Evaluating the Contamination Degree and Risk Assessment of Heavy Metals Around Active Dumpsite Environment: A Case Study of Ozoro Community, Delta State, Nigeria

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Original Research Article

ABSTRACT

The use of lowlands for refuse collection point (dumpsite) is a very common practice in Nigeria. However, people cultivated the areas within the vicinity of the dumpsites, without knowledge of the risk of these heavy metals. Therefore, this study was done to evaluate the risk of heavy metals pollution of soils within the vicinity of an active dumpsite. Four (4) soil samples (from 4 locations) at a depth of 0–20 cm were collected from the vicinity of the dumpsite. The heavy metals (e.g. iron lead, nickel and cadmium) concentration of the collected soil samples were analyzed according to American Society for Testing and Materials (ASTM) International methods. Pollution indices (contamination factor, enrichment factor, pollution load index and geoaccumulation index) were used to ascertain the level of heavy metals contamination of the dumpsite area. Results obtained

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from the soil tests revealed that, the dumpsite area had high heavy metals concentrations. The heavy metals concentrations were of this ranged: iron 3420 mg kg^{-1} to 4323 mg kg^{-1}, lead 28.92 mg kg^{-1} to 58.84 mg kg^{-1}, nickel 2.89 mg kg^{-1} to 6.91 mg kg^{-1}, and cadmium from 1.04 mg kg^{-1} to 2.05 mg kg^{-1}. The heavy metals concentrations ranked as Fe > Pb > Ni > Cd. Pollution indices results showed that cadmium had the highest contamination factor, enrichment factor, pollution load index and geoaccumulation index values, which portrayed that the dumpsite soil was heavily contaminated with cadmium. Results of the correlation showed a strong correlation (r = 0.87) between iron and nickel, indicating that the two heavy metals got their pollution from the source(s). Results obtained from this study will further help the government and environmental regulators to plan and carried out suitable remediation strategies, to clean the environment.

1. INTRODUCTION

Municipal wastes management had become a main problem to many environmental protection agencies in Africa, and Nigeria in particular. Growing human population and lack of effective waste management structures in Nigeria, had encouraged indiscriminate disposal of solid wastes along the roadsides and lowlands. This proliferation of "unmanaged" dumpsites can lead to seepage of toxic substances (mostly heave metals) from the solid wastes leachates into the surrounding. Agbeshie [1] reported that leachate from solid waste in an unmanaged dumpsite is one of the major causes of heavy metals contamination of the environment. This is because, if the leachates from solid wastes in a dumpsite seeped into the soil and water bodies, they usually had significant negative impact on the plants and animals within the ecosystem. According to [2-3], apart from the problem air pollution that resulted from the emission of toxic gassed and offensive odour, solid wastes dumpsites are major breeding grounds for diseases and pests, which can endanger human health. One of the main concerns of poor solid waste management is the release of toxic substances (heavy metals) into the environment [4]. According to International Agency for Research on Cancer (IARC, 2018) solid wastes usually consists of toxic and hazardous elements such as: Arsenic (As), cadmium (Cd), chromium (Cr) and nickel (Ni) which are classified as g carcinogens elements [5].

Heavy metals are those metals that occurred naturally in the earth crust, with specific gravity higher than 5 kg/m^3. Some of these heavy metals include: iron (Fe), copper (Cu), lead (Pb), Nickel (Ni), etc. [6]. Heavy metals toxicity has been a major concern, since heavy metals can accumulate in the soil thereby causing potential threat to plants and animals through the food web system [7-9]. Soils usually received heavy metals contamination through two major sources: natural and anthropogenic sources. Natural sources are independent of human actions, e.g. rocks weathering; while anthropogenic sources are dependent of human actions, e.g. improper wastes management, agricultural activities, etc. [10-11]. According to Wuana [12] anthropogenic activities such as: improper disposal of high metal wastes, discriminate discharge of leaded fuel and lead-based paints, fertilizers applications, animals wastes, sewage sludge and industrial effluents, are responsible for heavy metals contamination of the environment. According to [13] heavy metals contaminations of the environment possess a serious threat to both adults and children. Ying [14] reported that high level heavy metals contamination of the soil can lead to acute and chronic diseases such as: cancer, renal dysfunction, osteoporosis, and cardiac failure. Likewise, Tong et al. [15] stated that absorption and accumulation of heavy metals in human bodies can affect the central nervous system, which can result in seizures, headache or even coma. According to Zhou [16] high accumulation of Cu in the body seriously affect the intelligence quotient (IQ) OF children through impaired attention.

Environmental pollution through heavy metals contamination, resulting from poor dumpsites management had been investigated by many scientists. Cortez [17] reported that soils around dumpsite are susceptible to heavy metals contaminations; hence they are not suitable for crop production. In the works of Ndukwu [18], high heavy metals concentrations were observed in the soils around dumpsites, which resulted in their accumulation in plants growing around the area. Heavy metals accumulation in soil and plants, were observed around active dumpsites within Ibadan metropolis of Oyo State, Nigeria [19]. Although Ojebah [20] studied the

bioavailability of some heavy metals in selected dumpsites in Ozoro community of Delta State, but there was no thorough investigation on the impact of the dumpsites on their vicinity. Therefore there is scarcity of current information on the environmental impact (contamination degree) of this active dumpsite on it's environ. This is because, since heavy metals are non-biodegradable, they can accumulate in the environment, until they exceed the maximum permissible limits approved by Nigeria department of petroleum resources (DPR) and World Health Organization for soil and sediments. Therefore, this study was undertaken to evaluate the current environment impact (contamination degree) of an active dumpsite on Ozoro community. The objectives of this work were to: (i) determine the heavy metals (Fe, Pb, Ni and Cd) concentrations within the vicinity of a major dumpsite at Isoko North L.G.A. of Delta state, and (ii) evaluate the pollution level of the heavy metals within the dumpsite neighborhood, using contamination factor, enrichment factor and the pollution load index. Information provided by this study will be helpful in proper management of the dumpsite, to avoid environmental pollution.

2. MATERIALS AND METHODS

2.1 Climate and Geology of the Study Area

The research was carried out in the end of the rainy season (November 2020) at the Ozoro community municipal solid waste dumpsite. Geographically, Ozoro community falls Fig. 1 within the tropical forest zone and characterized by two major climatic seasons (rainy and the dry season). The rainy season starts from March and ends in October with the average rainfall of about 1800 mm, while the dry seasons starts around November and ends in March. The mean temperature during the rainy reason is about

24°C, while the mean temperature during the dry season is about 30°C [21]. Solid wastes are brought from Ozoro metropolis by the municipal waste collectors and private individuals to the dumpsites. The dumpsite is about six years old and it is subjected to seasonal burning during the dry season. The soil type found in the area where the dumpsite is located is mainly alluvial soil type. Occasionally, during strong rainstorm there will be an enormous flooding of the dumpsite area, which can enhance the mobility of the heavy metals in the soil.

2.2 Sampling of Soil Samples

Four different spatial locations within the vicinity of the dumpsite were chosen for the purpose of this study. In the same geographical region, another location 2 km away from dumpsite was chosen as the control point (representing a geochemical background). The control location had no recorded waste disposal for the past ten years, and it is covered with natural vegetation. Brief description of the sample locations is presented Table 1. In each sampling location, soil sample was collected (0-20 cm depth) with the aid of soil auger, and poured immediately into a black polyethylene bag. After each sampling, the soil auger was washed and dried with a cloth to remove all remnants of the old soil sample from it. A total of five (5) soil samples were sampled from the five locations investigated in this research.

2.3 Soil Sample Preparation and Analysis

The soil sample was air-dried at room temperature Fig. 2, grind with a porcelain mortar and pestle, before it were sieved using a 2 mm gauge sieve. Then 10 g of the sieved sample was poured into thermal resistance glassware, mixed with 15 ml of three concentrated acids (HNO$_3$, HCl, and H$_2$SO$_4$ mixed at a ratio of 5:1:1), and digested in a water

Table 1. Description of the sample points

Spatial point	Remarks
Point A (DS1)	Back of the dumpsite, about 50 m downward away from the dumpsite. There was no vegetation cover.
Point B (DS2)	Directly in front of the dumpsite, 50 m (upland) away from the dumpsite. There was no vegetation cover.
Point C (DS3)	100 m away from the dumpsite, in the western direction, and it was covered with spare vegetation
Point D (DS4)	100 m (upland) north of the dumpsite, with dense vegetation cover
Point E (Control)	2 km (upland) north of the dumpsite, and it was covered with dense natural vegetation.

DS1, DS2, DS3 and DS4 are codes assigned to Points A, B C, and D for clarity

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Fig. 1a. Nigeria map
Source: [22].

Fig. 1b.Ozoro community map

Fig. 2. Drying of the soil samples at room temperature

bath at a temperature of 90°C, until a transparent solution was achieved [23]. The digested soil sample was cool down at room temperature, filtered into 100mL volumetric flask with the aid of a Whatman No.1 filter paper, and diluted with distilled water up to the 100 mL mark. From the diluted digested solution, these heavy metals (Fe, Ni, Pb and Cd) concentrations were analyzed by using the Flame Atomic Absorption Spectrophotometer (FAAS), according to ASTM International recommended procedures D1971/4691 [24]. The experiment was conducted in triplicate and the average values of the heavy metals obtained were recorded.

2.4 Contamination Assessment

2.4.1 Contamination Factor (CF)

Heavy metal contamination factor is calculated by using the expression given in Equation 1 [25].

$$\text{Contamination Factor} = \frac{Conc. at\ sampled\ point}{Conc. at\ control\ point} \quad (1)$$

The contamination factor scale is as presented below:

CF < 1 = low contamination,
1 < CF < 3 = moderate contamination,
3 < CF < 6 = considerable contamination,
CF > 6 = high contamination

2.4.2 Enrichment Factor (EF)

The enrichment factors of the heavy metals in the soil sampled collected from the dumpsite vicinity is calculated by using the expression in Equation 2 [26].

$$Enrichment\ factor = \frac{C_x/C_{fe}(Sample)}{C_x/C_{fe}(Control)} \quad (2)$$

C_x = heavy metal concentration at the sampled point
C_{fe} = Concentration of the reference element.

Iron has been adopted as the reference metal by many researchers. The reference metal should be particularly stable in the soil; hence its concentration should not be affected by anthropogenic activities [27].

The enrichment factor scale is as presented below:

EF ≤ 2 = low minimal
2 < EF ≤ 5 = moderate
5 < EF ≤ 20 = significant
EF > 20 = very high

2.4.3 Pollution Load Index (PLI)

This is the rate at which the soil sample heavy metal concentration exceeded the heavy metal concentration at the control point. It is calculated using the formula stated in Equation 3 [28-29].

$$\mathbf{PLI} = \sqrt[n]{CF_1 \times CF_2 \times CF_3 \times CF_4 \times ... \times CFn} \quad (3)$$

where:

CF = contamination factor of each metal,
n = total number of metals.

Pollution Load Index is classified as:

PLI < 1 = unpolluted
PLI = 1 baseline level of pollution
1 > PLI ≤ 2 moderately polluted
2 > PLI ≤ 4 highly polluted
PLI > 4 very highly polluted [30].

2.4.4 Geoaccumulation index (I_{geo})

This index is used to evaluate the degree of heavy metals pollution in the environment, and it is expressed in the formula given in Equation 4 [27].

$$I_{geo} = Log_2 \frac{C_n}{1.5B_n} \quad (4)$$

Where:

Cn = Heavy metal concentration at the sampled location,
Bn = the heavy metals concentration at the control point
1.5 = Constant value. This value was introduced to minimize the effect of possible variations in the

control values which may be attributed to lithologic variations in the soil [31].

Geoaccumulation index is classified as follow:

I_{geo} <0 = Uncontaminated
0 < I_{geo} <1 = Uncontaminated to moderately contaminated
1 < I_{geo} <2 = Moderately contaminated
2 < I_{geo} <3 = Moderately to heavily contaminated
3 < I_{geo} <4 = Heavily contaminated
4 < I_{geo} <5 = Heavily to extremely contaminated
I_{geo} > 5 = extremely contaminated [32].

2.5 Statistical Analysis

The data obtained from this research were statistically analyzed using the MS Excel 2015 (Microsoft Corporation Redmond, WA 98052). The summary of the readings was plotted in Microsoft Excel 2015.

3. RESULTS AND DISCUSSIONS

3.1 Heavy Metals Concentrations

The average heavy metals concentrations of the soil samples collected from the four dumpsites are presented in Table 2. It was observed from the results that the heavy metals concentrations of the soil sampled form the dumpsites, were higher the values recorded at the control stations. Intensification of heavy metals pollution occurred from the discharged of leachates from untreated wastes into the environment [33]. The breakdown of the heavy metals concentrations and variation across the study area are discussed below.

Average Fe concentration of the soil samples from the four sampled points ranged between 3420 mg/kg and 4323 mg/kg. According to the results, soil sample collected from DS1 had the highest iron concentration 4323 mg/kg, while the soil sample collected from DS3 had the lowest iron concentration 3420 mg/kg. It was observed from the results that DS2 and DS4 soil samples recorded iron concentrations of 4120 mg kg^{-1} and 3833 mg kg^{-1}, respectively. The higher iron concentration observed at DS1 and DS3 can be attributed to the volume and concentration of solid wastes leachates that it received. Iron bearing and other metallic wastes can increased the concentration of iron in the soil, within the neighborhood of dumpsites [19]. It terms of the soil nickel concentration, it was observed that the nickel concentration ranged from 2.89 mg/kg to

6.91 mg/kg. The highest Ni concentration (6.91 mg kg^{-1}) was recorded in the soil collected from DS1, while the lowest nickel concentration (2.89 mg kg^{-1}) was recorded in the soil sample collected from DS4. Though the nickel concentrations of the four soil samples were higher than the control (1.08 mg kg^{-1}), the values were within the maximum permissible limit of 35 mg/kg of dry soil approved by Nigeria department of petroleum resources (DPR) and World Health Organization [34-35]. From the analysis of the results, it revealed that lead concentration varied across the sampled points. The highest lead concentration (58.84 mg kg^{-1}) was recorded at DS1, while the least lead concentration (28.92 mg/kg) was recorded at DS4. Soil samples collected from DS 2 and DS 3 recorded mean lead concentration of 30.21 mg.kg and 49.86 mg/kg, respectively Table 2. The control point had average soil lead concentration of 8.21 mg kg^{-1}. When compared with DPR and WHO recommended maximum permissible limit, the results showed that the soil lead concentration was within the standard limits set by the regulatory agencies. According to Manahan [36] lead is the fifth most common industrial pollutant, and its sources incudes batteries, PVC materials, paint and plumbing materials, etc. The highest lead concentration recorded at DS1 could be attributed to the proximity of the sampled location to the dumpsite, and the downward position of the location which encourages lead movement within the soil. In a study on leaching of heavy metal at some selected dumpsites in Nigeria, Awokunmi et al. [37] reported similar movement of Pb away from the center of the dumpsite down the slope. According to [38] Pb is a hazardous heavy metal which can inhibit soil microbial activities in the soil even at minute concentration.

Cadmium concentration of the soil samples, sampled from the area varied widely from 1.04 mg kg^{-1} to 2.05 mg kg^{-1} Table 2. As portrayed by the results, DS1 soil sampled had the highest cadmium concentration (2.05 mg kg^{-1}), while DS2 recorded the least cadmium concentration of 1.04 mg kg^{-1}. The results obtained from the soil samples collected from DS3 and DS4, revealed that DS3 soil sample had cadmium concentration of 1.85 mg kg^{-1}, and the D4 soil sample had cadmium concentration of 1.93 mg kg^{-1}. As shown by the results, all the soil samples including the control soil sample, had cadmium concentration which is higher than the 0.8 mg kg^{-1} of dry soil recommended by DPR and WHO. Weggler [39] reported that anthropogenic activities such as fertilizers and pesticides

applications, industrial wastes discharge, batteries, etc. are some of the major causes in cadmium contamination of the environment. Cadmium is highly persistent in the soil, plants and animal bodies, hence when once absorbed into the body it can remains resident for many years [40]. An [41] confirmed the high toxicity of Cd in soils samples, as it hinders activities of essential microorganisms in the soil and altered the physicochemical characteristics of the soils samples.

This study results affirmed the previous studies [1,37] who reported that the leachates from solid wastes, significantly increased the soil heavy metals concentrations. According to Awokunmi [37], the concentrations of iron (3,000 mg kg^{-1} - 5,000 mg kg^{-1}), lead (3,500 mg kg^{-1}– 6,860 mg kg^{-1}), nickel (18 mg/kg – 335 mg/kg) and cadmium (219 mg kg^{-1} – 330 mg kg^{-1}) recorded at the dumpsites soil samples, were significantly higher than the results obtained at the control location. Agbeshie [1] reported that the iron, cadmium and lead concentrations of soil samples collected from a dumpsite in Ghana, were higher than the concentrations recorded in the control soil sample. The differences observed in the soil heavy metals concentrations between our results and other studies results [1,20], could be attributed to the sampling period, to the age of the dumpsite, transport mechanisms, remediation potential of the natural vegetation, locations at which the soil samples were sampled and organic materials present in the sampling location. Studies [42-44] showed that many plant species and organic materials (microbial decomposition) have significantly impacts on the remediation of the heavy metals content in the soil, thus lowering the heavy metals accumulation in the soil. Although the soil acts as a natural sink for the heavy metals, the concentration of heavy metals in the soil is influenced by its geotechnical properties, the soil hydraulic conductivity, the amount of remediation materials (e.g. grass, organic materials), concentration of the pollutant, moisture content, distribution of heavy metals within the soi, etc. [45].

Additionally, the higher heavy metals concentrations recorded in this study compared to previous results of [20], signified that heavy metals is accumulating in the area at a faster rate, hence approaching its heavy metals contamination threshold. Therefore, there is an urgency of relocating it from its present location, since it is located within residential area, to

prevent heavy metals related ailments. According to [46] environmental toxicity of heavy metals resulting from their concentration exceeding standard maximum approved limits has received heightened consideration from many environmentalists. It had being reported by previous study [47] that high concentration of Cd, Pb and Cu in the soil is causing an alarming combination of environmental and health problems. Furthermore, Tseng [48] stated that prolonged exposure of human beings to hazardous materials such as Ni, Cd, and Cu through contaminated soils seriously affect the central nervous system, gastric and respiratory system of the body.

3.2 Correlation Relationship among the Heavy Metals in the Dumpsite Area

Table 3 presents the correlation relationship between the heavy metals sampled from the dumpsite at the four locations. As presented in Table 3, the strongest correlation (r = 0.87) was recorded between iron and nickel. The relationship between lead and nickel, lead and cadmium showed a weak correlation (r <06), while the relationship between iron and cadmium, iron and lead, nickel and cadmium showed a very poor correction (r <0.2). The high correlation between iron and nickel portrayed that one source was their main source of contamination [49].

3.3 Evaluating the Contamination of the Soil Samples using Pollution Indices

3.3.1 Contamination factor

The results of contamination factors of the heavy metals in relation to their sampling points are presented in Fig. 3. As shown in Fig. 3, the contamination factors of the heavy metals varied widely across the dumpsite area. Generally, iron had the lowest contamination factor across the study area, while cadmium had the highest contamination factor across the study area. At sampling location DS1, iron contamination was at the considerable degree, while the remaining heavy metals (lead, nickel and cadmium) contaminations were of the high contamination level. As for sampling location DS2, iron, lead and nickel contaminations were at the considerable degree, while the cadmium contamination was at the high contamination level. Iron and nickel were at moderate contamination degree at sampling location DS3,

while lead and cadmium recorded high contamination degree at the same sampling location DS3. Nickel was at moderate degree of contamination at DS4, iron and lead were at moderate contaminations, cadmium was at high contamination at DS4. As seen in the results, sampling location DS1 had the highest contamination factors (mean ~ 10.69), while sampling location DS2 had the lowest contamination factors (mean ~ 6.19). Contamination factor is essential in evaluating the toxicity of heavy metals in the environment, and their potential sources. According to Sha'Ato [50], soils with high contamination factors (CF ≥1) signify that they mainly acquired their contamination through anthropogenic sources.

3.3.2 Enrichment factor

The heavy metals enrichment factors are presented in Fig. 4. As shown in Fig. 4, the order of the heavy metals enrichment factor at sampling location DS1 was in following order Ni >Pb > Cd, while at sampling location DS2 it followed Pb > Ni > Cd ranking order. At sampling location DS3 the tanking order was Ni > Pb > Cd, while at DS4 it was Ni > Pb > Cd. As presented in Fig. 4, the nickel enrichment factor at all the sampling locations was at low minimal level (EF ≥ 2.0), portraying that natural sources (e.g. rock weathering) may be responsible for the nickel contamination of the area. In contrast to the nickel enrichment factor result, the cadmium enrichment factor at all the sampling locations ranged from moderate level to significant level (EF ≥ 2.0), this portrayed that anthropogenic sources (e.g. solid wastes leachates) was responsible for the cadmium contamination of the soil. Likewise, the lead enrichment factor at DS1 and DS3 was greater than 2, which revealed that anthropogenic sources (e.g. solid wastes leachates) were responsible for the pollution of the soil. The analysis of the results had shown that irrespective of the sampling location, cadmium had the highest enrichment factor, which can be ascribed to anthropogenic pollution.

3.3.3 Pollution Load Index (PLI)

The analysis of the results for the heavy metal pollution load index is presented in Fig. 5. These results indicated that the dumpsite recorded PLI values ranging from 3.23 to 20.77 for iron, lead, nickel and cadmium across the sampling locations. As shown in Fig. 5, cadmium had the highest PLI (20.77), while iron had the lowest PLI

of 3.23. The results further revealed that the neighborhood was very highly polluted with nickel and cadmium (PLI > 4), which may be attributed to the nature of solid wastes deposited in the dumpsite [29]. The relative high PLI values for all the heavy metals investigated in this study, further affirmed that leachates from anthropogenic sources are responsible for the pollution of the area.

3.3.4 Geoaccumulation index (I$_{geo}$)

The heavy metals Geoaccumulation index values across the dumpsite area are presented in Table 4. The results revealed that soil samples at DS1 and DS2 were moderately polluted, while the soil samples at DS4 was moderately to heavily pollution with iron. Lead was in the range of 2 - 3

(moderately to heavily pollution) at DS1 and DS3, but 1 - 2 (moderately pollution) at DS2 and DS4. Then as for nickel, DS1 had moderately to heavily pollution and DS2 had moderately pollution, but DS3 and DS4 had uncontaminated to moderately pollution. Similarly, cadmium was in the range of 3 - 4 (heavily contaminated) at DS2 and DS3, but 4 – 5 (heavily to extremely contaminated) at DS1 and DS4. As seen in the results, none of the sampled locations was purely uncontaminated with the four heavy metals studied. This study had revealed that the contamination of the area is increasing and spreading rapidly across the dumpsite neighborhood, as against the localized results obtained b [20] in their previous research on the area three years ago.

Table 2. Average values of the soil heavy metals concentrations of the study and control areas

Location	Iron (mg kg^{-1})	Lead (mg kg^{-1})	Nickel (mg kg^{-1})	Cadmium (mg kg^{-1})
DS1	4323±221	58.84±9	6.91±0.8	2.05±0.04
DS2	4120±209	30.21±11	5.08±1.1	1.04±0.05
DS3	3420±122	49.86±10	3.05±0.9	1.85±0.09
DS4	3833±124	28.92±5	2.89±0.9	1.93±0.04
Control	1211±83	8.21±4	1.08±0.03	0.98±0.05
DPR	-	85	35	0.8
WHO	-	50	35	0.8

± Standard deviation

Table 3. Correlation of heavy metals in dumpsite area

	Iron	Lead	Nickel	Cadmium
Iron	1.00			
Lead	0.09	1.00		
Nickel	0.87	0.52	1.00	
Cadmium	-0.16	0.58	-0.05	1.00
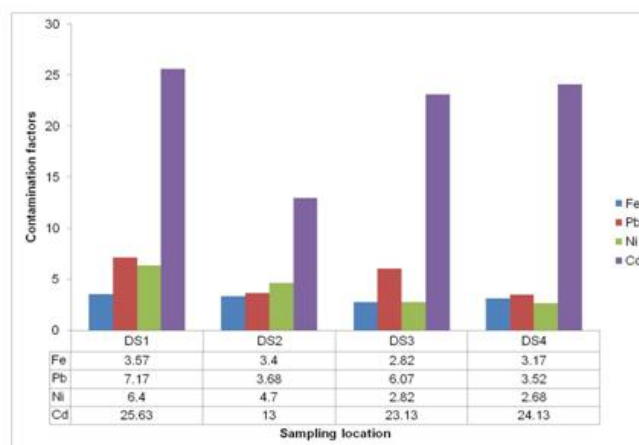
Fig. 3. Contamination factors of the metals

	DS1	DS2	DS3	DS4
Pb	2.01	1.08	2.15	1.11
Ni	1.79	1.38	1	0.85
Cd	7.18	3.82	8.19	7.62
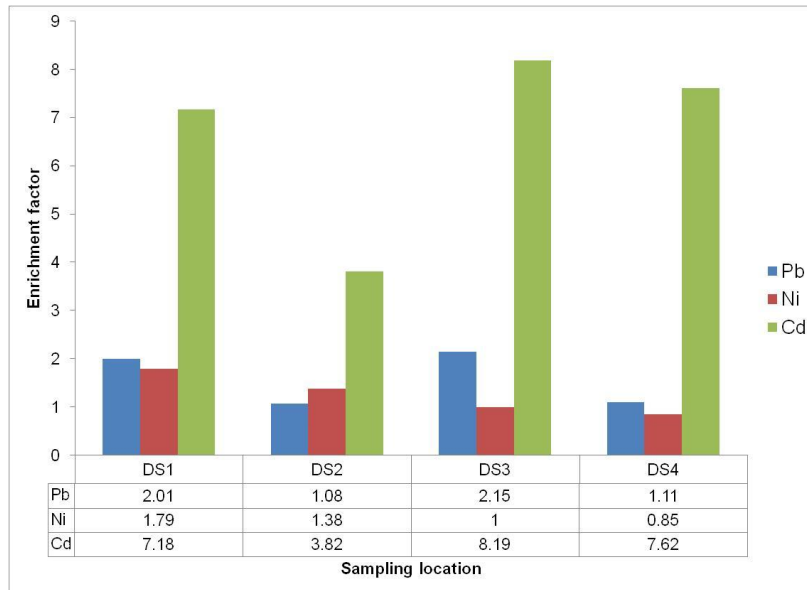
Fig. 4. Enrichment factors of the metals
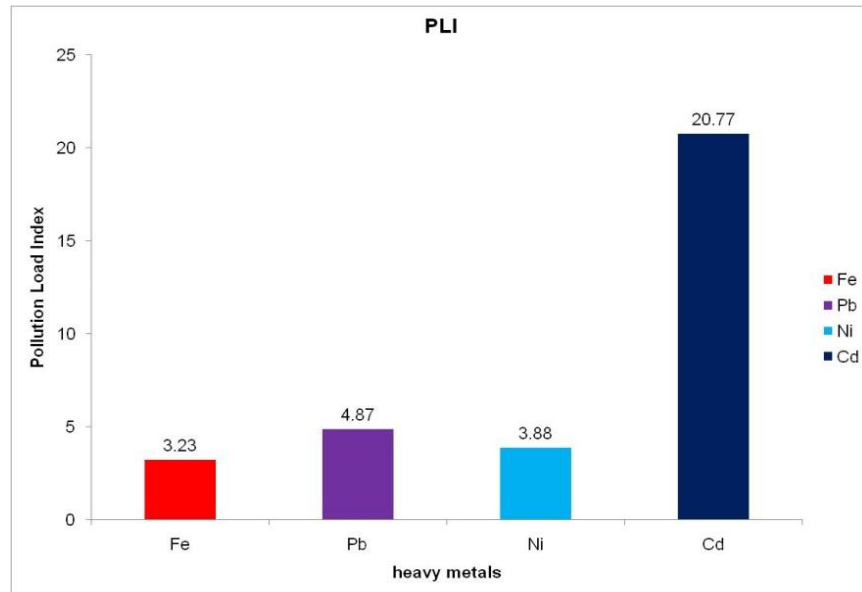
Fig. 5. Pollution load index of the metals

These results had revealed the significance of proper solid waste disposal, and proper remediation of the environment, mostly within the vicinity of dumpsites. Heavy metals are poisonous to the body, and their side effects include: poor IQ in children, kidney failure, gastrointestinal tract problem, etc. [51]. Baldwin [52] stated that excess lead can caused irreparable damage to the brain, nervous system, red blood cells and the kidney. According to Rosen [53] the threat of lead poisoning in human beings increases as the soil lead concentration increases, since lead contaminated soil or dust deposits is more dangerous in human beings than its absorption by the plant. These results will be helpful in planning suitable solid waste management and dumpsite remediation strategies in Nigeria and Delta State in particular.

Table 4. Geoaccummulation index of heavy metals in dumpsite area

	Fe	Pb	Ni	Cd
DS1	1.251	2.257	2.094	4.094
DS2	1.182	1.292	1.651	3.116
DS3	0.911	2.017	0.911	3.946
DS4	2.077	1.232	0.832	4.006

4. CONCLUSION

This study was carried out to determine the level of heavy metals contamination of soils around an active solid waste dumpsite. Soil samples were collected at four locations within active dumpsite at Ozoro community, and their heavy metals (Fe, Pb, Ni and Cd) concentrations determined, and their pollution level calculated. Results obtained from the study indicated that, the heavy metals concentration values recorded within the dumpsite were higher than the values recorded at the control location. Regardless of the sampling location, the heavy metals concentrations ranked as Fe > Pb > Ni > Cd. When compared with DPR and WHO recommended maximum permissible limit, the results showed that the soils lead and nickel concentrations were within the standard limits set by the regulatory agencies. The results of contamination factors of the heavy metals revealed that, the contamination factors of the heavy metals varied widely across the dumpsite area. Generally, iron had the lowest contamination factor across the study area, while cadmium had the highest contamination factor across the study area. The enrichment factor results showed that, cadmium enrichment factor at all the sampling locations was at ranged between moderate and significant, while the nickel enrichment factor at all the sampling locations was at low minimal level (EF ≥ 2.0). Results obtained from the pollution load index indicated that the dumpsite recorded PLI values ranging from 3.23 to 20.77 for iron, lead, nickel and cadmium across the sampling locations. As shown by the results, cadmium had the highest PLI (20.77), while iron had the lowest PLI of 3.23. The geoaccumulation index of the dumpsite varied from moderately to heavily contamination with metals of Fe, Pb and Ni, except Cd which was extremely contaminated at the dumpsite. Results obtained from this study suggested that area surrounding the dumpsite is not appropriate for crop production; this is due to accumulation of these heavy metals by the crops. In addition, these results will further help the government and environmental regulators to plan and carried out suitable remediation strategies, to clean the environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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