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A Study of the pollution levels of some Heavy Metal in soil and Water at Ugwuaji-the old Enugu Central dumpsite

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ABSTRACT: The purpose of this research is to examine the soil and water contamination levels of specific heavy metals at the Ugwuaji site, which was formerly the Enugu central dumpsite but is now a residential and agricultural community. At 15-meter intervals in each of the four cardinal directions, we gathered soil and water from the study area, while a 100-meter distance served as a control. To measure the extent of pollution, the pollution and geoaccumulation index was employed. According to the findings, the area is dirtier in the north and east than in the west and south. To the east, west, north, and south, respectively, the soil PI values for Cd and Pb were 245.28 mg/kg, 222.15 mg/kg, 239.53 mg/kg, and 218.48 mg/kg, which were the most dominant elements. Percolation index values for lead in soil are 28.87 mg/kg in east, 26.0 mg/kg in west, 28.01 mg/kg in north, and 20.92 mg/kg in south. While in water the order is Pb>Cd>Cr>As>Hg, and in soil it is Cd > Pb >Hg > As > Cr, the pollution index and geoaccumulation index measure the same thing in water. There is a great deal of contamination, as indicated by the high geoaccumulation index and pollution levels. It is clear that the investigated region provides a significant threat to human health and the environment, rendering it unfit for residential or agricultural use without substantial rehabilitation.

KEY WORDS: Ugwuaji, Assessment, Heavy metals, Pollution index, Geoaccumulation index, Direction.

INTRODUCTION

High levels of infrastructure development are a contributing factor to people leaving rural areas for urban ones. Half or more of the world's population now resides in urban areas, with many more grouped together in larger metropolitan areas (Weiland et al., 2007). The next decades should see a continuation of this trend toward urbanization on a global scale (UNWUP 2022). All of Nigeria's cities have seen massive population booms without proper demographic planning, making this a major issue in developing nations generally. Cities like Lagos, Ibadan, Kano, Port Harcourt, Enugu, and others in Nigeria experience extremely worrying annual population growth due to the fact that rural-to-urban migration is the country's predominant migration pattern (Oyeleye 2022).

Some of the negative outcomes that have been linked to this migration include issues with housing, poverty, crime, food scarcity, pollution, and climate change (.Magaji, & Jenkwe 2019). All of Nigeria's cities have one thing in common: they're all experiencing the environmental problem of overcrowding and the persistent practice of turning former landfills into new neighborhoods and farms. The majority of the time, these areas are not thoroughly studied for their pollution indices before being turned into farmland or residential areas.

Heavy metals are one of the most common debris found at landfills (Igwilo et al., 2024, Alloway 2013). It is especially concerning that these elements—lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), and mercury (Hg)—as well as Nikel (Ni), zinc (Zn), and copper (Cu)—are toxic, persistent, and bioaccumulative (Gupta et al., 2020). Metals found in landfills mostly come from human-made sources, such as garbage from homes, businesses, hospitals, and other medical facilities, as well as electronic and pharmaceutical waste. Disposal of waste in open dumps can cause these metals to seep into the groundwater and soil, endangering human and environmental health (Khan et al., 2008). Contamination of agricultural produce by heavy metals, which can enter the food chain, reduced soil fertility, altered microbial activity, and contaminated underground water are all consequences of heavy metal accumulation in soil (Aditi and, Gagan 2021). The following indices are used to assess the level of heavy metal contamination in the soil: enrichment factor, geoaccumulation index, contamination factor, pollution index, potential contamination index, and modified pollution index. As for the evaluation of metal-related soil risks, the potential ecological risk index and the modified potential ecological risk index are utilized (Chinonso et al., 2020). According to multiple studies, the former Enugu central dumpsite at Ugwuaji contains heavy metal contamination (Ameh and Okenwa 2021, Obianuju 2024, Ajah et al., 2015, Ogbuene 2012). Nevertheless, as far as we are aware, the area has been the subject of almost no studies following its transformation into agricultural and landfill areas. The study's goals are as follows: (i) to analyze the soil and crop quality parameters at Ugwuaji, the official Enugu Central Dumpsite; (ii) to find out how polluted the soil and plants are; (iii) to figure out how bad the heavy metal contamination is; and (iv) to figure out what kind of health risks that pollution poses to humans.

2.0 MATERIALS AND METHODS

2.1 Description of study area

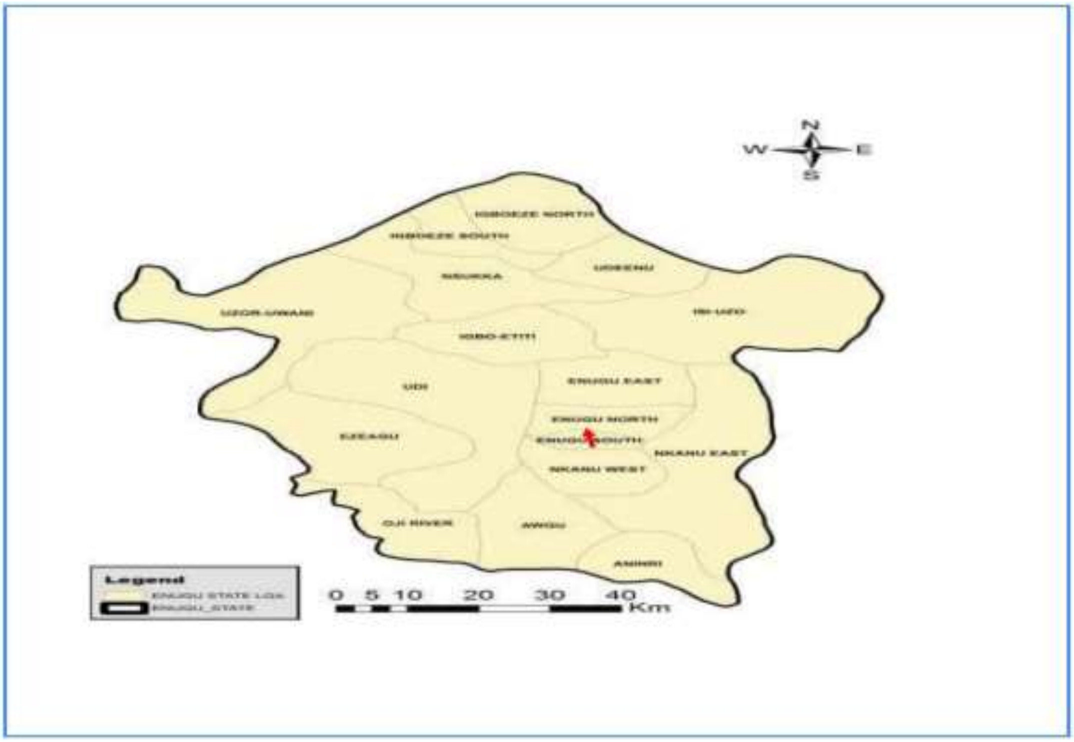

Fig. 1 (Map of Enugu State showing the study area

Enugu state is one of the five Southeastern states of Nigeria, located between latitude 6°.00’N and 7°.00’N and longitude 7°.00’E and 7°.45’E. It falls within the humid tropical rainforest belt of the Southeastern Nigeria. It has two distinct seasons: dry and rainy seasons. The rainy season commences in March and ends in October, followed by the dry season. The annual rainfall ranges between 937.2 mm to 2243.3 mm while the temperature ranges between 20.3°C to 32.16°C (Kabata-Pendias, and Mukherjee 2007; WHO 2010). The 2006 census put the population of Enugu at 722, 664 (Kabata-Pendias and Mukherjee 2007). Enugu State Waste Management Authority (ESWAMA) municipal solid waste (MSW) disposal site of approximately 7.878 ha of land space, is located in the southern part of Enugu Metropolis with its geographic position system (GPS) coordinates as: Elevation: 186 m; North: 6°26.27’; and East: 7°32.831’.

The dump site is about 1.6 kilometers away off Enugu-Port Harcourt expressway as shown in Figure 1. The site slopes gently downwards away from its centre in all directions into the environs. The dumpsite is the final disposal ground for all wastes (domestic, construction/demolition, industrial and agricultural) generated in Enugu metropolis. The dumpsite was originally conceived as a landfill but has degenerated to a massive open dump because of poor management, inadequate manpower and lack of requisite technology. The bottom is not lined for leachate containment, and no compaction is undertaken. There is no perimeter fencing, hence scavengers and stray animals roam the dumpsite unrestricted. ESWAMA is supposed to be a waste management authority but what it essentially does is to undertake waste collection within Enugu metropolis and disposal of collected waste at the central dumpsite. The waste does not undergo any level of treatment or processing before disposal.

2.2 Collection and preparation of the soil and plant samples

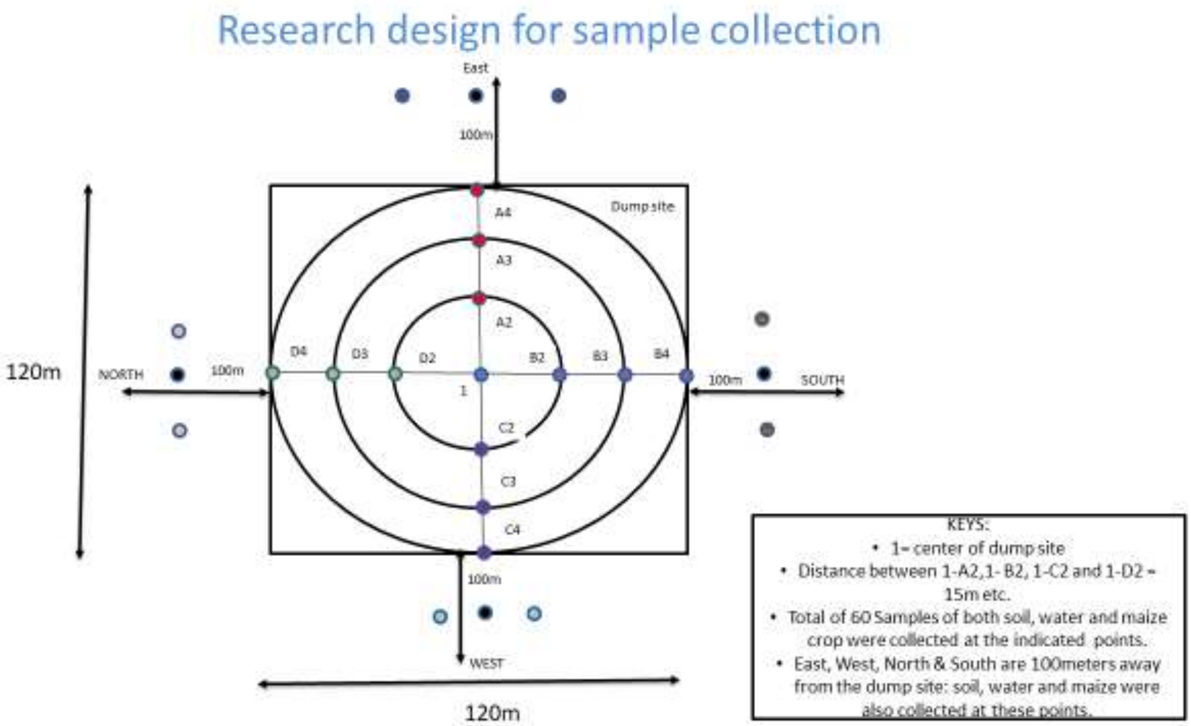

Fig 1. Research design for sample collection

2.3 Sample collection

The area was split into four equal parts, each measuring ninety degrees, to make it easier to collect data. The next phase was to put in circular loops every fifteen meters, starting in the middle of the trash site. The nodes, which were made by the concentric loops and the 90° radial lines crossing each other, were where experimental soil samples were taken. The nodes were 15 meters apart from the main dump site. The nodes were strategically positioned along the radial lines 1-A4, 1-B4, 1-C4, and 1-D4 to determine the appropriate number of loops required before commencing sampling rigorously. After confirming that there was no significant variation in pollutant concentration between two nodes during two successive loops, it was determined that more looping was unwarranted. After setting up concentric loops every 15 meters, a full sampling was done. The loops were built in the middle of the landfill. Soil samples were collected from the center of the dumpsite (1) and from the nodes formed by the junction of the loops with the radial lines set at a 90-degree angle. Auger bits were used to gather soil samples from places that were between zero and fifteen meters deep. There are 13 places to sample for each of the three groups: unclean soil, polluted maize plants, and polluted water. In addition, four samples of soil, water, and plants were taken from a spot one hundred meters away from the edge of the waste site. The samples were taken from the radial lines 1-A4, 1-B4, 1-C4, and 1-D4. Figure 1 has more information. The samples were put in a clear polythene bag and sent to the lab for testing. At first, they were dried out in an oven, and then they were ground up with a pestle and mortar. This made it easier to get the best texture possible. After the sieve separated the samples, one gram of each finely powdered sample was chosen for the digesting process. Nitric acid from Supra Pure Merck and hydrogen peroxide at a concentration of thirty percent were used in an open tank for the digesting process. We used a calibrated atomic absorption spectrophotometer (AA320N) to look at the samples for each heavy element. We got results that better represent the real conditions at the disposal site by using this strategy. Cadmium, zinc, arsenic, and lead are the things that are being looked at. The American Association of State Highway and Transportation Officials (AASHTO) did a soil test and found that the area they looked at contained lateritic soil. Lateritic soil is different from other types of soil because it is reddish, sandy, and has a lot of clay. The following list gives specific information on the soil: It has a specific gravity of 2.41, and 26.8% of it may pass through a No. 200 sieve. The plasticity index is 11, the moisture content is 12.5%, the bulk density is 2.1 g/cm^3, the dry density is 1.98 g/cm^3, and the porosity is 0.36. A soil characterization approach showed that the soil is made up of 52% gravel, 14% sand, 16% silt, and 18% clay.

2.4 Risk assessment were performed using the following already established indices

2.4.1 To measure the degree to which human activities have altered the concentrations of heavy metals in environmental matrices such as soil or sediment, geochemists employ the Enrichment Factor (EF). To do this, it uses a conservative element to normalize the concentration of a heavy metal in the sample and compares it to a reference background value (Loska et al., 2003; Sutherland, 2000).

The following formula is used to compute the EF: The expression EF is defined as follows: (1) The concentration of the heavy metal of interest is denoted as CiCi, whereas the concentration of the reference or normalizing element is represented by

CrefC_{ref}. The natural or background ratio, which can be found in uncontaminated reference samples or typical crustal values, is represented by the denominator (Taylor and McLennan, 1985).

2.4.2 Geoaccumulation Index (Igeo) of Heavy Metals in Soils.

Soil and sediment heavy metal contamination can be quantitatively assessed using the Geoaccumulation Index (Igeo), which compares present concentrations to pre-industrial levels. Müller has extensively used it for assessing soil contamination since its introduction in the 1960s, when it was applied to sediments.

$$Igeo = \log_2 \frac{Ci}{1.5XSi} \qquad (2$$

- Si = geochemical background concentration of the metal (often from local or global background values)
- 1.5 = background matrix correction factor (accounts for natural lithogenic variations)
- Ci = metal concentrations at the study area

Igeo Classification indicator

Müller proposed a classification scale that is used to interpret the Igeo values: It is considered clean when it's below zero. Moderate pollution is indicated by a value between 0 and 2. Extreme pollution occurs when the value is greater than 5, while heavy pollution occurs when it is between 2 and 4.

3.0 RESULTS AND DISCUSSIONS

Figure 2: Result Of heavy metal concentration analysis in the soil (0.15m Depth) at 1-100m distance along East, West, North and South directions of the waste dump site studied.

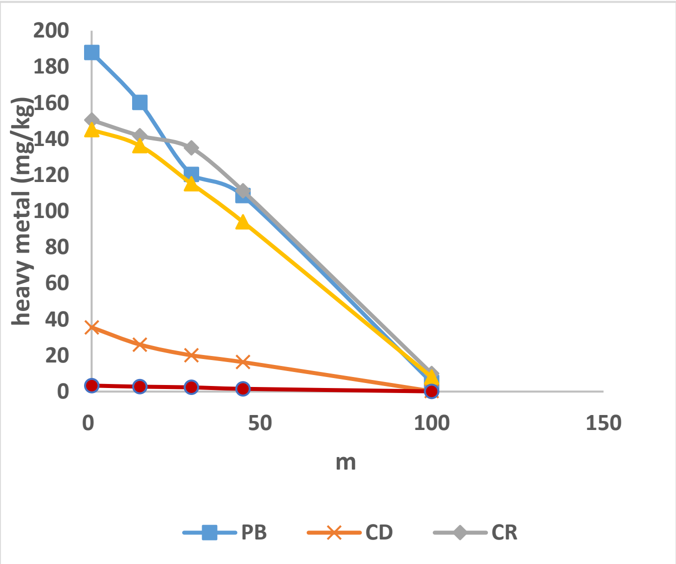

Fig 2 : Distribution of heavy metal concentration in the soil at the study area along the east direction (ED).

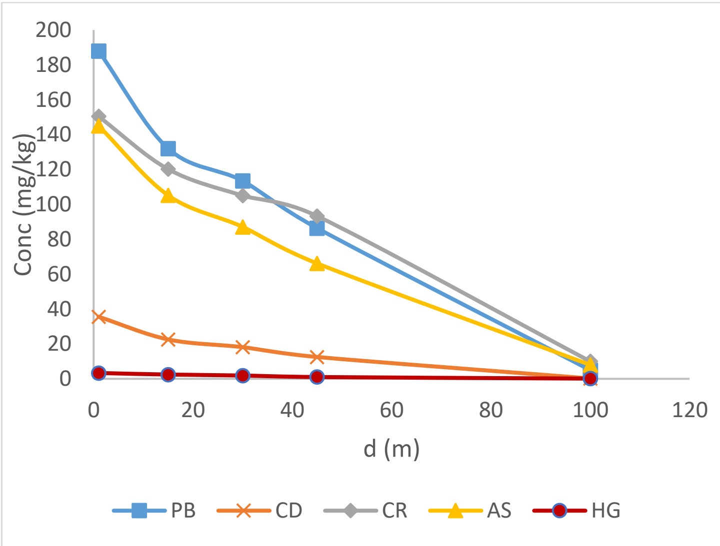

Figure 3: Distribution of heavy metal concentration in the soil with distance along the west direction (WD).

Soil samples were taken at a depth of 0.15 m along the east direction (ED) of the study region, and Figure 2 shows the distribution of heavy metal concentration within a 1-100 m range. The graphic clearly demonstrates that metal concentrations are highest near the dumpsite and progressively decrease as one moves farther away. The deposition of heavy metal pollutants into the soil around a body of water by surface runoff and rainfall explains this pattern (Adelekan & Abegunde, 2011). Topsoil is both the most accessible layer to humans due to direct contact and the primary rooting zone for crops; the data shows how vulnerable this layer is due to the sampling's shallow depth (0.15 m). Chemical characteristics, mobility, and soil particle affinity may account for some of the observed diversity among the heavy metals seen in the figure. Some metals, like lead and cadmium, are known to bind tightly to clay and organic materials, causing them to accumulate in specific areas; on the other hand, chromium and arsenic may be more soluble in soils with certain pH and textures (Kabata-Pendias & Mukherjee, 2007). Bioaccumulation in crops and groundwater contamination are potential hazards due to the closeness of increased concentrations within the first 30-50 m, indicating that the dumpsite is still a point source of contamination.

In addition, as shown in Figure 2, contamination continues up to 100 m eastward even though heavy metal concentrations decrease with distance from the dumpsite. The area's terrain is likely to blame for this. Neurological diseases, kidney damage, and reduced crop yield have been linked to elevated levels of hazardous metals such as Pb, Cd, Cr, As, and Hg (WHO, 2010; Alloway, 2013). According to Yadav et al. (2015), soil remediation procedures like phytoremediation, soil washing, or immobilization are necessary before these areas can be safely repurposed. This is supported by the distribution profile in Figure 2.

In Figure 3, we can see how the concentrations of heavy metals in the soil change as we move westward along the dumpsite. Lead (Pb) concentrations are greatest in the first 30 m and then steadily decline with distance, according to the results. Because Pb is relatively immobile but strongly bound to organic matter and clay particles in soil, this tendency is not surprising (Alloway, 2013). Because of the danger of exposure through hand-to-mouth play and dust inhalation, particularly for children living in residential areas, the presence of Pb in topsoil is concerning (WHO, 2010). It is possible to detect quantities of cadmium (Cd) as deep as 80 m in soil because Cd is more mobile than lead (Pb). This poses a threat to agriculture because Cd can be readily taken up by plants through their roots and ends up in their edible parts (Järup, 2003). Although chromium (Cr) is not very mobile, it does show up in concentrated areas, most often as a result of metal components in municipal garbage or residues from industrial waste. The presence of hexavalent Cr (Cr VI), a carcinogenic type of Cr, is of particular concern (ATSDR, 2012). According to Kabata-Pendias and Mukherjee (2007), arsenic (As) has a modest westward spread and is linked to organic waste leaching and its ability to interact with soil iron oxides. Even at low quantities, mercury (Hg) poses a threat because it can remain in soils and either evaporate or be transformed into methyl mercury, a form that is extremely harmful to ecosystems and humans (WHO, 2010).

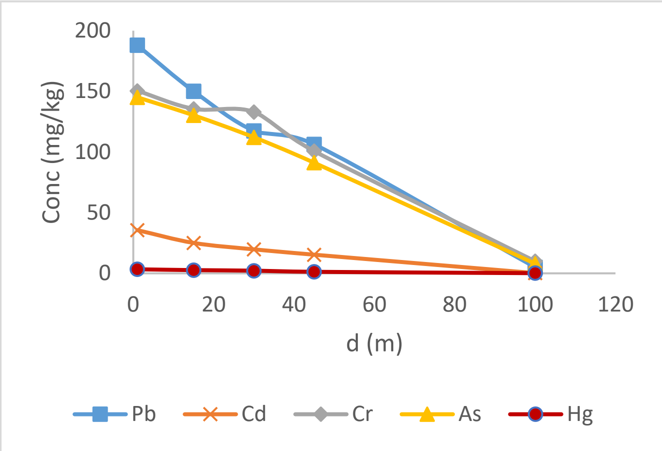

Figure 4 : Distribution of heavy metal concentration in the soil at the study area along the north direction (ND).

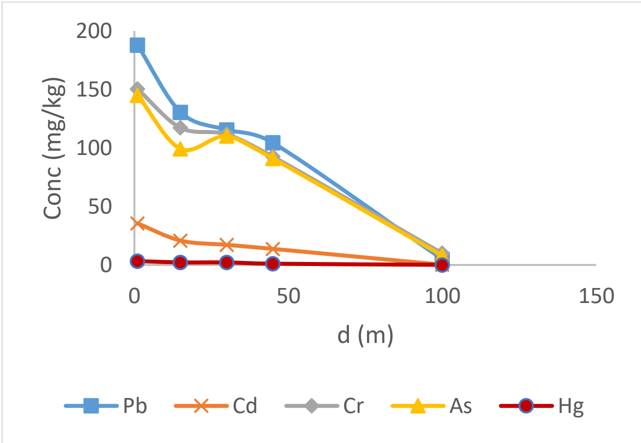

Figure 5: Distribution of heavy metal concentration in the soil at the study area along the south direction (SD).

The distribution of heavy metal concentrations toward the north is shown in Figure 4. The contamination gradient is flatter to the east than the west, which might be because less water flows in that direction. Lead levels are still high in the immediate vicinity of the landfill, although they drop sharply after 50 meters. However, the fact that Pb remains in residential areas for a long time shows that children are at risk for brain damage from exposure (Alloway, 2013). Because of its solubility and poor adsorption in soils, Cd remains detectable levels even at greater distances, which is a greater cause for concern. Crops grown in this area would absorb Cd, increasing the dangers to human health from what people eat (Singh et al., 2010). Anthropogenic and lithogenic factors are both reflected in the unequal distribution of Cr. Skin lesions and malignancies can be caused by Cr at hazardous levels (ATSDR, 2012). As is present in quantifiable quantities in both directions, drawing attention to the dangers of long-term exposure. There is evidence that consuming water or food polluted with arsenate over an extended period of time can cause cancer and cardiovascular problems (WHO, 2010). Even at low concentrations, mercury can bioaccumulate and pose a threat to future food crops grown in the same soil (Kabata-Pendias, 2011). Figure 4 shows that even seemingly unaffected locations can nonetheless pose substantial heavy metal hazards.

The heavy metal concentrations tend to move southward, as seen in Figure 5. This direction seems to be one of the dirtiest. It is probable that the concentrations are higher because the slope and drainage improve the flow of leachates. This direction is especially dangerous for residential or agricultural use due to the high concentrations of Pb, Cr, and As within the first 50 m. The fact that Cd levels are rising and spreading farther proves that it is mobile and has major consequences for agriculture. Soil contaminated with Cr increases the risk of cancer and respiratory problems when exposed to it for an extended period of time (ATSDR, 2012). It appears that there may be leaching via surface runoff, as the levels are higher than in other soil directions. Due to arsenic's status as a powerful carcinogen and endocrine disruptor, this is crucial (WHO, 2010). Although at lower concentrations, mercury builds up in the topsoil because of its attraction to organic materials; there is a chance that it may volatilize and end up in the food chain. This diagram highlights the southern route as the weakest, calling for stringent land-us restrictions.

3.2 Distribution Of heavy metal concentrations in well-water at 1-100m distance along East, West, North and South directions of the waste dump site.

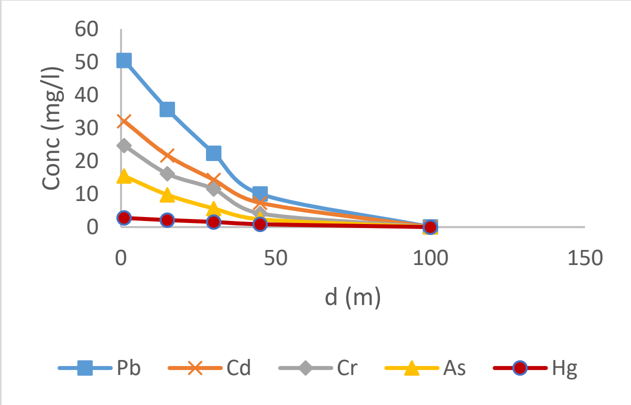

Figure 6: Distribution of heavy metal concentration in the water at the study area along the East direction (ED).

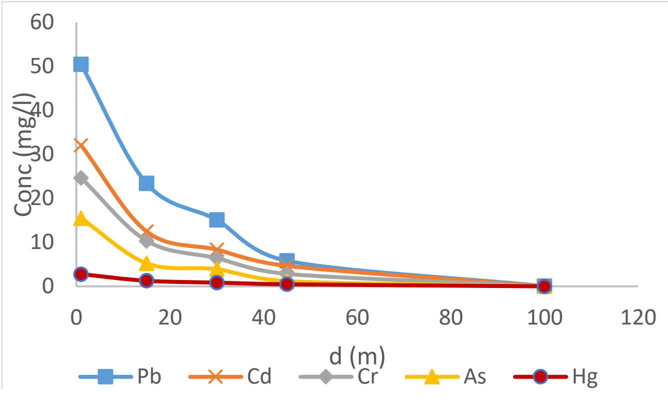

Figure 4. 6: Distribution of heavy metal concentration in the water at the study area along the west direction (WD).

According to Figure 6, the amounts of heavy metals in the water vary with distance to the east of the landfill. The Lead, Cadmium, Chromate, Arsenic, and Mercury levels in the leachate are higher than the limits allowed by the World Health Organization (WHO), as shown in the Figure. Deterioration in cognitive function and hypertension can result from long-term exposure to lead, cadmium, mercury, and arsenate in the water at the dumpsite (WHO, 2010). Since Cd is very soluble, it is an even greater cause for alarm because it remains detectable throughout the entire 100-meter sampling distance, endangering agricultural and drinking water supplies (Järup, 2003). There is a noticeable amount of chromium, which suggests that metallic waste was used. One known carcinogen is hexavalent Cr in water (ATSDR, 2012). High concentrations of arsenic make the water unfit for human consumption; prolonged exposure to the mineral causes skin problems and malignancies of the internal organs. It is the transformation of mercury (Hg) into methylmercury that poses the greatest threat in aquatic systems; methylmercury bioaccumulates in fish and subsequently in humans (Kabata-Pendias, 2011). Figure 1 shows that all water sources to the east of the dump are unfit for human and agricultural consumption.

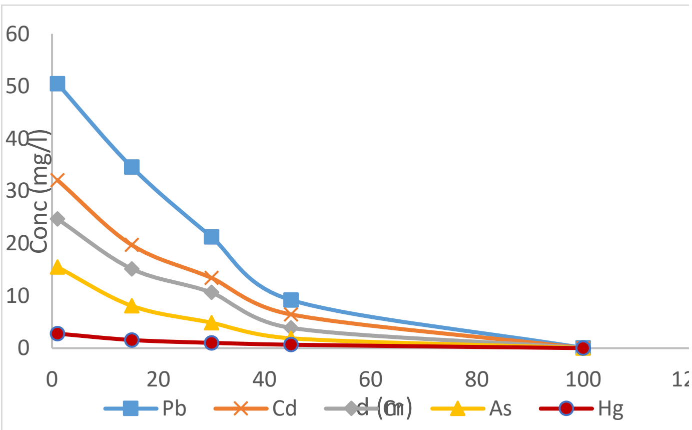

Figure 4. 7: Distribution of heavy metal concentration in the water at the study area along the north direction (ND).

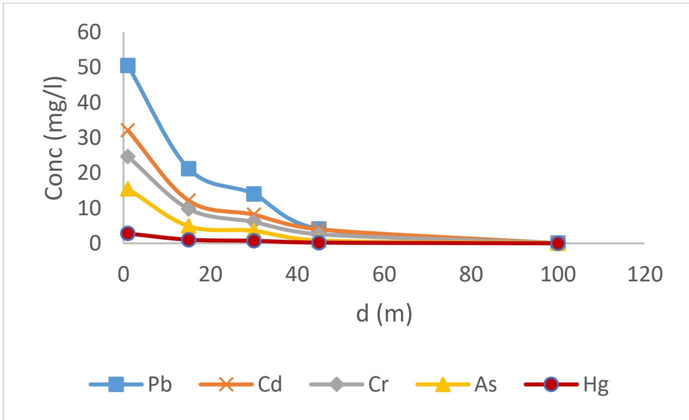

Figure 9: Distribution of heavy metal concentration in the water at the study area along the south direction (SD).

Metal concentrations are decreasing westward as a result of soil filtration and dilution, as seen in Figure 7. Nevertheless, the levels of lead and cadmium are still too high for human consumption. Because of its great solubility, cadmium, in particular, remains present at any distance. In terms of long-term use, chromium is moderate, which is nevertheless cause for concern. Additionally, there are trace but noticeable levels of arsenic, and mercury, because to its bioaccumulative nature, poses dangers even at low doses. Even after diluting, water flowing westward is still dangerous due to heavy metals, as seen in figure 7. Contamination moving northward is less severe, but still noticeable, as shown in Figure 8. Close to the landfill, levels of lead, cadmium, and cr are still too high. Given its mobility and contamination levels, Cd continues to persist further away. While mercury is found in minute concentrations, arsenate is present at significant levels. Due to cumulative hazardous dangers, this water is still unsafe for residential use, even though the amounts are lower than in the east or south.

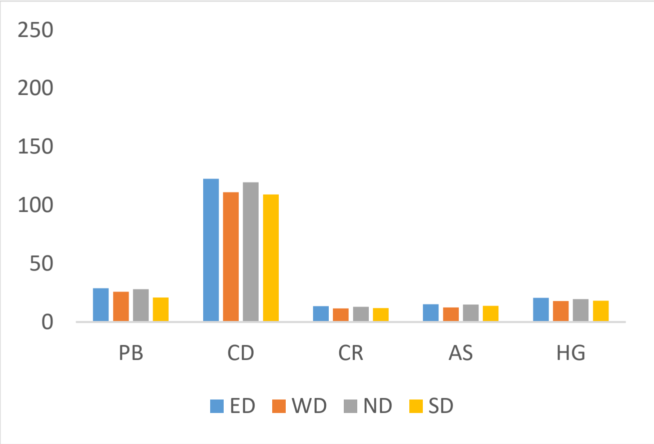

Figure 9: Directional variation of pollution index (PI) in the soil at the study area

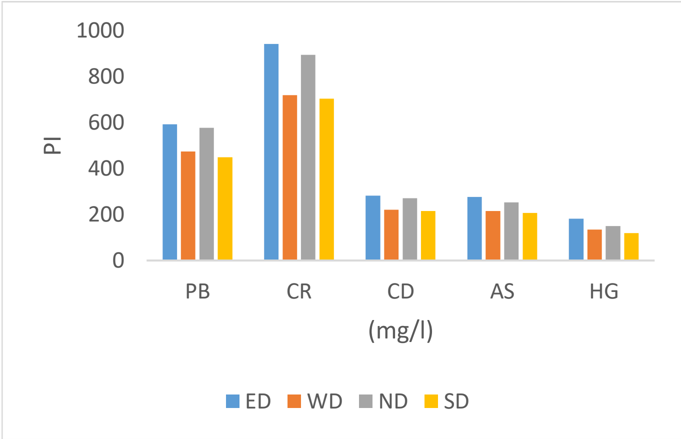

Figure 10 : Directional variation of pollution index (PI) in the water along study

The most heavily polluted water can be seen moving southward in Figure 9, which indicates a strong leachate flow. The levels of lead and cadmium are significantly higher than what is considered safe. The water poses serious threats to public health due to its extremely high arsenic content. Since mercury has a propensity to accumulate in food chains, it exacerbates the toxicity. Beyond what is considered safe by the World Health Organization, the Cr levels are quite high. According to these numbers, the dumpsite's southern direction is the most pressing problem area that needs fixing right now.

3.3 The east, west, north, and south directions of the waste dumpsite show directional variation of the pollution index (PI) in the soil at distances of 1-100m.

Soil samples were taken at different distances from the old dumpsite, and the Pollution Index (PI) is shown in Figure 10. Values above 1 indicate contamination beyond natural background levels, making the PI an essential tool for soil quality assessments (Hakanson, 1980). The graphic clearly illustrates that the east and south directions are the most affected by the rising PI values. The PI shows that lead (Pb) is highly concentrated close to the dump, which is consistent with its strong binding to organic materials and soil colloids. Due to its persistence and resistance to leaching, Pb pollution in soils poses a long-term concern (Alloway, 2013). According to the World Health Organization (2010), individuals can get hypertension and neurological impairment if they are exposed to lead dust or soil for an extended period of time. The fact that cadmium (Cd) has high PI values in every direction indicates that it is easily soluble and mobile in soils. Because Cd can be readily transferred to crops cultivated in polluted soils, Cd pollution is particularly worrisome. Kidney failure and bone loss have been associated with chronic Cd use (Järup, 2003). Although the chromium (Cr) PI readings are moderate, they are nonetheless cause for concern. Although hexavalent Cr (Cr VI) is less mobile than Cd, it is extremely hazardous and carcinogenic, which could explain its existence due to industrial waste inputs (ATSDR, 2012). Because of its link to the breakdown of organic waste, arsenic (As) shows up at higher PI values in the east and south. Skin rashes, cardiovascular difficulties, and malignancies can be caused by chronic as exposure from soil to crop transfer (WHO, 2010). Despite having lower PI levels than Pb and Cd, mercury (Hg) is nevertheless a major concern because of its toxicity. Mercury can seep into food chains through crops even at low amounts, where it can cause developmental delays and neurological impairment (Kabata-Pendias, 2011). Soil contamination around the Ugwuaji dumpsite ranges from moderate to heavy in all directions, with Cd, Pb, As, and Cr being the most prevalent contaminants. This poses major implications for future residential and agricultural usage, as shown in Figure 10.

The Pollution Index (PI) of water samples collected around the dumpsite is shown in Figure 4.14. The fact that leachate infiltration is having a major impact on the quality of both surface and groundwater is confirmed by the elevated PI values, which are most noticeable in the south and east directions. There is clear evidence of lead pollution, as the PI readings are higher than the permissible limits. Lead in drinking water has been associated with neurological problems in adults and developmental delays in children (WHO, 2010). Consistent with its great mobility in water systems, Cd demonstrates concerning PI values in both directions. According to Singh et al. (2010), when Cd is present in irrigation water, it builds up in crops, increasing the danger of kidney and bone damage when consumed. There is moderate contamination, although it is persistent, on Cr. Cr VI is especially dangerous in water since it is both carcinogenic and mutagenic when present in high concentrations (ATSDR, 2012). Due to the high levels of pollution, particularly in the southern regions where PI measurements reveal quantities that beyond safe drinking standards. Chronic it is known to cause skin, bladder, and lung malignancies when consumed through water (WHO, 2010). Even though mercury pollution is lower than lead and Cd levels, it can nevertheless pose a threat in aquatic habitats due to its transformation into methylmercury. Humans face indirect exposure concerns from methylmercury because it bioaccumulates in fish and other aquatic species (Kabata-Pendias, 2011). Therefore, as shown in Figure 11, the water surrounding the Ugwuaji dumpsite is not suitable for farming or human consumption, especially in the directions to the east and south. On the pollution index, Cr> Pb> Cd> As> Hg is in the middle.

3.4 Directional variation of Geoaccumulation index (Igeo) in the soil at 1-100m distance along east, west, north and south directions of the waste dumpsite.

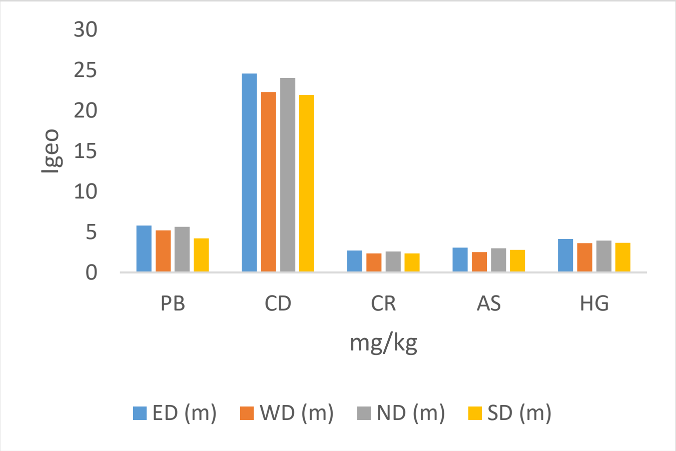

Figure 11: Directional variation of geoaccumulation index (Igeo) in the soil

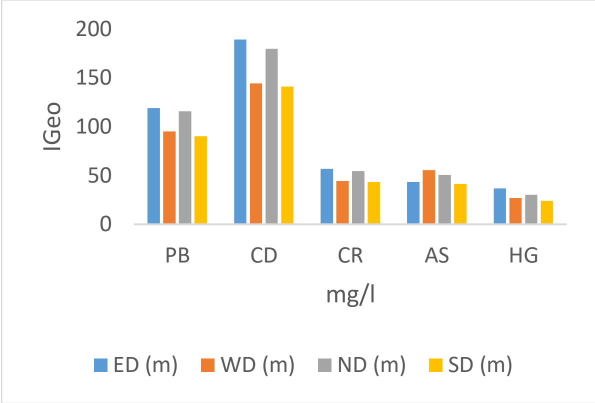

Figure 12: Directional variation of geoaccumulation index (Igeo) in the water

Soil Geoaccumulation Index (Igeo) is shown in Figure 11. In order to distinguish between heavy metals that occur naturally and those that are the result of human activity, Igeo is useful (Müller, 1969). Soils facing south and east are deemed moderately to severely contaminate according to the findings. Pb and Cd, which indicates that the dumpsite has a substantial anthropogenic enrichment, dominate the Igeo values. Cd's strong solubility guarantees ongoing dangers of plant uptake, but Pb's immobility implies it will persist for decades without cleanup (Alloway, 2013). The moderate Cr contribution indicates that inputs including metallic and industrial wastes are present in the waste streams. Igeo values are higher in the south, which makes sense given the paths of surface runoff and leachate. Despite its diminished visibility, mercury poses a threat due to its persistence and the possibility of methylation. Soil treatment is essential prior to residential conversion, as the Igeo results show that the soils are unfit for agricultural usage. Igeo is assessed for water samples in Figure 12. The data show that heavy metals have been artificially enriched, with the greatest concentrations found in the south and east. The levels of lead and cadmium are significantly higher than the natural background, as confirmed by the Igeo readings. For communities that depend on groundwater, these metals pose a serious threat; they mostly come from the leachates of MSW dumpsites. The south shows a high enrichment of as, suggesting that groundwater routes have been contaminated. Chronic because cancer and neurological problems caused by exposure have been well-documented (WHO, 2010). The contribution of Cr is moderate, but the role of Hg is essential because to its toxicity and bio accumulative tendency in aquatic habitats, despite its lower presence (ATSDR, 2012). Anthropogenic heavy metals have a significant influence on the water resources surrounding the Ugwuaji dumpsite, as seen in this figure, making them unfit to drink without extensive treatment.

4.0 CONCLUSION

The findings from this study reveal alarming levels of heavy metal contamination in both soil and water at the Ugwuaji site, a location that has transitioned from a central dumpsite to a residential and agricultural area. Elevated concentrations of cadmium and lead—particularly in the northern and eastern zones—highlight the uneven distribution of pollutants and underscore the severity of environmental degradation. The pollution and geoaccumulation indices confirm that the contamination poses a serious risk to human health and ecological stability. Without comprehensive remediation efforts, the site remains unsuitable for habitation or farming, and urgent intervention is required to prevent long-term environmental and public health consequences.

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REFERENCES

1. Adelekan, B. A., & Abegunde, K. D. (2011). Heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria. International Journal of the Physical Sciences, 6(5), 1045–1058.

2. Aditi Shreeya Bali and, Gagan Preet Singh Sidhu (2021). 5 - Heavy metal contamination indices and ecological risk assessment index to assess metal pollution status in different soils. Heavy Metals in the Environment: Impact, Assessment, and Remediation Pages 87-98
3. Agency for toxic substances and disease registry (2012).Toxicological profile for chromium.U.S. Department of Health and Human Services, public health service. https://doi.org/10.15620/cdc:14972
4. Ajah K C, Joel A & Chidozie, C. N. (2015). Spatiality, seasonality and ecological risks of heavy metals in the vicinity of a degenerate municipal central dumpsite in Enugu, Nigeria. Journal of Environmental Health Science and Engineering,13(5).
5. Alloway, B. J. (2013). Heavy metals in soils: Trace metals and metalloids in soils and their bioavailability (3rd ed.). Springer.
6. Alloway, B. J. (2013). Heavy metals in soils: Trace metals and metalloids in soils and their bioavailability (3rd ed.). Springer. https://doi.org/10.1007/978-94-007-4470-7
7. Ameh, G. I., and Okenwa, Jennifer. (2021). "Assessment of Seasonal Variation on Heavy Metal Concentration in the Soil of Ugwuaji Solid Waste Dump Sites". *Asian Journal of Biotechnology and Genetic Engineering* 4 (1):85-92. https://journalajbge.com/index.php/AJBGE/article/view/44.
8. Chinonso E. Emelumonye, Andrew M. Oroke, Eric I. Nwafor, Aloysius C. Eze Felix E. Arcilla Jr (2020). Assessment of Heavy Metal Concentration in the Soil of Ugwuaji Solid Waste Dump Environs, Enugu Nigeria. Iamure International Journal of Ecology and Conservation**.** Vol 32, 37-48
9. Gupta, N., Yadav, K. K., & Kumar, V. (2020). A review on current status of municipal solid waste management in India. *Journal of Environmental Management*, 243, 74–95. https://doi.org/10.1016/j.jenvman.2019.04.011
10. Hakanson, L. (1980). An ecological risk index for aquatic pollution control: A sedimentological approach. Water Research, 14(8), 975–1001. https://doi.org/10.1016/0043-1354(80)90143-8
11. https://doi.org/10.1016/B978-0-12-821656-9.00005-5
12. Igwilo, S.C., Bello, I.E., & Magaji J.I.I (2024). Assessment of Heavy Metal Concentrations in Soils at Selected Waste Dump Sites in Abuja Municipal Area Council (Amac), Federal Capital Territory, Nigeria International Journal of Chemistry and Chemical Processes, 10 (6), 1-16
13. Kabata-Pendias, A. (2011). Trace elements in soils and plants (4th ed.). CRC Press. https://doi.org/10.1201/b10158
14. Kabata-Pendias, A., & Mukherjee, A. B. (2007). Trace elements from soil to human. Springer.
15. Kanayochukwu C Ajah , Joel Ademiluyi , Chidozie C Nnaji (2015). Spatiality, seasonality and ecological ris3s of heavy metals in the vicinity of a degenerate municipal central dumpsite in Enugu, Nigeria. J Environ Health Sci Eng
16. Khan, S., Cao, Q., Zheng, Y. M., Huang, Y. Z., & Zhu, Y. G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. *Environmental Pollution*, 152(3), 686–692. https://doi.org/10.1016/j.envpol.2007.06.056
17. Loska, K., Cebula, J., Pelczar, J., Wiechuła, D., & Kwapuliński, J. (2003). Use of enrichment and contamination factors together with geoaccumulation indexes to evaluate the content of Cd, Cu, and Ni in the Rybnik water reservoir in Poland. *Science of the Total Environment*, 305(1–3), 33–41.
18. Magaji, J.Y. & Jenkwe, E.D. (2019). An assessment of soil contamination in and around Mpape dumpsite, Federal Capital Territory (FCT), Abuja Nigeria. Global Journal of Earth and Environmental Science, 5(3), 73-81.
19. Müller, G. (1969). Index of geoaccumulation in sediments of the Rhine River. GeoJournal, 2(3), 108–118.
20. Obianuju A. Anwara (2024). Pollution-Level-Assessment of Heavy Metals from Solid Waste in Soil and Crops at Ugwuaji Dumpsite, Enugu South L.G.A of Enugu State, Nigeria. Journal of Environment and Earth Science 14(2), 9-18
21. Ogbuene E.B. (2012). Impact of temperature and rainfall disparity on human comfort index in Enugu urban environment, Enugu State, Nigeria. J Environ Issues Agric Dev Ctries. 2012;4(1):92–103.
22. Oyeleye Oyewale Idowu (2020). Challenges of Urbanization and Urban Growth in Nigeria. American Journal of Sustainable Cities and Society Issue 2, Vol. 1, 79-95
23. Singh, A., Sharma, R. K., Agrawal, M., & Marshall, F. M. (2010). Health risk assessment of heavy metals via dietary intake of foodstuffs from wastewater irrigated site of a dry tropical area of India. Food and Chemical Toxicology, 48(2), 611–619. https://doi.org/10.1016/j.fct.2009.11.041
24. Sutherland, R. A. (2000). Bed sediment-associated trace metals in an urban stream, Oahu, Hawaii. *Environmental Geology*, 39(6), 611–627.
25. Taylor, S. R., & McLennan, S. M. (1985). The Continental Crust: Its Composition and Evolution. Blackwell, Oxford.
26. United Nations, World Urbanization Prospects (2022) – The 2019 Revision. Population Division, Department of Economic and Social Affairs, United Nations Secretariat**.**
27. Weiland, U. M. Richter, H. D. Kasperidus, U.F.Z (2005). Environmental management and planning in urban regions – are there differences between growth and shrinkage? Sustainable development and planning 11. Vol 1, 441-451

28. World Health Organization. (2010). Exposure to arsenic: A major public health concern. WHO Press. https://www.who.int/ipcs/features/arsenic.pdf
29. Yadav, S. K., Juwarkar, A. A., Kumar, G. P., Singh, S. K., & Chakrabarti, T. (2015). Bioaccumulationand phyto-translocation of arsenic, chromium and zinc by Jatropha curcas L.: Impact of amendments. Environmental Science and Pollution Research, 22(11), 8842–8852. https://doi.org/10.1007/s11356-014-4069-5