavy metals in soil samples collected from the Baralola dumpsite in Ikire, Osun State, Nigeria. The primary aim was to evaluate the levels of cadmium, lead, copper, zinc, nickel, and manganese. Soil samples were collected from four different points around the dumpsite between May and December 2024 and were analyzed using standard acid digestion and appropriate laboratory techniques. Results revealed that cadmium concentrations ranged from 0.3 to 7.0 mg/kg (mean: 2.32 ± 1.88 mg/kg), and lead levels ranged from 22.5 to 1060 mg/kg (mean: 317.5 ± 431.0 mg/kg), both exceeding the World Health Organization (WHO) permissible limits of 0.8 mg/kg and 85 mg/kg, respectively. The Geoaccumulation Index (Igeo) indicated that cadmium and lead posed significant contamination risks, while copper, zinc, nickel, and manganese remained within safe limits. The high contamination levels of cadmium and lead highlight a considerable threat to human health, particularly for nearby residents who may be exposed through soil contact, water sources, or the food chain. The study concludes that urgent remediation efforts and stricter waste management policies are required to prevent further environmental degradation and health hazards. It contributes valuable data to support environmental health policies and offers a foundation for future research on soil contamination and community health risk assessments in the region.

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Heavy metal contamination in soil is a growing global concern due to its serious implications for environmental and human health. This issue has been significantly amplified by rapid industrialization, urban expansion, and poor waste management practices. In developing countries, like Nigeria, the situation is often worsened by weak environmental regulations and inadequate infrastructure, which make it difficult to effectively manage hazardous and non-hazardous waste (Xiao *et al.*, 2019; Aigberua and Tarawou 2018; Ojekunle *et al.*, 2021). Open dumpsites are one of the leading contributors to soil

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contamination with heavy metals. These sites often receive a mixture of municipal, industrial, and sometimes hazardous waste without proper segregation or treatment. As these wastes decompose, they release heavy metals such as cadmium, lead, zinc, copper, nickel, and manganese into the soil. These metals can then leach into groundwater or be taken up by plants, thereby entering the food chain and impacting both environmental quality and public health (Ali *et al*., 2019; Oyinloye and Awokola, 2022). What makes heavy metals particularly concerning is their persistent and non-degradable nature. Unlike organic pollutants, heavy metals do not break down over time. Instead, they accumulate in the soil and remain active for years or even centuries. This persistence allows them to be absorbed by crops and other plants, thus entering the food chain and threatening food safety (Islam *et al*., 2018; Fosu-Mensah *et al*., 2021). Among the most dangerous heavy metals are cadmium and lead. Even at low concentrations, cadmium is toxic. It can cause kidney damage, skeletal issues like bone weakening, and respiratory diseases. Long-term exposure has also been associated with cancer (Chen *et al*., 2020). Lead is no less harmful. It is a well-known neurotoxin that affects both children and adults. In children, lead exposure can lead to poor cognitive development, learning disabilities, and behavioral problems. In adults, it may cause hypertension, kidney dysfunction, and fertility issues (Zhang *et al*., 2020; Wu *et al*., 2022). Aside from their health impacts, heavy metals also degrade soil quality and agricultural productivity. They interfere with nutrient availability, harm beneficial microorganisms, and disrupt soil structure and fertility. Plants grown in metal-contaminated soil often show reduced growth, low yield, and compromised nutritional value. This is particularly problematic in areas where agriculture is a primary source of livelihood (Zhu *et al*., 2019; Liu *et al*., 2021). Numerous studies have documented the growing concern of heavy metal contamination in soil, especially in rapidly urbanizing and industrializing regions. In Nigeria, high levels of cadmium and lead have been reported in soil samples taken from unmanaged dumpsites. For example, Ojekunle *et al*. (2021) found that soil in such areas far exceeded acceptable safety limits for several heavy metals. Similarly, in other parts of West Africa and Asia, urban waste dumping and industrial effluent discharges have been directly linked to rising levels of soil contamination (Fosu-Mensah *et al*., 2021; Ali *et al*., 2019). In China, heavy metal contamination is particularly prevalent in industrial zones. Studies there reveal not only polluted soil but also negative consequences for agriculture and public health (Chen *et al*., 2020). In India, agricultural soil is often affected by untreated industrial waste and excessive pesticide use, posing risks to both the environment and food safety. Solving the problem of heavy metal pollution in soil requires a comprehensive approach involving both remedial actions and preventive strategies. Among the remediation methods, phytoremediation the use of specific plants to extract, absorb, or stabilize heavy metals has gained attention. This method is cost-effective and eco-friendly, although its success depends on factors such as plant species, soil type, and metal concentration (Zhao *et al*., 2022). Other methods include soil washing and immobilization, which aim to reduce the mobility and bioavailability of heavy metals in soil. From a policy perspective, there is an urgent need to strengthen environmental regulations and improve waste management systems. This includes enforcing stricter rules for industrial discharge, encouraging cleaner production methods, and ensuring that municipal waste is properly collected, sorted, and treated. Promoting public awareness is also critical citizens must be educated on the dangers of improper waste disposal and empowered to participate in community-based environmental monitoring (Liu *et al*., 2021). The widespread presence of heavy metals in soils particularly around unmanaged dumpsites poses serious threats to health, agriculture, and ecological balance. The lack of proper waste handling, especially in developing nations, has made this a pressing environmental challenge. In light of this, the current study seeks to evaluate the concentration of selected heavy metals cadmium, copper, zinc, lead, nickel, and manganese in soil collected from an open dumpsite in Baralola, Ikire, Osun State, Nigeria. Using appropriate laboratory techniques following acid digestion, this study aims to provide data that can inform environmental safety standards, public health interventions, and waste management reforms in the region.

MATERIALS AND METHODS

Study Area: Ikire, the capital of Irewole Local Government Area of Osun State in the South Western part of Nigeria; is a town which is the closest to Oyo State and also refers to as the gateway town to Osun State lies on latitudes 07^0 30'N and longitudes 04^0 20'E. According to 2006 population Census, Ikire was estimated to have 143, 599 inhabitants. Baralola dumpsite is situated at Baralola Compound, Olaiya Street, in Ikire, Irewole Local Government Area of Osun State. The dumpsite has been in existence for about 60 – 70 years and is surrounded by residential houses and receives all their solid wastes. Wastes are of different types ranging from organic to inorganic; hazardous and non-hazardous. The surrounding

houses have their hand dug well and depend on these wells for their domestic water supply. Table 1: Shows the description of the sample codes and the coordinates of the sampling points. Fig 1 shows the picture of the dumpsite and Fig 2 shows Map of the study area (Ikire).



Fig 1: Baralola Dumpsite, Ikire**.**

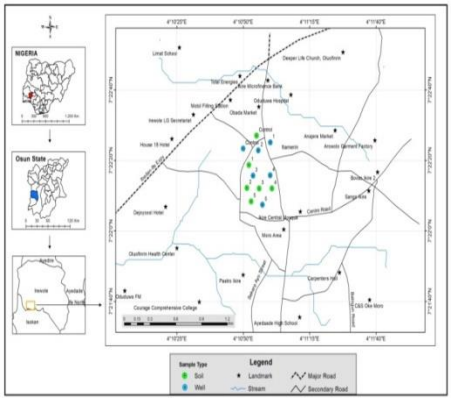


Fig 2: Map of the study area (Ikire)

Sample Collection and preservation: Sampling Plan: The dumpsite was divided into four radial transects in order to investigate the distribution of heavy metal concentration at the site and four soil samples were collected based on the classification. The coordinate of the sampling points were referenced with a Global Positioning System (GPS). At each sampling point, the topsoil layer was scraped off while portions of soil were scooped within a depth of 5 – 15 cm using a cutlass. The collected portions were subsequently combined to give a composite of each of the individual sample. The soil samples were labeled accordingly and stored in a polythene bag.

Sample treatment: Sampling was carried out in December, 2024. Collected samples were kept in polythene bags and transported to the laboratory. Soil samples were air dried in the laboratory for few days at room temperature until they were properly dried. Large objects (stone, sticks) were removed. Samples were then gently ground with porcelain mortar and pestle, sieved through a 2mm sieve and stored in small polythene bags for metal analysis.

Quality Control Protocol: Quality assurance and quality control were ensured by meticulously following the written procedures for sampling handling both on the field and in the laboratory. Instruments and equipments used were calibrated. Quality control techniques were performed such as cleaning of apparatus, glassware and method blank determination. Standards were used to verify calibration accuracy. Analytical procedures were validated by carrying out duplicate analysis.

Determination of heavy metals in soil (APHA, 2005): The <2mm fraction soil samples were digested to determine the heavy metal concentration. Approximately 1g of the soil sample was weighed into centrifuge tubes and 10 mL of 2M HNO_3 was then added. The mixture were heated over water bath for 2 hours and shaken at 20 min interval. The solutions were filtered into 25 mL volumetric flasks. The flasks were made up to mark with distilled water and the concentration of the heavy metals were determined with AAS

Ecological Risk Assessment: The following factor was calculated to estimate the risk posed to humans from exposure to the heavy metals.

Geoaccumulation Index (I_{geo}): The geoaccumulation index I_{geo} values were calculated for different metals as introduced by Muller (1969) as follows:

$$I_{geo} = \log_2\left(\frac{C_n}{1.5B_n}\right) \qquad (1)$$

Where C_n is the measured concentration of the element in the soil sample; B_n is the geochemical background for the element. The factor 1.5 was introduced as a correction factor to normalize the background metal concentration values that are due to lithogenic variations and anthropogenic effects (Loska *et al*., 1997). Muller (1981) proposed seven grades or classes of the geoaccumulation index with soil quality as follows: Class 0; $I_{geo} \leq 0$ = unpolluted: Class 1; $0 < I_{geo} < 1$ = unpolluted to moderately polluted: Class 2; $0 < I_{geo} < 2$ = moderately polluted: Class 3; $2 < I_{geo} < 3$ = moderately polluted to highly polluted: Class 4; $3 < I_{geo} < 4$ = polluted: Class 5; $4 < I_{geo} < 5$ = highly polluted to very highly polluted: Class 6; $5 < I_{geo} < 6$ = very highly polluted

The I_{geo} class 0 indicated the absence of contamination while the I_{geo} class 6 represents the upper limit of the contamination. The highest class 6 (very strong contamination) reflects 100 folds

enrichment of the metals relative to their background values (Harikumas *et al*., 2010).

Quality Assurance: Duplicate Analysis: Duplicate sample analysis was done to determine reproducibility or consistency in the method. Duplicate samples were digested and analyzed the same way as the original samples. The percent difference was calculated by dividing the difference between the two results by their average as follows:% difference = $(x - y) / ((x + y) / 2) \times 100\%$
Where x = result of the first analysis; Y = result of second analysis

RESULTS AND DISCUSSION

The study evaluated the concentration of heavy metals in soil samples collected from a dumpsite to assess potential environmental and health risks. Results showed varying levels of heavy metals, including cadmium, copper, zinc, lead, nickel, and manganese, some of which exceeded the maximum permissible limits set by the World Health Organization (WHO, 1996).

Manganese (Mn): The concentration of manganese ranged from not detected (ND) in Sample 2 to 0.30 mg/kg in Sample 4. Although WHO has no specified limit for manganese in soil, the levels reported here are relatively low and similar to findings by Ogunbanjo *et al*. (2020) in a study conducted near municipal dumpsites in Lagos, where Mn levels were found to be below toxicity thresholds. Manganese is an essential nutrient for plants but can become harmful at elevated concentrations, particularly in groundwater.

Copper (Cu): Copper levels were ND in Sample 1 but rose significantly in Sample 4 (52.30 mg/kg), which exceeds the WHO standard of 36 mg/kg. Elevated copper in this sample suggests possible contamination from metal waste or industrial runoff. This aligns with the findings of Adeyeye and Adebayo (2019) in Akure, who observed copper concentrations ranging between 10–45 mg/kg in soils near waste disposal sites. Copper, though essential in trace amounts, becomes toxic at high levels and can impair soil microbial activity.

Lead (Pb): The most alarming result is the extremely high concentration of lead, especially in Sample 4 (1060.00 mg/kg) and Sample 5 (325.00 mg/kg), which drastically exceed the WHO safe limit of 85 mg/kg. These results are consistent with previous studies by Yusuf *et al*. (2021) in northern Nigeria, which reported elevated lead levels in soil samples collected near open dumpsites. Such high levels are indicative of intense contamination, possibly from batteries, paints, or e-waste, and pose severe health risks including neurological damage in children.

Cadmium (Cd): Cadmium concentrations in all samples were far above the WHO threshold of 0.80 mg/kg, with Sample 4 reaching 7.00 mg/kg. This supports findings by Iwegbue *et al*. (2018) in Delta State, who reported elevated cadmium levels near unregulated dumpsites. Chronic exposure to cadmium is linked to kidney failure, bone diseases, and cancer, making this result highly concerning from a public health perspective.

Nickel (Ni): Nickel levels varied between 5.00 mg/kg and 75.00 mg/kg, with no specific WHO guideline for soils. However, Sample 4 again shows a very high concentration, which could be related to industrial waste or corrosion of metal equipment. A study by Bello *et al*. (2020) in Ogun State found similar trends in areas near auto-mechanic workshops. Though not regulated by WHO in soils, nickel can still cause allergic reactions and respiratory problems at high levels.

Zinc (Zn): Zinc concentrations were within safe limits, with the highest being 23.00 mg/kg in Sample 4, well below the WHO limit of 50.00 mg/kg. These values are consistent with results from Nwachukwu et al. (2017), who found zinc to be relatively stable and within tolerable limits in soil samples near municipal waste sites. Zinc is an essential nutrient, but excessive amounts may cause phytotoxicity.

Table 1: heavy metal concentration results of soil samples (mg/kg)

Heavy Metal	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	WHO Standard (1996)
Manganese(mg/kg)	0.10 ± 0.01	ND	0.08 ± 0.01	0.30 ± 0.01	0.05 ± 0.01	Not Specified
Copper (mg/kg)	ND	3.00 ± 0.10	4.50 ± 0.10	52.30 ± 0.30	16.50 ± 0.10	36.00
Lead(mg/kg)	22.50 ± 0.20	65.00 ± 0.20	115.00 ± 0.50	1060.00 ± 2.00	325.00 ± 1.00	85.00
Cadmium(mg/kg)	2.30 ± 0.10	1.30 ± 0.10	0.30 ± 0.10	7.00 ± 0.20	2.00 ± 0.10	0.80
Nickel(mg/kg)	22.50 ± 0.10	5.00 ± 0.10	5.00 ± 0.10	75.00 ± 0.20	18.80 ± 0.10	Not Specified
Zinc(mg/kg)	8.00 ± 0.10	7.30 ± 0.10	6.50 ± 0.10	23.00 ± 0.20	4.50 ± 0.10	50.00

ND = Not Detected

Table 2: Geoaccumulation indices of heavy metals

Zinc	Copper	Nickel	Cadmium	Manganese	Lead
0.04	0.19	0.23	3.32	$2.26x10^{-5}$	2.80

Geoaccumulation Index (Igeo): The Geoaccumulation Index (Igeo) was used to assess the pollution levels of these heavy metals in the soil. The results indicate high pollution levels for lead (Igeo = 2.80) and cadmium (Igeo = 3.32), signifying that the soil is heavily contaminated with these elements. This level of contamination implies a high anthropogenic influence, likely from waste disposal practices at the dumpsite (Luo *et al*., 2018). Conversely, the Igeo values for copper, nickel, zinc, and manganese were below 1, indicating that the soil is not significantly polluted with these metals. This differentiation in Igeo values emphasizes the need for targeted remediation efforts, focusing particularly on mitigating lead and cadmium contamination to protect environmental and public health.

Conclusion: This study contributes significantly to existing knowledge by providing empirical data on heavy metal contamination levels in Baralola dumpsite, Ikire, Osun State. It highlights the environmental and public health risks associated with unregulated waste disposal. The findings serve as a scientific reference for future environmental assessments and policy decisions in similar rural settings. This work also emphasizes the need for ongoing monitoring and remediation efforts. By identifying specific pollutants and their concentrations, the study fills a gap in local contamination data. Ultimately, it advances understanding of how dumpsites affect soil quality and human health in developing regions.

Declaration of Conflict of Interest: The authors declare that no conflict of interest or personal relationship that could have influence the work reported in this paper.

Declaration of Data Availability Statement: Data is available upon request from first author

REFERENCES

Adeyeye, AO; Adebayo, AA (2019). Assessment of heavy metal pollution in soil and groundwater near municipal dumpsites in Akure, Nigeria. *Afr. J. Environ. Sci. Technol. 13*(6), 230–239. https://doi.org/10.5897/AJEST2019.2706

Aigberua, AO; Tarawou, T (2018). Assessment of heavy metals in soils around municipal solid waste dumpsites in Yenagoa, Bayelsa State, Nigeria. *J. Appl. Sci. Environ. Manage. 22*(5), 645–649. https://doi.org/10.4314/jasem.v22i5.4

Ali, H; Khan, E; & Ilahi, I (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. *J. Chem. 2019*, Article 6730305. https://doi.org/10.1155/2019/6730305

American Public Health Association (APHA). (2005). *Standard methods for the examination of water and wastewater* (21st ed.). American Water Works Association.

Bello, OS; Oladoja, NA; Arowolo, TA (2020). Evaluation of heavy metal contamination from automobile workshops in Ogun State, Nigeria. *Environmental Risk Assessment and Remediation, 4*(2), 62–70.

Chen, L; Zhou, S; Shi, Y; Wang, C; Li, B (2020). Heavy metal contamination and ecological risk assessment in agricultural soils around a lead/zinc mining area in Southwestern China. *Intern. J. Environ. Res. Pub. H. 17*(10), 3734. https://doi.org/10.3390/ijerph17103734

Fosu-Mensah, BY; Addae, E; Yirenya-Tawiah, D; Nyame, FK (2021). Heavy metals contamination anhuman health risk assessment in soil and food crops around municipal solid waste dumpsites in Ghana. *Environmental Monitoring and Assessment, 193*, 22. https://doi.org/10.1007/s10661-020-08763-1

Harikumar, PS; Jisha, TS; Nasir, UP (2010). Distribution of heavy metals in the core sediments of a tropical wetland system. *Intern. J. Environ. Sci. Technol. 7*(1), 119–130.

Islam, MS; Ahmed, MK; Habibullah-Al-Mamun, M; Masunaga, S (2018). Assessment of trace metals in fish species of urban rivers in Bangladesh and health risk implications. *Environ. Toxicol. Pharm. 58*, 152–162. https://doi.org/10.1016/j.etap.2017.12.006

Iwegbue, CMA; Nwajei, GE; Iyoha, EH. (2018). Heavy metal contamination of topsoil in the vicinity of dumpsites in Delta State, Nigeria. *Environ. Res. J. 12*(3), 83–89.

Liu, L; Li, W; Song, W; Guo, M; Jiang, Z (2021). Environmental risk assessment and source apportionment of heavy metals in soil from a typical brownfield in North China. *Ecotoxicol. Environ. S. 213*, 112015. https://doi.org/10.1016/j.ecoenv.2021.112015

Loska, K; Cebula, J; Pelczar, J; Wiechuła, D; Kwapuliński, J (1997). Use of enrichment, and geoaccumulation factors to evaluate the contamination of heavy metals in the Rybnik water reservoir in Poland. *Environ. Geo. 30*(1–2), 51–56. https://doi.org/10.1007/s002540050130

Luo, L; Ma, Y; Zhang, S; Wei, D; Zhu, YG (2018). An inventory of trace element inputs to agricultural soils in China. *J. Environ. Mgt*, *88*(4), 1320–1326. https://doi.org/10.1016/j.jenvman.2007.07.017

Muller, G. (1969). Index of geoaccumulation in sediments of the Rhine River. *Geoj. 2*, 108–118.

Muller, G (1981). Die Schwermetallbelastung der Sedimente des Neckars und seiner Nebenflüsse: Eine Bestandsaufnahme. *Chemie der Erde, 42*, 133–149.

Nwachukwu, MA; Feng, H; Alinnor, J. (2017). Assessment of heavy metal pollution in soil and their implications within and around mechanic villages. *Environ. Earth Sci. 61*(2), 451–462. https://doi.org/10.1007/s12665-009-0355-4

Ogunbanjo, OO; Aderemi, AO; Adepoju, SA (2020). Levels of heavy metals in soil and vegetables from selected dumpsites in Lagos, Nigeria. *J. Environ. Sci. Toxicol. Food Technol. 14*(2), 41–47.

Ojekunle, ZO; Jinadu, OO; Taiwo, AM (2021). Human health risk assessment of heavy metals in soil of open dumpsites in Nigeria. *Sci. Afr. 13*, e00901. https://doi.org/10.1016/j.sciaf.2021.e00901

Oyinloye, MA; Awokola, OS (2022). Assessment of heavy metals in surface soil from dumpsites in Akure, Nig. *Environ. Res. Technol. 5*(1), 1–10.

World Health Organization. (1996). *Permissible limits of heavy metals in soil and plants*. WHO.

Wu, Y; Liu, H; Wang, W; Li, F; Wei, C (2022). Exposure to lead and its impact on human health in China: A rev. *Environ. Pollut. 292*, 118295. https://doi.org/10.1016/j.envpol.2021.118295

Xiao, R; Guo, D; Ali, A; Mi, S; Liu, T; Li, R (2019). Pollution characteristics and risk assessment of heavy metals in agricultural soil in the Liaohe River Basin. *Environ. Sci. Pollut. Res. 26*, 13542–13555. https://doi.org/10.1007/s11356-019-04629-y

Zhang, H; Liu, M; Zhang, Y (2020). Lead exposure and neurodevelopmental outcomes in children: A systematic rev. *Environ. Res. 183*, 109139. https://doi.org/10.1016/j.envres.2019.109139

Zhao, FJ; Ma, Y; Zhu, YG; Tang, Z; McGrath, SP (2022). Soil contamination in China: Current status and mitigation strategies. *Environ. Sci. Technol. 56*(4), 2175–2184. https://doi.org/10.1021/acs.est.1c05915

Zhu, Y; Yang, J; Dai, Q (2019). Heavy metals in soil-rice system around e-waste sites in South China: Risk assessments and effects of soil properties. *Environ. Geochem. H. 41*, 221–235. https://doi.org/10.1007/s10653-018-0115-2