



Physicochemical and Spatial Assessment and Heavy Metal Contamination in Soils from a Central Dumpsite: Implications for Environmental and Human Health

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Abstract

This study assessed the physicochemical properties and heavy metal concentrations of soils from the central dumpsite in Effurun, Delta State, Nigeria. Soil samples were collected from three distinct locations within the dumpsite and analyzed for pH, macronutrients, texture, bulk density, pore size, and heavy metal content. Results revealed that the soils were slightly acidic (pH 5.0–6.3) with high sand content (72.40%) and low clay fraction (10.41%), conditions that favor leaching and contaminant mobility. Macronutrient concentrations—particularly nitrogen (3.15%) and phosphorus (1.49 mg/kg)—were elevated, likely due to organic waste input. Heavy metals such as chromium (25.72 mg/kg), cadmium (9.21 mg/kg), and lead (36.64 mg/kg) exceeded FEPA and WHO thresholds, posing potential risks to human health and the environment. Spatial variation across sampling points reflected differences in waste types and disposal intensity, with location A exhibiting the highest concentrations of most metals. Correlation analysis showed strong positive relationships among several parameters, suggesting common sources or synergistic interactions. Comparison with a control site confirmed elevated contamination levels in the dumpsite. These findings highlight the urgent need for environmental monitoring, remediation, and improved waste management strategies to prevent soil degradation and groundwater contamination in the area.

Keywords: Physicochemical Properties; Heavy Metals; Soil Contamination; Dumpsite Assessment; Groundwater Pollution and Environmental Monitoring

Introduction

The global population is projected to reach 10 billion by the year 2050 [1,2]. Nigeria, the most populous country in Africa and the 8th globally, had already surpassed 140 million people by 2015 [3]. This rapid population growth has been accompanied by a surge in waste generation, culminating in environmental degradation, particularly in urban areas. Solid waste, a by-product of industrial, commercial, and domestic activities, varies in form, composition, and toxicity. Whether biodegradable or hazardous, its final impact is environmental pollution—particularly of the soil and groundwater systems [4,5].

Soils have historically served as the ultimate repository for various forms of waste, especially in developing nations where waste management infrastructure is limited [6]. The central dumpsite in Effurun, Delta State, exemplifies this issue. Waste from residential, commercial, and mechanical sources—including batteries, solvents, engine oil, and pesticides—is dumped without segregation, introducing potentially hazardous heavy metals into the soil matrix [7]. These metals, including lead (Pb), cadmium (Cd), chromium (Cr), and nickel (Ni), are non-biodegradable and can persist in the environment, accumulating in the soil and eventually infiltrating groundwater or entering the food chain [8].

Heavy metals are particularly mobile in acidic soils, where lower pH enhances their solubility and leaching potential [9]. Thus, understanding the interaction between soil pH and metal concentrations is vital in assessing contamination risk. Additionally, soil texture and structure—including sand, silt, and clay content—determine porosity and permeability, influencing how easily contaminants migrate through the soil profile [10]. Physical properties also provide insight into the soil's capacity to retain or release pollutants.

This study focused on evaluating the impact of waste disposal on soil quality at the Effurun dumpsite by (iv) examining how heavy metal concentrations vary with soil pH, (v) comparing metal levels with established standards from WHO, FEPA, and USEPA, and (vi) analyzing key physical soil parameters such as texture, bulk density, and pore space. Through this, the research aims to provide a scientific basis for assessing the environmental risk posed by the dumpsite and inform appropriate management strategies for soil and groundwater conservation.

Materials and Methods

Study area

The study was conducted at the central dumpsite located in Effurun, Uvwie Local Government Area of Delta State, Nigeria. The site lies at latitude 5.5715700°N and longitude 5.7760200°E, with an elevation of approximately 9 meters above sea level. Effurun is situated within the tropical rainforest belt, characterized by high humidity and rainfall throughout most of the year. The area experiences a mean annual temperature of about 32°C and annual rainfall of 2,600 mm. The region supports a diverse range of human activities, including oil exploration, agriculture, manufacturing, trade, and services. The soil and hydrological properties of the Niger Delta, where the study site is located, are shaped by alluvial and marine deposits, leading to hydromorphic, poorly-drained soils with variations in texture and chemical composition.

Research design and sampling

The study employed a **Complete Random Design (CRD)** with **systematic random sampling** to assess the impact of solid waste

on soil quality. Three sample sites were selected based on the age of deposited waste:

- **Site A:** Waste deposited for approximately 3 years
- **Site B:** Waste deposited for approximately 10 years
- **Site C:** Control site located about 3 km away from Site B and unaffected by dump activities

From each site, three independent composite soil samples were collected at a depth of 0–30 cm. Sampling was conducted at around 11:30 am in early March to ensure uniform environmental conditions.

Sources of data

Both **primary and secondary data** were utilized in this study:

- **Primary data** were obtained from laboratory analyses of the collected soil samples.
- **Secondary data** were sourced from institutions such as the Ministry of Lands and Survey (Delta State), Federal Ministry of Environment, Delta State Environmental Protection Agency, Federal University of Technology Owerri (FUTO), Delta State University, and the Petroleum Training Institute, among others.

Laboratory analysis

Soil samples were subjected to physicochemical and heavy metal analysis using standardized procedures:

Soil pH

Measured using a pH meter and supported by litmus paper. A 1:2 soil-to-water ratio was prepared and allowed to stand for 30 minutes before pH readings were taken.

Total nitrogen

Determined using the **Kjeldahl method**, involving acid digestion, distillation, and titration. Results were calculated as a percentage of total Kjeldahl nitrogen.

Available phosphorus

Measured using a spectrophotometer at a wavelength of 880 nm following the ascorbic acid method. Absorbance values were compared to a calibration curve for quantification.

Heavy metals (Pb, Cr, Zn, Cd, Mn, Fe, Ni)

Concentrations of selected heavy metals were analyzed using an **Atomic Absorption Spectrophotometer (AAS)**. Standard calibration curves were generated for each metal to determine concentrations in mg/kg.

Particle size distribution

Hydrometer method was used to estimate the percentage of sand, silt, and clay using sodium hexametaphosphate as a dispersing agent.

Bulk density

Determined using water displacement technique. Bulk and particle densities were computed from soil volume and weight relationships.

Infiltration rate

Measured using funnel infiltration tests. Soil-filled funnels were set in graduated cylinders and infiltration was monitored over time. Pore sizes were also estimated based on air displacement.

Ethical considerations

Although the study did not involve human subjects, all procedures adhered to environmental research best practices. Soil collection was conducted with proper consent from local authorities and ensured minimal environmental disturbance.

Statistical analysis

Data analysis was performed using **SPSS® version 17.0** and **Microsoft Excel**. Descriptive statistics (mean, range, standard deviation, and standard error) were computed for all measured parameters. One-Way **ANOVA** was used to test for significant differences in soil properties across the sites. **Pearson correlation coefficients** were calculated to assess the relationships among soil physicochemical parameters.

Results

Some of the analyzed parameters exhibited relatively narrow variations. These include soil pH, which ranged from 5.0 to 6.3 with a mean of 5.5 ± 0.18 . Total nitrogen content varied between 2.06% and 3.91% (3.15 ± 0.24), while available phosphorus ranged from 1.17 mg/kg to 1.80 mg/kg (1.49 ± 0.08). Silt content ranged from 15.10% to 18.80% (17.19 ± 0.44), clay content from 10.12% to 10.90% (10.41 ± 0.09), and sand content from 70.60% to 74.40% (72.40 ± 0.44). Bulk density varied from 2.01 g/cm³ to 2.36 g/cm³ (2.15 ± 0.04), while pore space ranged from 26.70% to 29.70% (27.90 ± 0.30), as shown in Table 1. In contrast, wide variations were observed in the concentrations of heavy metals. Chromium ranged from 4.22 mg/kg to 42.42 mg/kg (25.72 ± 5.07), zinc from 7.39 mg/kg to 25.36 mg/kg (17.80 ± 2.49), and cadmium from 0.52 mg/kg to 14.60 mg/kg (9.21 ± 2.16). Lead concentrations varied between 8.56 mg/kg and 55.20 mg/kg (36.64 ± 6.85), manganese from 0.66 mg/kg to 12.49 mg/kg (7.51 ± 1.67), iron from 15.20

Parameters	Min	Max	Range	Mean	S.D	SE	FEPA Standard
pH	5.0	6.3	1.3	5.5	0.54	0.18	-
Nitrogen %	2.06	3.91	1.85	3.15	0.73	0.24	-
Phosphorus (mg/kg)	1.17	1.80	0.63	1.49	0.24	0.08	-
Silt %	15.10	18.80	3.70	17.19	1.32	0.44	-
Clay %	10.12	10.90	0.78	10.41	0.28	0.09	-
Sand %	70.60	74.40	3.80	72.40	1.31	0.44	-
Bulk density g/l	2.01	2.36	0.35	2.15	0.11	0.04	-
Pore size %	26.70	29.70	3.00	27.90	0.89	0.30	-
Cr (mg/kg)	4.22	42.42	38.20	25.72	15.21	5.07	0.03
Zn (mg/kg)	7.39	25.36	17.97	17.80	7.47	2.49	-
Cd (mg/kg)	0.52	14.60	14.08	9.21	6.49	2.16	0.01
Pb (mg/kg)	8.56	55.20	46.64	36.64	20.56	6.85	0.05
Mn (mg/kg)	0.66	12.49	11.83	7.51	5.02	1.67	-
Fe (mg/kg)	15.20	77.84	62.64	50.46	26.49	8.83	-
Ni (mg/kg)	0.82	15.11	14.29	9.54	6.55	2.18	0.10

Table 1: Comparative Changes in Physicochemical parameters.

mg/kg to 77.84 mg/kg (50.46 ± 8.83), and nickel from 0.82 mg/kg to 15.11 mg/kg (9.54 ± 2.18), respectively, as detailed in Table 1.

Spatial changes in mean of physical and chemical parameters

Spatial variations were observed in both the physical and chemical parameters across the different sampling locations. In terms of soil texture, silt content was highest at Location B (18.6%) and lowest at Location A (15.73%). Clay content peaked at Loca-

tion A (10.53%) and was lowest at Location C (10.19%), while sand content was highest at Location A (73.73%) and lowest at Location B (70.90%) (Figure 1).

Soil pH also varied spatially, with the highest value recorded at Location C (6.2) and the lowest at Location B (5.1). Regarding macronutrients, nitrogen concentration was highest at Location B (3.72%) and lowest at Location C (2.20%). Phosphorus levels were

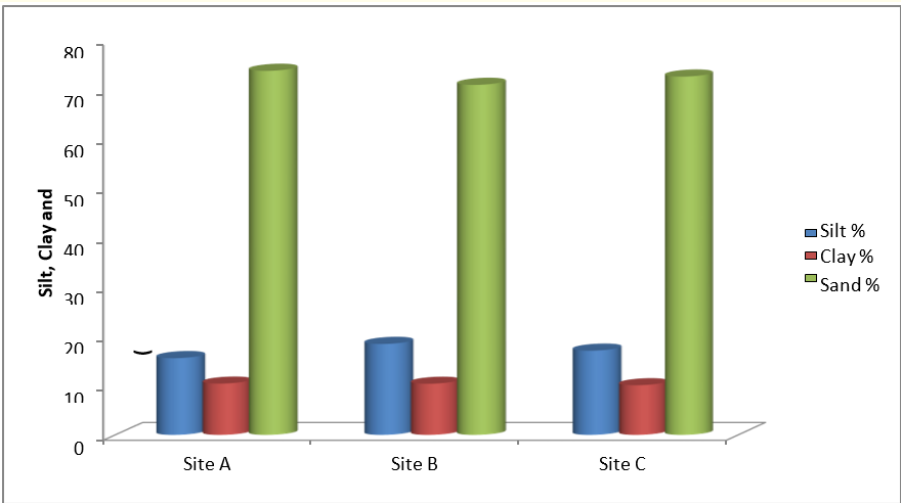


Figure 1: Spatial variation in mean of Silt, Clay and Sand content.

highest at Location A (1.64 mg/kg) and lowest at Location C (1.20 mg/kg) (Fig. 2). Bulk density showed the highest value at Location A (2.26 g/cm^3) and the lowest at Location B (2.04 g/cm^3). Pore

space was greatest at Location A (28.68%) and lowest at Location B (26.97%) (Figure 3).

With respect to heavy metals, chromium and zinc recorded their highest concentrations at Location A (39.44 mg/kg and 22.69 mg/

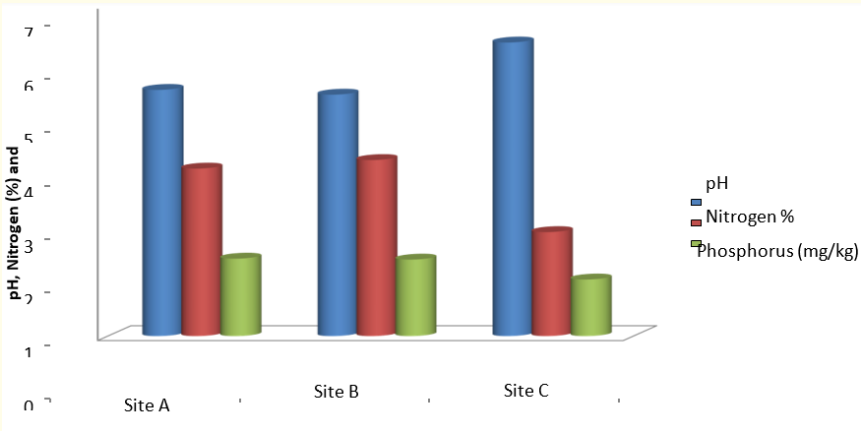


Figure 2: Spatial variation in mean pH, Nitrogen and Phosphorus content.

kg, respectively) and their lowest at Location C (6.11 mg/kg and 8.10 mg/kg, respectively). Cadmium peaked at Location B (13.57 mg/kg) and had the lowest value at Location C (0.61 mg/kg) (Figure 4). Lead was highest at Location B (52.87 mg/kg) and lowest at Location C (9.49 mg/kg). Manganese and iron concentrations were also highest at Location A (11.16 mg/kg and 71.54 mg/kg, respec-

tively), while the lowest values were recorded at Location C (0.89 mg/kg and 15.62 mg/kg, respectively). Similarly, nickel reached its highest concentration at Location A (14.85 mg/kg) and lowest at Location C (0.89 mg/kg) (Figure 5).

Results show that sand was highest in the three sites, followed by silt and lastly clay.

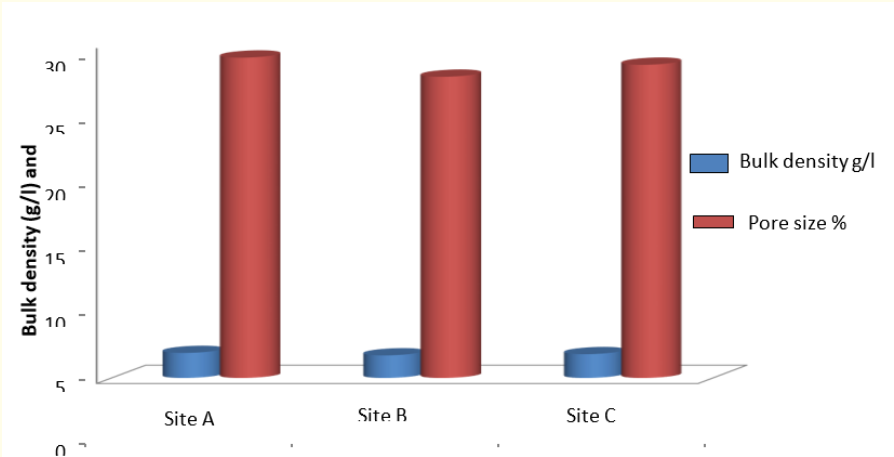


Figure 3: Spatial variation in mean of Bulk density (g/l) and Pore size (%).

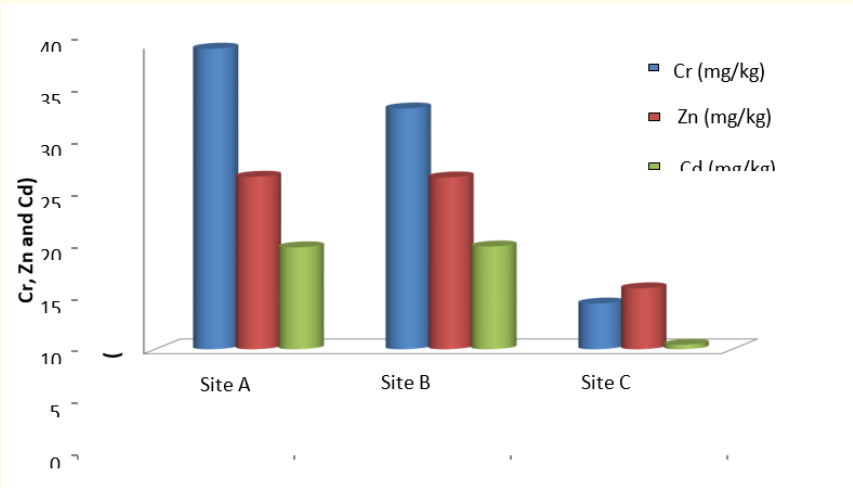


Figure 4: Spatial variation in mean of Bulk density (g/l) and Pore size (%).

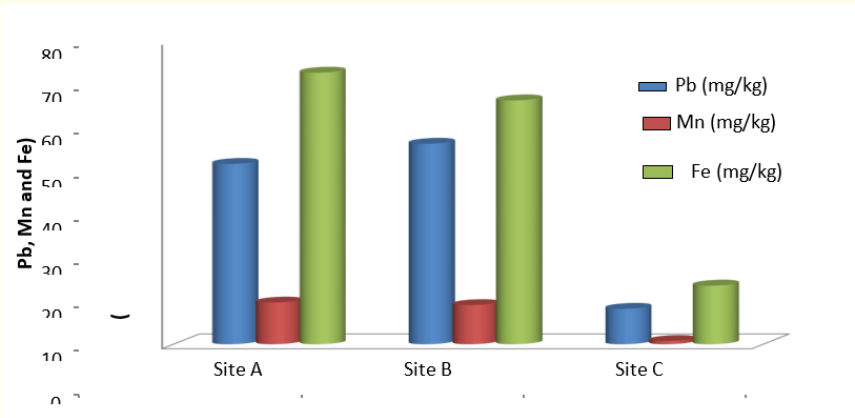


Figure 5: Spatial variation in mean of Pb, Mn and Fe content.

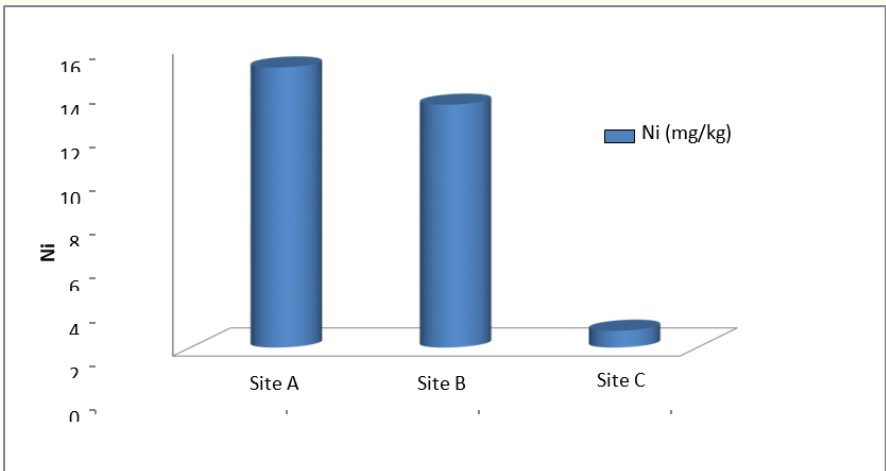


Figure 6: Spatial variation in mean of Ni content.

Results here showed that in the three sites A B and C pH is highest followed by nitrogen and phosphorus.

In figure 3 Mean variation in bulk density(g/l) and pore size (%), the three sites had very high bulk density and low pore size.

Results on Spatial variation in mean of Cr, Zn and Cd content showed that in sites A and B cr and zinc were highest followed by

cadmiuim while in site C, zinc was highest, followed by cr and lastly by cadmiuim.

Spatial variation in mean of Pb, Mn and Fe content showed that lead is highest in site A site B and site C.

Spatial variation in mean of Ni content revealed that Ni was highest in site A followed by site B and lastly by site C.

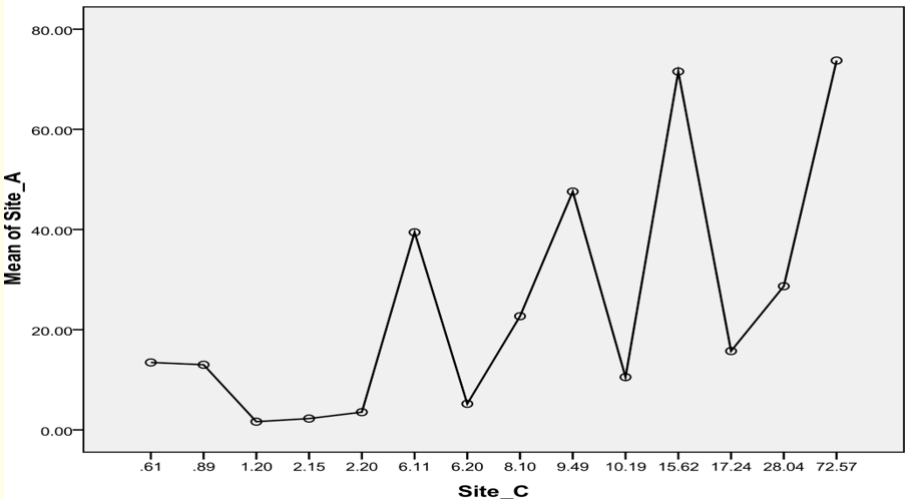


Figure 7: Structure of group means plot (Site A).

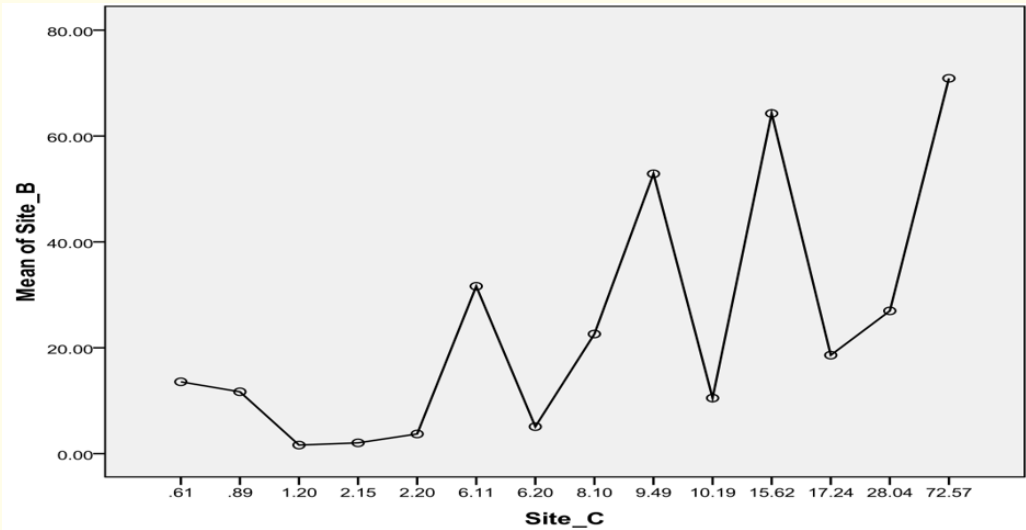


Figure 8: Structure of group means plot (Site B).

Test of homogeneity

The test of homogeneity of variance in means of the physical and chemical parameters revealed significant spatial inequality $F_{(29.73)} > F_{crit(3.95)}$ at $P < 0.05$ across the sampling sites. Further structure detection of group means using means plots, and using site C as the predictor variable, revealed that sand, iron, lead and

chromium were most responsible for the observed heterogeneity (figure 7 and 8).

Discussion

Soil quality is influenced by several physical attributes including structure, texture, infiltration rate, water-holding capacity, permeability, and bulk density—all of which determine its suitability for various land uses [11-14]. The results of this study revealed a

high sand (72.40%) and low clay (10.41%) content, corresponding to a relatively large pore size (27.90%). Sandy soils typically exhibit high infiltration and leaching potential, making them more vulnerable to groundwater contamination due to the low retention capability of pollutants. The low clay fraction, which normally acts as a barrier to contaminant transport, increases the risk of pollutant migration into aquifers. These observations align with those of Nyles and Ray (2019), who reported similar findings in sandy soils, particularly in relation to leaching and contamination risks.

The slightly acidic pH recorded in this study enhances the solubility and mobility of heavy metals, thus increasing the risk of groundwater contamination. This is consistent with the findings of the Niger Delta Environmental Survey (NDES, 1997), which reported similar pH conditions and associated risks in the Sombreiro-Effurun Deltaic Plains [14].

Elevated levels of nitrogen (3.15%) and phosphorus (1.49 mg/kg) in the dumpsite soils likely result from the decomposition of organic matter, including animal waste and agricultural residues. The presence of these nutrients, in combination with fertilizer runoff from surrounding farms, could contribute to eutrophication and groundwater pollution. Although trace amounts of heavy metals occur naturally in soils, elevated concentrations pose serious health risks. While some metals are essential micronutrients, excessive exposure—through ingestion of contaminated food, inhalation, or direct soil contact—can be hazardous, especially for children.

The USEPA (2002) has established guideline values for heavy metals in soil to inform remediation efforts. Figure 3 compares the average concentrations found in this study with safety standards from the USEPA, FEPA, and WHO. While all assessed metals fell within USEPA limits, several exceeded the lower thresholds set by FEPA and WHO, indicating environmental and public health risks. It's important to note that there are no universally accepted limits for metal concentrations in soils used for growing vegetables (Hanlon, *et al.* 2003). Previous studies by Moen, *et al.* (1986), the UK Department of Environment (1987), the Canadian Council of Ministers of the Environment (1992), and MAAF [15] confirm that heavy metal regulatory standards vary widely across countries.

Chromium levels were relatively high (25.72 mg/kg), likely due to inputs from electroplating, alloy manufacturing, and other in-

dustrial activities. Its hexavalent form is particularly concerning due to its carcinogenicity. Zinc (17.80 mg/kg) was slightly lower than the 27.2 mg/kg reported by Hardy, *et al.* (2008), possibly reflecting differences in local waste management and industrial emissions.

Cadmium (9.21 mg/kg) exceeded FEPA and WHO thresholds and may originate from pigments, electroplating, and battery waste. It is a known carcinogen and toxicant. Lead concentrations (36.64 mg/kg) were also elevated, likely due to its extensive use in lead-acid batteries, paints, and industrial by-products. Manganese (7.51 mg/kg), nickel (9.54 mg/kg), and iron (50.46 mg/kg) levels indicate widespread industrial influence. The variations from Hardy, *et al.* (2008) [16,17] could stem from differences in environmental conditions and waste handling practices.

Physicochemical parameters at the central dumpsite

The assessment of physicochemical parameters at the central dumpsite revealed substantial variability in both physical and chemical soil characteristics across different sampling locations. These differences reflect the nature, intensity, and duration of waste disposal activities at the site.

Soil physicochemical characteristics

Soil pH values ranged from 5.0 to 6.3 (mean: 5.5 ± 0.18), indicating slightly acidic conditions. Acidic environments can enhance the solubility and mobility of heavy metals, thereby increasing their bioavailability. Macronutrients such as nitrogen (2.06–3.91%; mean: 3.15 ± 0.24) and phosphorus (1.17–1.80 mg/kg; mean: 1.49 ± 0.08) were present in moderately high concentrations, likely due to the decomposition of organic waste, including agricultural residues.

Textural analysis revealed that sand dominated across all sampling sites (70.60–74.40%; mean: 72.40 ± 0.44), followed by silt (15.10–18.80%; mean: 17.19 ± 0.44) and clay (10.12–10.90%; mean: 10.41 ± 0.09). This texture suggests high permeability but low water and nutrient retention capacities. Bulk density values (2.01–2.36 g/cm³; mean: 2.15 ± 0.04) and pore size (26.70–29.70%; mean: 27.90 ± 0.30) further support the sandy nature of the soil, which may facilitate leaching of pollutants into groundwater systems.

Heavy metal concentrations

Heavy metals showed significant spatial variability. Chromium ranged from 4.22 to 42.42 mg/kg (mean: 25.72 ± 5.07), zinc from 7.39 to 25.36 mg/kg (mean: 17.80 ± 2.49), and cadmium from 0.52 to 14.60 mg/kg (mean: 9.21 ± 2.16). Lead ranged from 8.56 to 55.20 mg/kg, manganese from 0.66 to 12.49 mg/kg, iron from 15.20 to 77.84 mg/kg, and nickel from 0.82 to 15.11 mg/kg. The elevated levels of these metals—particularly Pb and Cd, which exceed permissible limits set by FEPA and WHO—highlight potential environmental and human health risks, including soil contamination, bioaccumulation, and groundwater pollution.

Spatial variation across sampling sites

Marked spatial differences were observed in the soil's physicochemical properties across the three sampling sites:

- **Location A** recorded the highest sand (73.73%) and clay (10.53%) content, along with elevated levels of chromium, zinc, manganese, iron, and nickel, suggesting a concentration of metallic and industrial waste.
- **Location B** exhibited the highest levels of nitrogen (3.72%), cadmium (13.57 mg/kg), and lead (52.87 mg/kg), likely due to the presence of organic and battery-related waste.
- **Location C** consistently recorded the lowest values for most parameters, which may be attributed to a reduced waste load or natural attenuation processes.

A test of homogeneity of variances revealed statistically significant spatial heterogeneity ($F = 29.73 > F_{\text{crit}} = 3.95$, $p < 0.05$). Structure plots indicated that sand, iron, lead, and chromium were the major contributors to this variation.

Correlations among parameters

Correlation analysis revealed strong positive relationships among several parameters. Phosphorus showed positive correlations with clay ($r = 0.999$), zinc ($r = 0.990$), cadmium ($r = 0.999$), and manganese ($r = 1.000$), indicating shared sources or synergistic interactions influencing soil retention and metal mobility. Similarly, strong correlations were observed among clay, zinc, manganese, iron, and nickel, suggesting interconnected geochemical

behavior. Conversely, negative correlations were observed between pH and nitrogen, and between cadmium and lead, pointing to potential antagonistic interactions or pH-mediated mobility effects.

Comparison with control site

When compared to a nearby control site, the dumpsite soil exhibited significantly elevated levels in nearly all parameters. Organic matter ($6.7 \pm 0.4\%$), total nitrogen ($0.41 \pm 0.03\%$), and phosphorus (18.2 ± 1.5 mg/kg) were markedly higher than values recorded at the control site ($2.6 \pm 0.3\%$, $0.13 \pm 0.01\%$, and 8.7 ± 0.9 mg/kg, respectively). Heavy metals such as lead (73.5 ± 6.4 mg/kg), cadmium (1.9 ± 0.2 mg/kg), and zinc (112.4 ± 9.7 mg/kg) also significantly exceeded control site values and, in several cases, surpassed international safety thresholds.

Conclusion

This study has demonstrated that the central dumpsite in Efurun exhibits significant variability in soil physicochemical properties and heavy metal concentrations, indicative of diverse and prolonged waste disposal activities. The soil was predominantly sandy with low clay content and slightly acidic pH, conditions that enhance permeability and increase the risk of leaching contaminants into the groundwater.

Elevated levels of macronutrients such as nitrogen and phosphorus suggest a strong presence of decomposable organic materials, while high concentrations of heavy metals—particularly cadmium, lead, and chromium—pose serious ecological and public health concerns. These metals, in some cases, exceeded national and international safety thresholds, highlighting the potential for bioaccumulation, soil degradation, and groundwater contamination.

Spatial analysis revealed significant differences in contamination levels among the sampling locations, reflecting variations in waste composition and disposal intensity. Strong correlations among certain physicochemical parameters and heavy metals suggest shared sources or interrelated mobility mechanisms within the soil matrix.

When compared with a nearby control site, the dumpsite soils exhibited substantially higher concentrations of most parameters, reinforcing the anthropogenic impact of unregulated waste disposal. These findings underscore the urgent need for remediation measures, stricter enforcement of environmental regulations, and the implementation of sustainable waste management practices to mitigate further degradation and safeguard environmental and human health.

Bibliography

1. U.N. Population of Nigeria (2018).
2. National Population Commission NPC. Nigeria's census figure (2015).
3. Afolabi TA and Ogundiran O. "Assessment of the Physicochemical Parameters and Heavy Metals Toxicity of Leachates from Municipal Solid Waste, Open Dumpsites". *Journal of Applied Science and Environmental Management* 5.2 (2018): 243-350.
4. Agwu EIC. "Environmental Sciences, A planner's view 1st Ed". Mishbet (Nigeria) Limited, Festac Town, Lagos, Nigeria (2015).
5. Mbagwu. "Pollution of the soil ecosystem is a major source of soil degradation". *International Journal of Environmental Science and Technology* 6.3(2015):337-346.
6. Adewole. "Soil Ecosystem Comm". *Communications in Soil Science and Plant Analysis* 34.17-18 (2008): 2419-2439.
7. Isirimah NO. "Understanding the Nature, Properties and Sources of Wastes for Quality Environment". Tom and Harry Publication Ltd. Port-Harcourt Nigeria (2012): 6,22 and 144.
8. Nyles C B and Ray R N. "The nature and properties of soils". 12th eds. United states of America (2019):743-785.
9. Chatterjee AK. "Water Supply, Waste Disposal and Environmental Engineering, Khanna, New Delhi". (2010): 205.
10. Uchegbu AN. "Environmental Management and Protection". Precision Publishers Enugu, Nigeria (2015): 108-133.
11. USEPA. "Supplemental guidance for developing soil screening levels for superfund sites". Office of solid waste and emergency response, Washington, D.C. (2020).
12. World Bank. "Environmental and Socio-Economic Characteristics of the Niger Delta". World Bank Report on the Niger Delta Region of Nigeria (2015).
13. Wagner H Richard. "Environment and Man". Toronto: W.W. Norton and Company, Inc (2024): 54-55.
14. Khitoliza R K. "Environmental pollution, management and control for sustainable development". 1st ed., S. Chand (ed.) S. Chand and Co. Ltd., New Delhi (2014): 309.
15. Kiely G. "Environmental Engineering International Edition McGraw Hill International Ltd". UK. (2017): 623-642.
16. Linsley RK and Joseph BE. "Soil and Water Resource Engineering". McGraw Hill Book Company (2015): 416-533.
17. Moen JET, *et al.* "Contaminated Soils". Assink, J.W. and Vanden Brink, WJ (eds.). martins Nijhott (2016).