Vol. 12(1), pp. 32-44, January-June 2020
DOI:10.5897/JECE2020.0461
Article Number: 27A314A63690
ISSN: 2141-226X

http://www.academicjournals.org/JECE

ACADEMIC JOURNALS
expand your knowledge

Journal of Environmental Chemistry and Ecotoxicology

Full Length Research Paper

Level and ecological risk assessment of heavy metals in old landfill in Bayelsa state, Nigeria

Uzoekwe Anayo Stephen[1]* and Richard Glory[2]

[1]Department of Chemistry, Faculty of Science, Federal University, Otuoke, Bayelsa State, Nigeria.
[2]Department of Community Medicine, Faculty of Clinical Sciences, Niger Delta University, Bayelsa State, Nigeria.

Received 23 February, 2020; Accepted 17 April, 2020

This study assessed the ecological fate of heavy metals within the vicinity of an area formally used as dump site in Igbogene, Bayelsa state. Soil auger was used to collect samples at 0 - 20 cm depth at 50, 100 and 150 m distances from the four cardinal points viz: North east and west and south east and west. The soil samples were sieved, ashed, digested and analyzed using atomic adsorption spectrometry. The heavy metals results ranged from 646.73 to 715.33 mg/kg (iron), 59.30 to 73.05 mg/kg (manganese), 83.20 to 114.18 mg/kg (zinc), 10.67 to 15.95 mg/kg (copper), 7.70 to 9.64 mg/kg (chromium), 11.56 to 14.48 mg/kg (cadmium), 10.09 to 13.86 mg/kg (lead), 4.57 to 6.33 mg/kg (nickel) and 3.52 to 4.92 mg/kg (vanadium). Statistically there was no significant variation (p>0.05) across the various distances for each of the metals studied, but apparent decline in values exist as the distance away from the landfill increased. In addition, each of the metals showed positive significant correlation with each other at p<0.01. Cluster analysis revealed two main clusters. These are samples from each of the latitude directions, southern direction (east and west) and northern direction (east and west). Pollution indices were higher in sample obtained from the southern direction (west and east) compared to northern area (west and east) but generally it ranged from no pollution to moderate pollution. Positive quantification of contamination indicates that pollution due to anthropogenic activities occurred in few instances. The ecological risk index showed low risk/fate of the heavy metals studied area.

Key words: Environmental risk, heavy metals, dumps site, pollution indices, wastes.

INTRODUCTION

Environmental problems appear to be on the increase globally, which undoubtedly impacts on environmental sustainability. Components of the environment mostly affected are the soil or land, air, water and sediments. These components are largely influenced by anthropogenic activities and to a lesser extent by natural processes (Izah and Angaye, 2016). Several human activities contribute to environmental pollution including poor waste management and effluent discharge during industrial processes.

Wastes are typically generated in different processing units including food production such as oil palm and cassava processing (Nnaji and Uzoekwe, 2018; Izah and Ohimain, 2015), markets (Ben-Eledo et al., 2017a, b), and manufacturing/ processing units. Wastes typically exist in the form of liquid that is effluents and solid. Of the

*Corresponding author. E-mail: uzoekwe_steve@yahoo.com.

entire waste stream, municipal solid wastes, which is either from domestic or industrial unit, is a source of concern to environmentalist. Basically, the domestic source of wastes are from household which include food remain, laundry etc. On the other hand, wastes from food vendors/ restaurants, auto-mechanic shops, medical facilities, schools, construction, industries are classified as commercial wastes. Wastes can also be classified based on the noxiousness to the environment and its associated biota, biodegradation potentials, physical nature or characteristics and based on source (Nnaji and Uzoekwe, 2018).

The soil receives most of the solid waste stream that are generated from human activities. By their nature some are easily degradable wastes such as food remains through the activities or indigenous microbes, while several others may be recalcitrant to degradation (such as pesticides) or better still non-biodegradable (such as glass). As such wastes have the tendency to alter the characteristics of the receiving soil. The alteration depends mainly on the exposure rate, toxicity and other factors such as climatic, physical, chemical, soil porosity, pH, temperature, organic matter, moisture and indigenous microbes that may cause transformation of the waste.

Municipal solid wastes are mainly managed through open dumping, landfill system, incineration, composting and recycling. Among these methods of household solid waste management landfill is the commonest. In the landfill heavy metals have been detected (Amadi et al., 2012; Njoku, 2014; Anikwe and Nwobodo, 2001; Oluseyi et al., 2014; Buteh et al., 2013; Akinbile, 2012). Heavy metals such as mercury, arsenic, cadmium and lead that do not have any known biological functions, while the essential ones such as chromium, copper, zinc, manganese, iron etc have biological function to living organisms but could be detrimental when their concentration exceed certain limit.

These heavy metals have different chemical species and their transport behaviour is quite different depending on the substrate such as soil, plant, water, and environmental factors such as temperature and pH. Heavy metals have the tendency to persist in the environment for long. Ecological risk assessment and pollution indices are some tools used in assessing the fate of metals in the environment. Therefore, this study is aimed at assessing the level and ecological risk assessment of heavy metals around a landfill in Igbogene, community Bayelsa State, Nigeria.

MATERIALS AND METHODS

Study area

Igbogene is one of the adjoining communities that make the Bayelsa State capital in Yenagoa local Government area of Bayelsa State. Authors have attributed the region as a sedimentary basin (Kigigha et al., 2018; Aghoghovwia et al., 2018). A tributary of Nun River known as Epie creek passes through the community. Like many other parts of Bayelsa State, the creek is a major receipt of solid wastes from human activities especially among household close to the surface water. Two major climatic conditions are common in the study area: wet season (which originally start from April and end in October) and dry season (which start from November and end in March of the following year). The relative humidity and atmospheric temperature of the area have been reported to be around 50-95% and 28 ±6°C, respectively all year round.

Sampling techniques

The soil sample were collected from east and west of southern and northern area of the various distances (50m, 100m, 150m) from the old dumpsite. The samples were collected with soil auger at 0-20 cm depth. The samples were packaged and labeled accordingly before being transported to the laboratory for analyses.

Sample preparation and analysis using atomic absorption spectrophotometer

The samples were air dried and sieved in 2.0 mm mesh. About 2 g of the sample was placed in a clean crucible and placed in a muffle furnace pre-heated at 200°C for 30 min, and then ashed for 4 h at 480°C. The sample was removed from the furnace and cooled. The sample was further digested with concentrated nitric acid by adding 2 ml of 5 M HNO_3 and evaporated to dryness on a sand bath. The sample was again placed in a cooled furnace and heated at 400°C for 15 min. The cooled sample was moistened with four drops of distilled water. 2ml of concentrated HCl was added and the sample evaporated to dryness and removed, thereafter, 5ml of 2M HCl added and the container swirled. The solution was filtered using Whatman filter paper No. 42 and transferred to a 25ml volumetric flask. The filtrated solution was made up to mark. The solution was aspirated into atomic absorption spectrophotometer (Model: PyeUnicam 969) and concentrations of various metals measured at varying wavelengths (Isaac and Kerber, 1971; Aigberua, 2015).

Quality assurance and quality control

The reagents used were of analytical grade. The reproducibility and reliability of the measurements were ensured by calibrating instruments used and procedural blanks determined.

Environmental risk assessment

Pollution indices and ecological risk was used to ascertain the risk associated with metals in the study area. The background or reference value was the geometric mean of the data which have been widely used in ecological risk assessments (Izah et al., 2017a, b, c; 2018; Bhutiani et al., 2017; Aghoghovwia et al., 2018; Uzoekwe and Aigberua, 2019). The factors considered in this study include contamination factor, degree of contamination, pollution load index, index of geoaccumulaton, quantification of contamination and ecological risk index.

The contamination factor (CF) and contamination degree was calculated based on the methods previously developed by Hakanson (1980) and applied by Bhutiani et al. (2017). The obtained values were classified based on the following criteria viz: CF < 1 (low contamination); 1 ≤ CF < 3 (moderate contamination); 3 ≤ CF < 6 (considerable contamination); CF ≥ 6 (very high contamination) for contamination factor and CD < 8 (low risk); 8 ≤ CD < 16 (moderate risk); 16 ≤ CD < 32 (considerable risk); CD > 32 (very high risk) for degree of contamination. Pollution load index was calculated based on the method previously described by Tomlinson et al. (1980) and have been applied by Bhutiani et al. (2017). The result values were ranked as PLI < 1 (no pollution); 1 < PLI < 2 (moderate pollution); 2 < PLI < 3 (heavy pollution); 3 < PLI (extremely heavy pollution).

Quantification of contamination was calculated based on the method described by Bhutiani et al. (2017) and applied by Aghoghovwia et al. (2018), Izah et al. (2017c). Positive quantification of contamination is an indication of contamination due to anthropogenic activities/ sources.

Geo-accumulation index (Igeo) was calculated based on the method developed by Muller (1969) and have been applied by Bhutiani et al. (2017), Izah et al. (2017c). The resultant values were classified as Igeo ≤ 0 (uncontaminated), 0 <Igeo ≤ 1 (uncontaminated to moderately contaminated), 1 <Igeo ≤ 2 (moderately contaminated), 2 <Igeo< 3 (moderately to heavily contaminated), 3 <Igeo< 4 (heavily contaminated), 4 <Igeo< 5 (heavily to extremely contaminated), Igeo ≥ 5 (extremely contaminated).

Ecological risk index (ERI) which is often used to investigate the fate of heavy metals in the environment was applied in this study. The ecological risk (Er) and ecological risk index (index) was calculated based the method developed by Hakanson (1980) and applied by Bhutiani et al. (2017). During the ecological risk calculation, the toxic factor used was based on the metals viz: Cr = 2, Pb = Cu =5, Cd = 30 and Zn = 1 (Hakanson, 1980), Ni = 5 (Xu et al., 2008; Soliman et al., 2015; Bhutiani et al., 2017) and Mn = 1 (Xu et al., 2008; Soliman et al., 2015). The result was classified as Er< 40 (low risk), Er 40 ≤ Er< 80 (moderate risk), 80 ≤ Er< 160 (considerable),160 ≤ Er< 320 (high) and Er ≥ 320 (very high) for ecological risk; and ERI <150 (low risk), 150 ≤ ERI < 300 (moderate risk), 300 ≤ ERI < 600 (considerable) and ERI ≥ 600 (very high) for ecological risk index.

Statistical analysis

SPSS version 20 was used to carry replicate and the result values were presented as mean ± standard error. One- way analysis of variance was carried out at p=0.05, and Duncan statistics was used showed significant difference between the various locations. Spearman rho correlation matrix was used to show the relationship between the metals. Hierarchical cluster analysis of the heavy metals concentration and sampling point was carried out at Euclidean Distance.

RESULTS AND DISCUSSION

The levels of heavy metals in an area formerly used landfill in Igbogene community of Bayelsa State, Nigeria is presented in Table 1. The concentration of the metals at varying distances 50 m, 100 m and 150 m were 715.33±215.26, 689.68±221.19 and 646.73±222.50 mg/kg, respectively (iron); 114.18±30.83, 101.18±28.60 and 83.20±31.31 mg/kg, respectively (zinc); 73.05±19.46, 63.10±17.25 and 59.30±17.29 mg/kg, respectively (manganese); 15.95±5.52, 13.57±5.78 and 10.67±4.68 mg/kg, respectively (copper); 14.48±10.35, 12.89±9.63 and 11.56±9.46 mg/kg, respectively (cadmium); 13.86±7.98, 11.84±6.52 and 10.09±5.47 mg/kg, respectively (lead); 9.64±6.87, 8.90±6.96 and 7.70±6.30 mg/kg, respectively (chromium);6.33±2.11, 5.18±1.67 and 4.57±1.70 mg/kg, respectively (nickel) and 4.92±1.52, 4.03±1.17 and 3.52±1.31 mg/kg, respectively for vanadium. Statistically, there was no significant deviations (p>0.05) across the three distances for each of the heavy metals. However, apparent difference exists for each of the metals concentration in the various distances, which decreases as the distances away from the old landfill increased. Basically heavy metals are metalloids that have relatively high densities (which is about 5 times greater than that of water), atomic weights, or atomic numbers greater (Izah et al., 2016; Izah and Angaye, 2016). These heavy metals have been reported in soil from diverse anthropogenic activities (Izah et al., 2017a). Possibly, due to the ability of vegetation to accumulate heavy metals, various levels has similarly been reported in plants (Izah and Aigberua, 2017; Ogamba et al., 2017, 2015). Variation in concentration of heavy metals have been reported around municipal solid waste dumpsite in different locations in Nigeria including Imo state (Amadi et al., 2012), Ebonyi state (Njoku, 2014; Anikwe and Nwobodo, 2001), Lagos state (Oluseyi et al., 2014), Bauchi state (Buteh et al., 2013) and Ondo state (Akinbile, 2012). The variation in these authors' reports with the values recorded in this study is due to the type of waste in the dumpsite, age and frequency of use of the dumpsite as well as the geology of the area. This is because most of the heavy metals have the tendency to occur naturally in our environment. The absence of significant variation and apparent decline in heavy metal concentration at distances away from the dumpsite suggest that metals have leached into the soil; metals being mobile in the soil and thus leaching is a common occurrence and plays a role in determining the fate of metal in the environment.

Table 2 shows the Spearman rho correlation matrix of heavy metals concentration in old landfill in Igbogene, Bayelsa State, Nigeria. All the metals showed positive significant relationship with each other at p<0.01. This is an indication that the metals in the soil studied may have come from similar source, which is an indication of significant relationship (Izah et al., 2017a). The positive relationship of the metals indicates common sources, mutual dependence and identical behavior during transport (Jiang et al., 2014; Izah et al., 2017a).

Figure 1 shows the hierarchical cluster analysis of the heavy metals concentration from landfill in Igbogene, Bayelsa state, Nigeria based on dependent variables. Two major clusters were formed with cluster 1 comprising nickel, vanadium, copper, lead, cadmium, chromium, manganese and zinc with equal distances, and cluster 2 with only iron. Figure 2 shows hierarchical cluster analysis of the heavy metals concentration from the landfill in Igbogene, Bayelsa state, Nigeria based on locations. Two main cluster was formed with cluster 1 comprising of North East and North West samples, while cluster 2 consist of South West and South East samples.

Table 1. Heavy metals concentration in old landfill in Igbogene, Bayelsa state, Nigeria.

Parameter	Distances (m)		
	50	100	150
Iron, mg/kg	715.33±215.26[a]	689.68±221.19[a]	646.73±222.50
Manganese, mg/kg	73.05±19.46[a]	63.10±17.25[a]	59.30±17.29[a]
Zinc, mg/kg	114.18±30.83[a]	101.18±28.60[a]	83.20±31.31[a]
Copper, mg/kg	15.95±5.52[a]	13.57±5.78[a]	10.67±4.68[a]
Chromium, mg/kg	9.64±6.87[a]	8.90±6.96[a]	7.70±6.30[a]
Cadmium, mg/kg	14.48±10.35[a]	12.89±9.63[a]	11.56±9.46[a]
lead, mg/kg	13.86±7.98[a]	11.84±6.52[a]	10.09±5.47[a]
Nickel, mg/kg	6.33±2.11[a]	5.18±1.67[a]	4.57±1.70[a]
Vanadium, mg/kg	4.92±1.52[a]	4.03±1.17[a]	3.52±1.31[a]

Data is expressed as mean± standard deviation (n=4); Different letters across the row indicate significant variation (p<0.05) according to Duncan statistics.

Table 2. Spearman rho correlation matrix of heavy metals concentration in old landfill in Igbogene, Bayelsa state, Nigeria.

Parameter	Fe	Mn	Zn	Cu	Cr	Cd	Pb	Ni	V
Fe	1.000								
Mn	0.944**	1.000							
Zn	0.965**	0.951**	1.000						
Cu	0.930**	0.909**	0.965**	1.000					
Cr	0.944**	0.902**	0.923**	0.965**	1.000				
Cd	0.944**	0.902**	0.923**	0.965**	1.000**	1.000			
Pb	0.944**	0.902**	0.923**	0.965**	1.000**	1.000**	1.000		
Ni	0.832**	0.853**	0.902**	0.965**	0.923**	0.923**	0.923**	1.000	
V	0.832**	0.853**	0.902**	0.965**	0.923**	0.923**	0.923**	1.000**	1.000

**Correlation is significant at the 0.01 level (2-tailed).

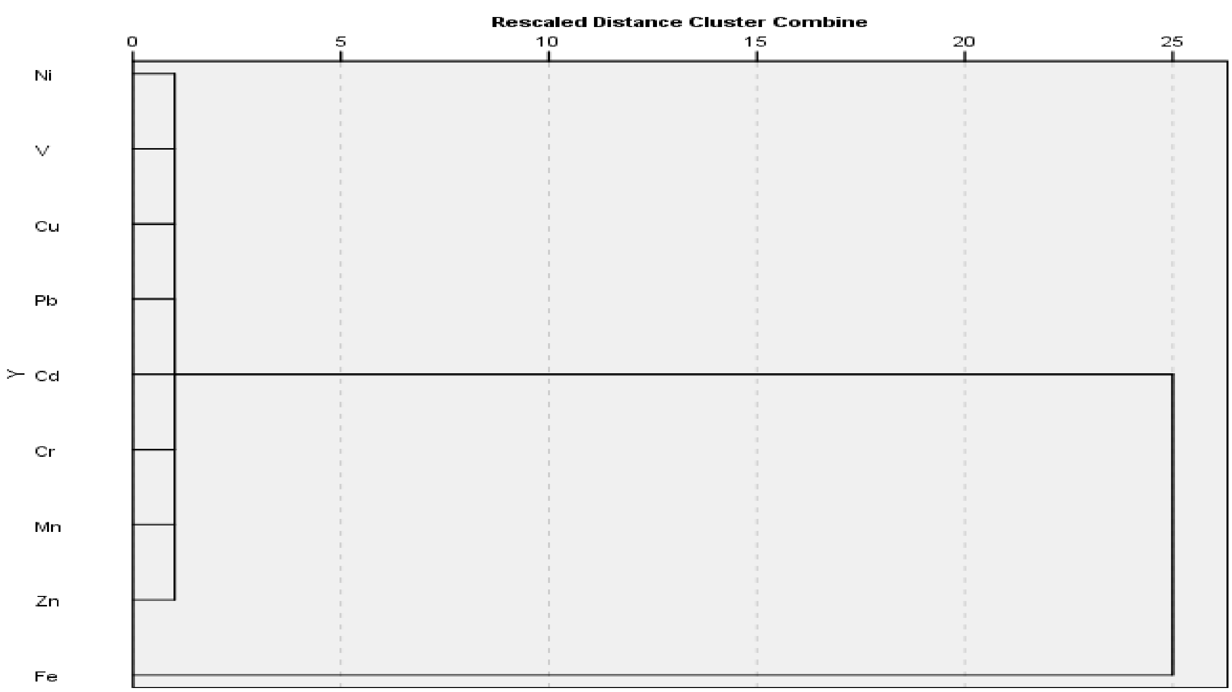

Figure 1. Hierarchical cluster analysis of the heavy metals concentration.

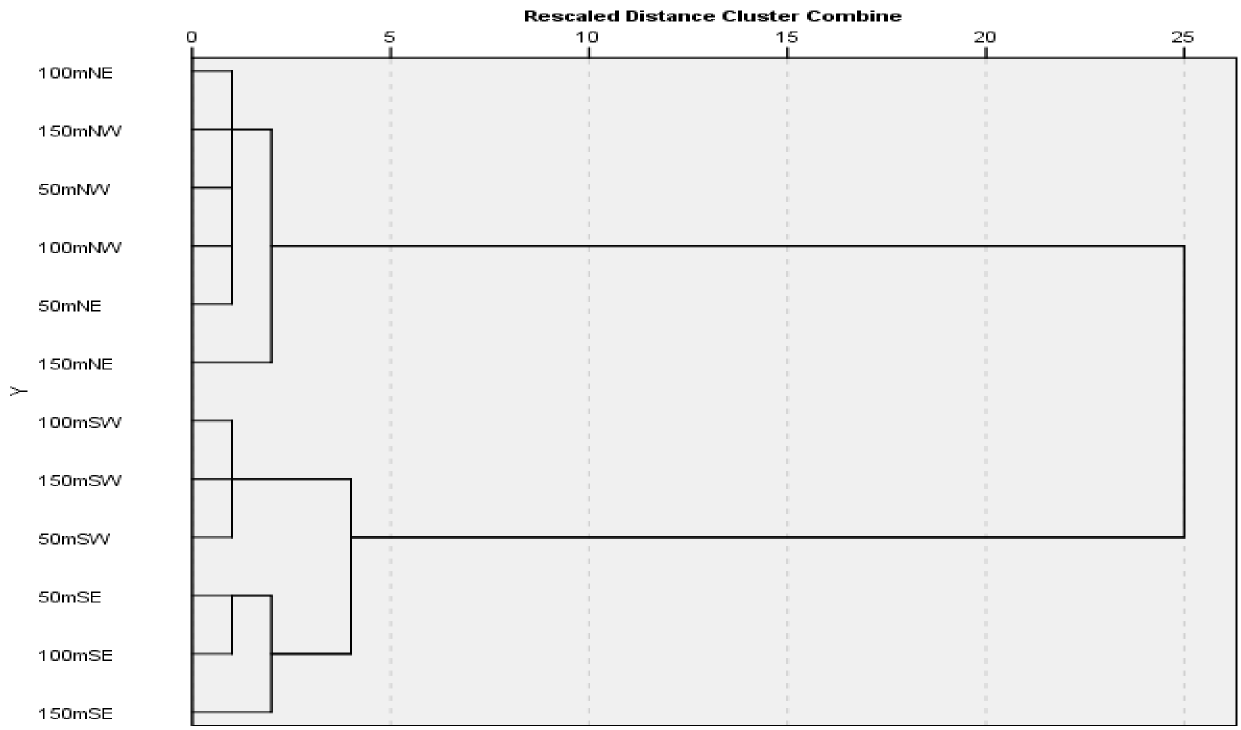

Figure 2. Hierarchical cluster analysis of the heavy metals.

Table 3. Contamination factor, degree of contamination and pollution load index of the heavy metals from old landfill area in Igbogene, Bayelsa State, Nigeria.

Location	Fe	Mn	Zn	Cu	Cr	Cd	Pb	Ni	V	CD	PLI
50 m NE	0.84	0.83	0.91	0.76	0.47	0.47	0.60	0.69	0.74	6.31	0.68
100 m NE	0.75	0.79	0.77	0.52	0.42	0.42	0.55	0.55	0.59	5.36	0.58
150 m NE	0.67	0.70	0.61	0.50	0.32	0.32	0.49	0.45	0.44	4.5	0.48
50 m NW	0.79	0.96	0.96	1.09	0.79	0.79	0.89	1.22	1.20	8.69	0.95
100 m NW	0.78	0.75	0.88	0.95	0.62	0.62	0.73	1.09	1.07	7.49	0.82
150 m NW	0.74	0.72	0.66	0.75	0.60	0.60	0.68	1.05	1.03	6.83	0.74
50 m SE	1.28	1.48	1.34	1.58	1.69	1.70	1.47	1.47	1.45	13.46	1.49
100 m SE	1.26	1.18	1.16	1.32	1.53	1.54	1.32	1.19	1.17	11.67	1.29
150 m SE	1.15	1.11	0.89	0.82	1.19	1.20	1.00	0.90	0.89	9.15	1.01
50 m SW	1.46	1.35	1.59	1.73	2.72	2.74	2.32	1.66	1.64	17.21	1.85
100 m SW	1.41	1.29	1.44	1.60	2.66	2.49	1.91	1.29	1.27	15.36	1.64
150 m SW	1.39	1.24	1.33	1.39	2.41	2.42	1.67	1.25	1.23	14.33	1.54

For contamination factor (CF): CF < 1 (low contamination); 1 ≤ CF < 3 (moderate contamination); 3 ≤ CF < 6 (considerable contamination); CF ≥ 6 (very high contamination).

Again within this cluster, sub-cluster was also formed. Basically with a major cluster close distances is an indication of significant relationship (Guan et al., 2014; Izah et al., 2017). Based on the formation of cluster with respect to cardinal points (South and North) there is an indication of the similar mobility pattern of heavy metals in the soil.

Table 3 shows the contamination factor, degree of contamination and pollution load index of the heavy metals from old landfill area in Igbogene, Bayelsa state, Nigeria. The contamination factor ranged from low contamination (CF < 1) to moderate contamination (1 ≤ CF < 3). The contamination factor for samples from North east and west showed low contamination factor except for copper in 50 m distance of North West, nickel and vanadium at 50 m, 100 and 150 m of North west that

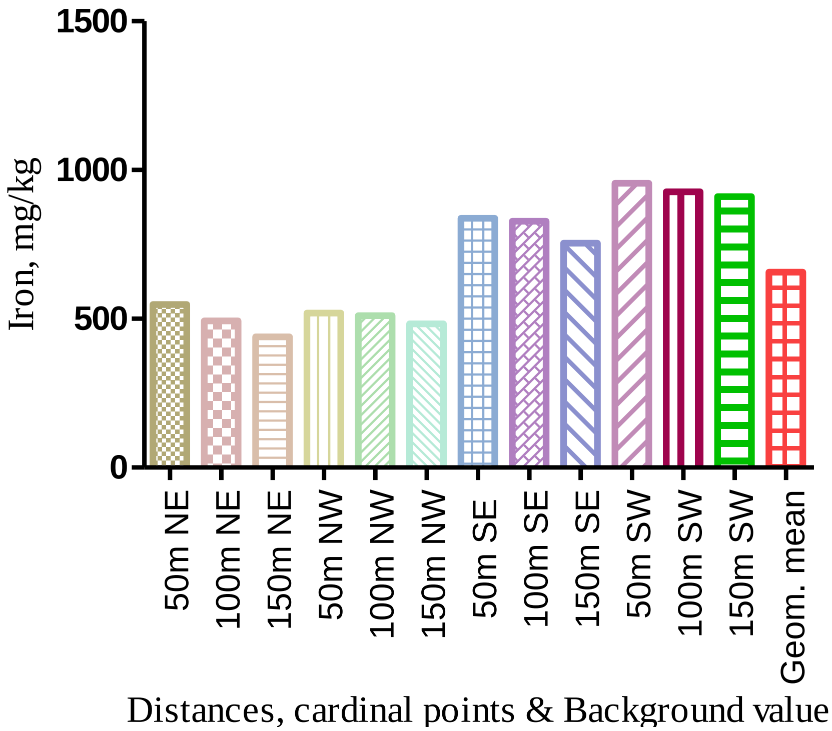

Figure 3. Concentration of iron based on distances, cardinal points and background value.

showed moderate contamination. The samples from the south east and west showed moderate contamination except for zinc, copper, nickel and vanadium at 150m of south east. The contamination degrees were in the range of low risk (CD < 8) to considerable risk (16 ≤ CD < 32). The contamination degree for samples in the north across the various distances depicts low risk except for 50m North West distance that showed moderate risk (8 ≤ CD < 16). All samples from the South depict moderate risk except for 50 m for south west distance that showed considerable risk. The pollution load index showed no pollution (PLI < 1) to moderate pollution (1 < PLI < 2). However, north east and west at the varying distances showed low pollution, while the south east and west at the varying distances showed moderate pollution. From the indices, the northern region had lower concentration of heavy metals compared to the southern area for each of the heavy metals including iron (Figure 3), manganese (Figure 4), zinc (Figure 5), copper (Figure 6), chromium (Figure 7), cadmium (Figure 8), lead (Figure 9), nickel (Figure 10) and vanadium (Figure 11). The trend suggests the mobility pattern of heavy metals in the area. The pollution indices (pollution load index, degree of contamination and contamination factor) observed in this study is in consonance with the work of other authors (Aghoghovwia et al., 2018; Bhutiani et al., 2017; Izah et al., 2017b). For degree of contamination (CD): CD < 8 (low risk); 8 ≤ CD < 16 (moderate risk); 16 ≤ CD < 32 (considerable risk); CD > 32 (very high risk); For pollution load index (PLI): PLI < 1 (no pollution); 1 < PLI < 2 (moderate pollution); 2 < PLI < 3 (heavy pollution); 3 < PLI (extremely heavy pollution).

Table 4 shows the index of geoaccumulation of heavy metals from old landfill area in Igbogene, Bayelsa State, Nigeria. The index of geoaccumulation ranged from no contamination (Igeo ≤ 0) to moderate contamination (0 <Igeo ≤ 1). For the all the heavy metals studied at varying distances at the norther area, the index of geoaccumulation showed no contamination. However, index of geoaccumulation were moderate at 50m distances at south east direction for copper, chromium and cadmium; 100m distance at south east direction for chromium and cadmium; 50 m distance at south west direction for zinc, copper, chromium, cadmium, lead, nickel and vanadium; 100m at south west direction for copper, chromium, cadmium and lead; and 150 m at south west direction for chromium, cadmium and lead. This is an indication mobility pattern of heavy metals in the study area. The trend of index of geoaccumulation in this study had some similarity with the work of other authors (Bhutiani et al., 2017; Izah et al., 2017c).

Table 5 shows the quantification of contamination of heavy metals from old landfill area in Igbogene, Bayelsa state, Nigeria. The study found that all the individual heavy metals values for northern direction showed negative quantification of contamination except for 50,

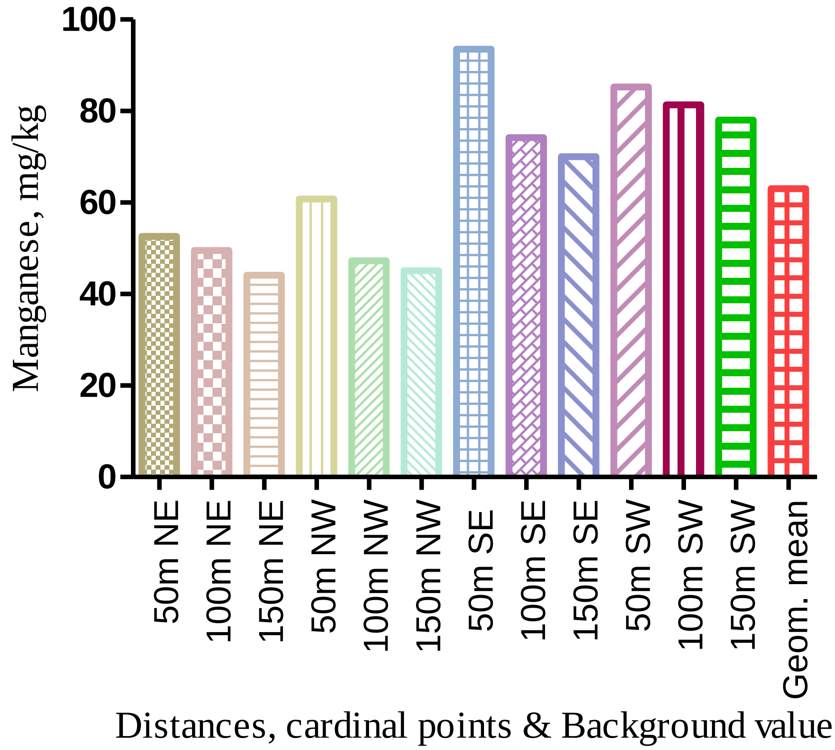

Figure 4. Concentration of manganese based on distances, cardinal points and background value.

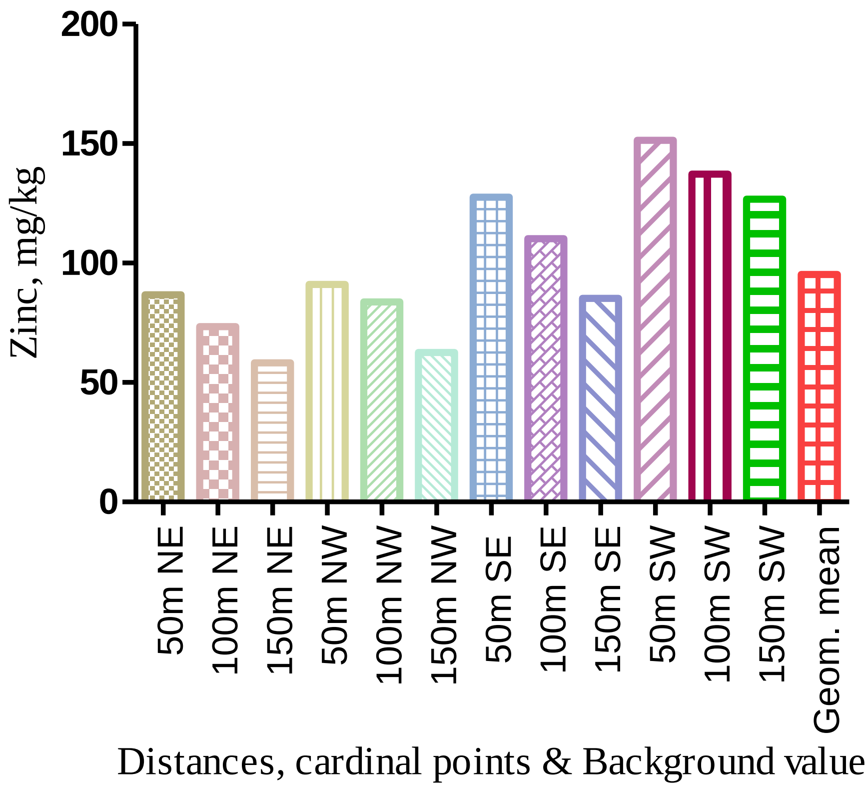

Figure 5. Concentration of zinc based on distances, cardinal points and background value.

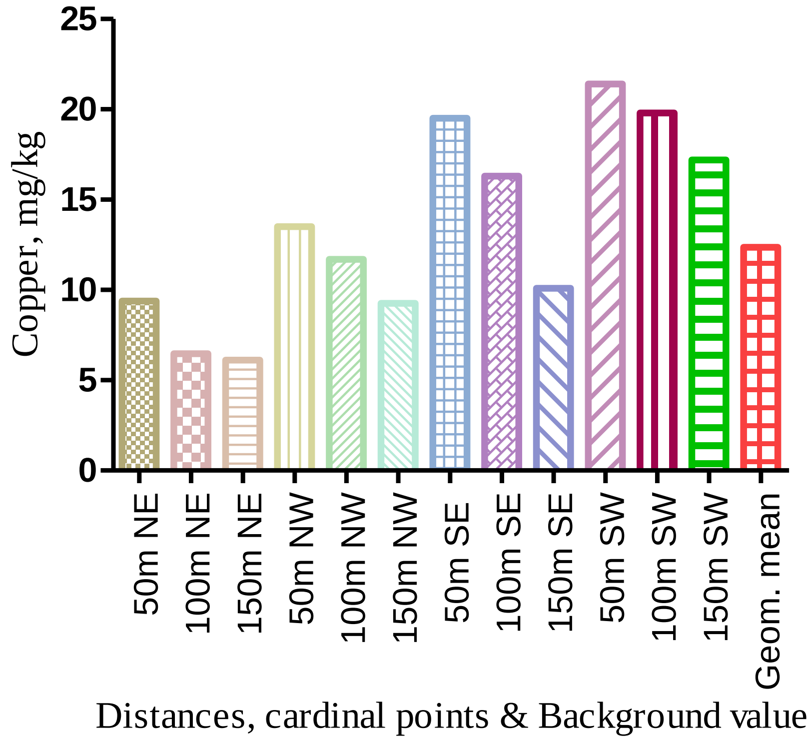

Figure 6. Concentration of copper based on distances, cardinal points and background value.

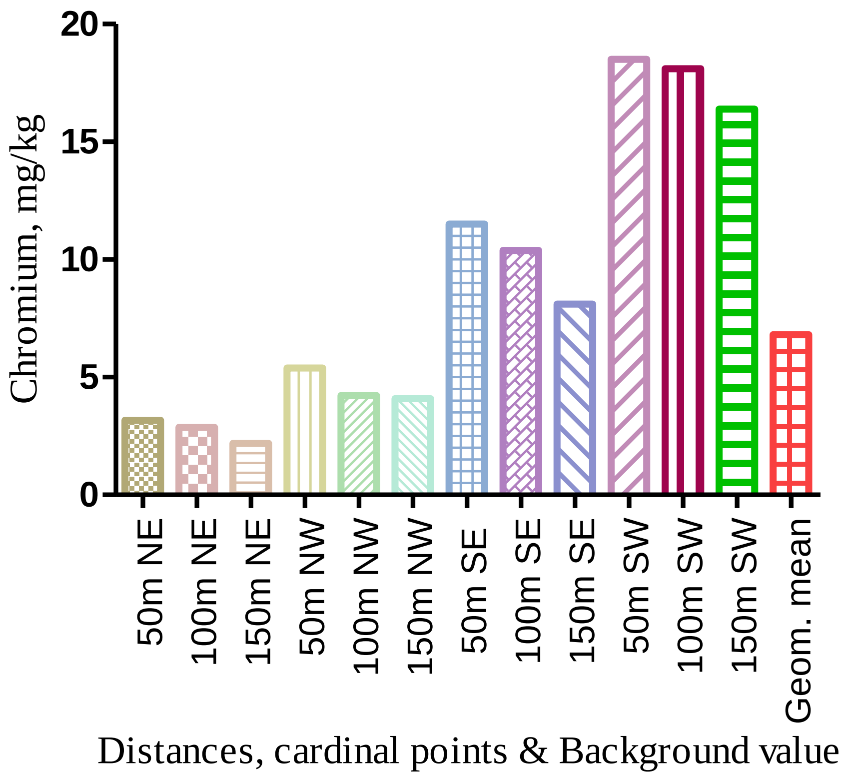

Figure 7. Concentration of chromium based on distances, cardinal points and background value.

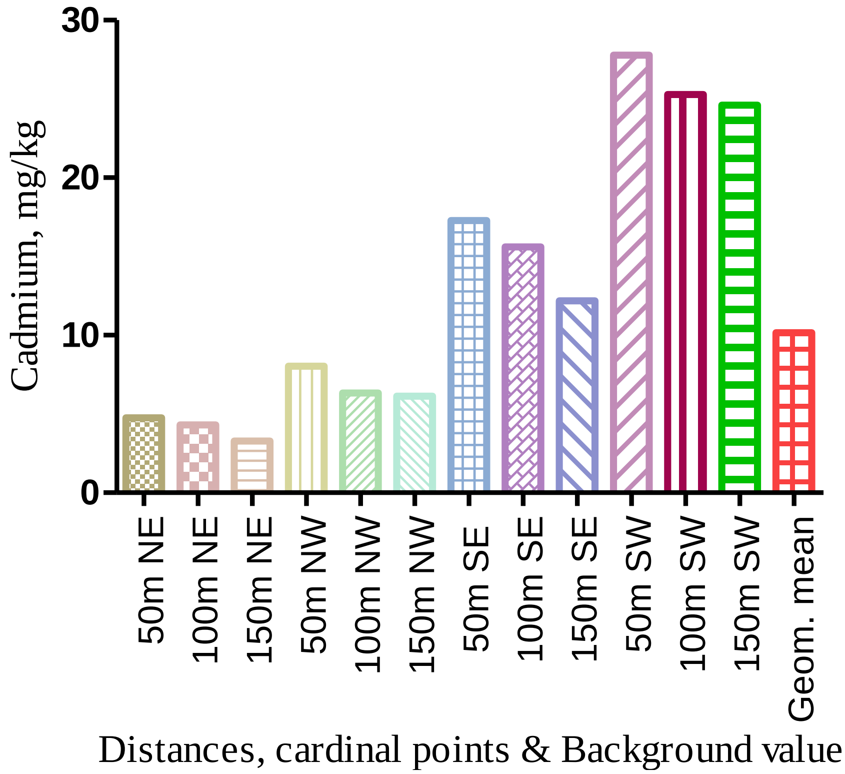

Figure 8. Concentration of cadmium based on distances, cardinal points and background value.

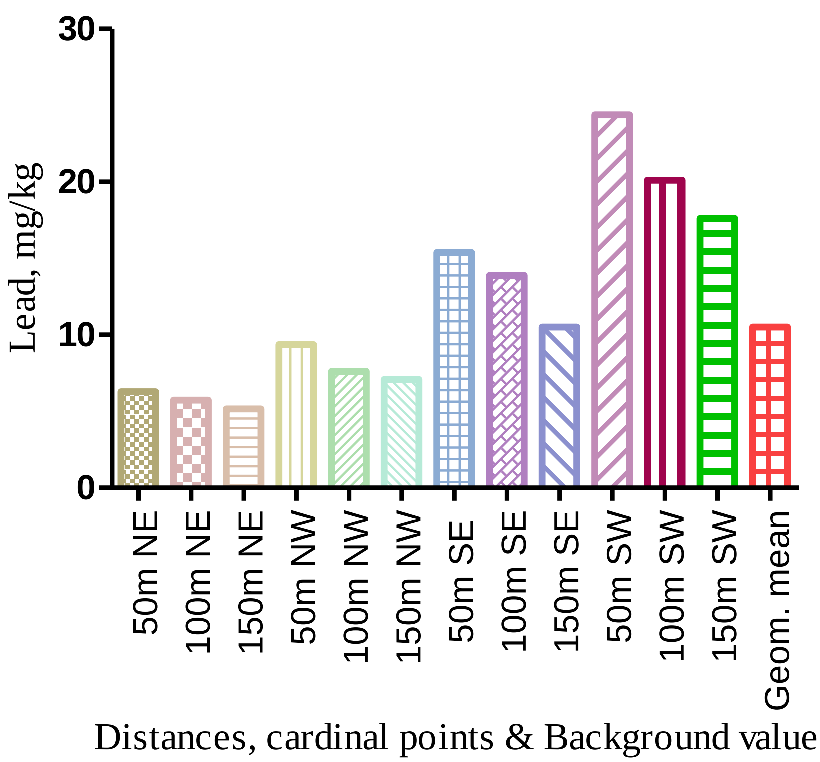

Figure 9. Concentration of lead based on distances, cardinal points and background value.

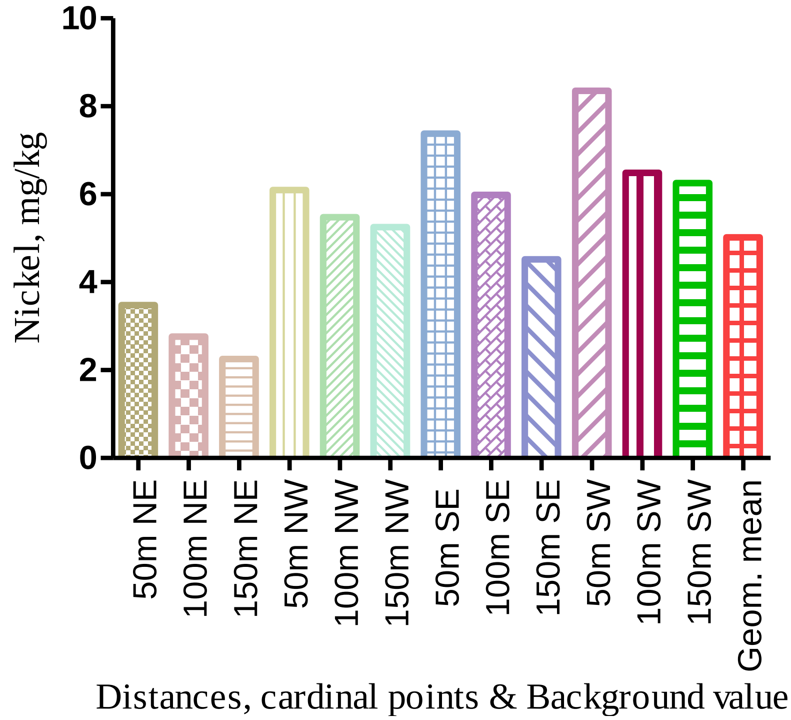

Figure 10. Concentration of nickel based on distances, cardinal points and background value.

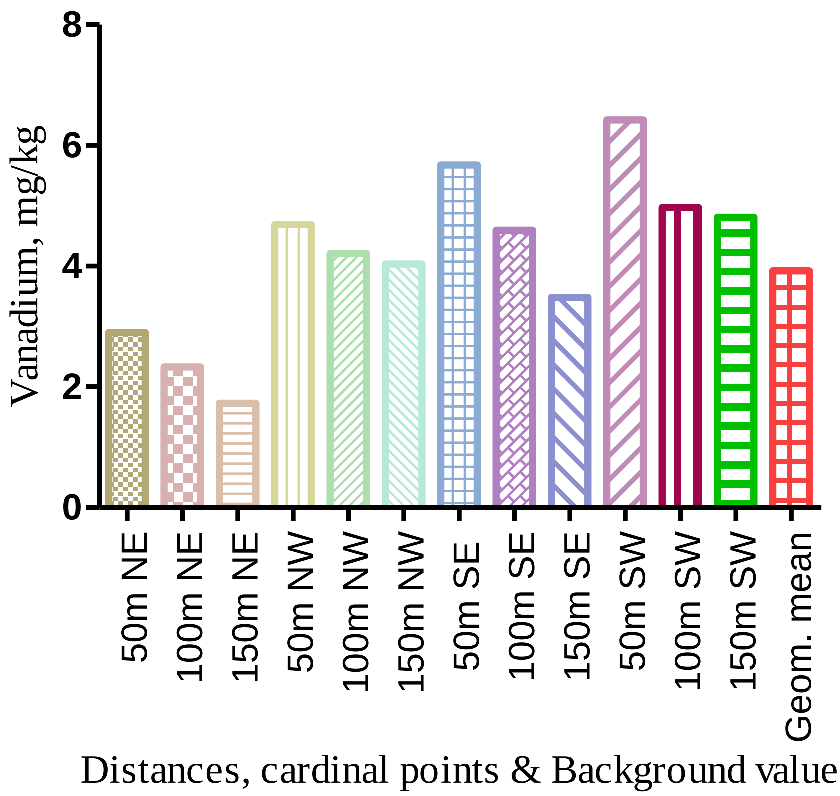

Figure 11. Concentration of vanadium based on distances, cardinal points and background value.

Table 4. Index of geoaccumulation of heavy metals from old landfill area in Igbogene, Bayelsa State, Nigeria.

Distance	Fe	Mn	Zn	Cu	Cr	Cd	Pb	Ni	V
50 m NE	-0.84	-0.85	-0.72	-0.98	-1.68	-1.68	-1.33	-1.11	-1.02
100 m NE	-1.00	-0.93	-0.96	-1.52	-1.83	-1.82	-1.46	-1.45	-1.34
150 m NE	-1.17	-1.10	-1.29	-1.60	-2.22	-2.21	-1.61	-1.74	-1.77
50 m NW	-0.92	-0.64	-0.65	-0.46	-0.92	-0.92	-0.75	-0.30	-0.33
100 m NW	-0.95	-1.00	-0.77	-0.66	-1.28	-1.27	-1.05	-0.46	-0.48
150 m NW	-1.03	-1.07	-1.19	-1.00	-1.32	-1.31	-1.15	-0.52	-0.54
50 m SE	-0.23	-0.02	-0.16	0.07	0.17	0.18	-0.03	-0.03	-0.05
100 m SE	-0.25	-0.35	-0.37	-0.19	0.03	0.03	-0.18	-0.33	-0.35
150 m SE	-0.38	-0.43	-0.75	-0.88	-0.33	-0.32	-0.59	-0.74	-0.76
50 m SW	-0.04	-0.15	0.08	0.21	0.86	0.87	0.63	0.15	0.13
100 m SW	-0.09	-0.22	-0.06	0.09	0.83	0.73	0.35	-0.21	-0.24
150 m SW	-0.11	-0.28	-0.17	-0.11	0.68	0.69	0.16	-0.27	-0.29

Igeo ≤ 0 (uncontaminated), 0 <Igeo ≤ 1 (uncontaminated to moderately contaminated), 1 <Igeo ≤ 2 (moderately contaminated), 2 <Igeo< 3 (moderately to heavily contaminated), 3 <Igeo< 4 (heavily contaminated), 4 <Igeo< 5 (heavily to extremely contaminated), Igeo ≥ 5 (extremely contaminated).

Table 5. Quantification of contamination of heavy metals from old landfill area in Igbogene, Bayelsa State, Nigeria.

Distance	Fe	Mn	Zn	Cu	Cr	Cd	Pb	Ni	V
50 m NE	-19.72	-19.79	-9.88	-31.77	-114.15	-113.00	-67.36	-44.25	-35.17
100 m NE	-33.28	-27.29	-29.80	-91.04	-137.28	-135.73	-83.42	-81.88	-68.24
150 m NE	-49.59	-42.88	-63.41	-101.96	-210.96	-208.81	-103.68	-123.11	-126.59
50 m NW	-26.40	-3.63	-4.58	8.44	-26.35	-26.37	-12.41	17.70	16.42
100 m NW	-28.66	-33.21	-13.69	-5.64	-61.37	-60.51	-37.93	8.39	6.89
150 m NW	-35.90	-39.71	-52.19	-33.62	-66.50	-65.47	-48.03	4.38	2.97
50 m SE	21.64	32.61	25.28	36.62	40.78	41.27	31.75	31.98	30.99
100 m SE	20.75	15.08	13.63	24.17	34.52	34.87	24.39	16.19	14.78
150 m SE	12.95	9.99	-11.82	-22.38	16.03	16.72	-0.10	-11.06	-12.64
50 m SW	31.30	26.13	37.07	42.24	63.19	63.45	56.93	39.88	38.94
100 m SW	29.21	22.59	30.56	37.58	62.38	59.84	47.71	22.65	21.13
150 m SW	27.91	19.22	24.81	28.14	58.48	58.70	40.28	19.68	18.50

100 and 150 m distances for North West direction for nickel and vanadium that showed positive quantification of contamination. For the southern area, the quantification of contamination was positive except for few metals (zinc, copper, lead, nickel and vanadium at 150 m of south east direction) that showed negative quantification of contamination. Authors have reported that positive quantification of contamination suggest pollution due to anthropogenic sources (Bhutiani et al., 2017; Izah et al., 2017c; Aghoghovwia et al., 2018; Uzoekwe and Aigberua, 2019).

Table 6 shows the ecological risk assessment of heavy metals from old landfill area in Igbogene, Bayelsa State, Nigeria. The ecological risk was in the range of low risk (Er< 40) to moderate risk (Er 40 ≤ Er< 80). Basically samples from the both southern and northern direction showed low ecological risk for the heavy metals (manganese, zinc, copper, chromium, cadmium, lead and nickel) except for cadmium in 50, 100 and 150 m in south west and 50 and 100m in south east direction. Furthermore, the ecological risk showed low risk (ERI <150). The trend of cadmium observed in this study is in accordance with previous works by authors (Izah et al., 2018; Aghoghovwia et al., 2018; Zhu et al., 2012; Uzoekwe and Aigberua, 2019; Todorova et al., 2016). The concentration of cadmium in the studied area is high, whichis an indication of the effect of anthropogenic activities.

Conclusion

Management of municipal waste is problematic in many developing nations. The commonest means of managing

Table 6. Ecological risk assessment of heavy metals from old landfill area in Igbogene, Bayelsa State, Nigeria.

Location	Ecological risk							ERI
	Mn	Zn	Cu	Cr	Cd	Pb	Ni	
50 m NE	0.83	0.91	3.80	0.94	14.10	3.00	3.45	27.03
100 m NE	0.79	0.77	2.60	0.84	12.60	2.75	2.75	23.10
150 m NE	0.7	0.61	2.50	0.64	9.60	2.45	2.25	18.75
50 m NW	0.96	0.96	5.45	1.58	23.70	4.45	6.10	43.20
100 m NW	0.75	0.88	4.75	1.24	18.60	3.65	5.45	35.32
150 m NW	0.72	0.66	3.75	1.20	18.00	3.40	5.25	32.98
50 m SE	1.48	1.34	7.90	3.38	51.00	7.35	7.35	79.80
100 m SE	1.18	1.16	6.60	3.06	46.20	6.60	5.95	70.75
150 m SE	1.11	0.89	4.10	2.38	36.00	5.00	4.50	53.98
50 m SW	1.35	1.59	8.65	5.44	82.20	11.60	8.30	119.13
100 m SW	1.29	1.44	8.00	5.32	74.70	9.55	6.45	106.75
150 m SW	1.24	1.33	6.95	4.82	72.60	8.35	6.25	101.54

Er< 40 (low risk); Er 40 ≤ Er< 80 (moderate risk); 80 ≤ Er< 160 (considerable); 160 ≤ Er< 320 (high); Er ≥ 320 (very high); ERI <150 (low risk); 150 ≤ ERI < 300 (moderate risk); 300 ≤ ERI < 600 (considerable); ERI ≥ 600 (very high).

wastes is through dumping in a landfill which is set ablaze during the dry season. In some area, the landfill is moved to another location probably due to developmental works/ activities. This study assesses the ecological risk of heavy metals in area formerly used as landfill in Igbogene, Bayelsa State, Nigeria. The study found that the concentration of the individual metals apparently increased as distance away from the dumpsite increased. In addition, it was found that various metal levels, pollution indices were higher in sample obtained from the southern direction (west and east) compared to northern area (west and east), which gives insight into metal mobility pattern in the area. On the overall, the positive quantification of contamination suggests pollution due to anthropogenic activities in the area, while the ecological index suggests low risk/ fate.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

ACKNOWLEDGEMENT

The author is grateful to Macgil Environmental and Engineering Co. Ltd for their AAS used during this analysis and also appreciate Mr. Egeonu Ama of Chemistry Department, Federal University, Otuoke for his assistance in collecting the samples.

REFERENCES

Aghoghovwia OA, Izah SC, Miri FA (2018). Environmental risk assessment of heavy metals in sediment of Nun River around Gbarantoru and Tombia Towns, Bayelsa State, Nigeria. Biological Evidence 8(3):21-31.

Aigberua AO (2015). Evaluation of polycyclic aromatic hydrocarbons, heavy metals and physicochemical characteristics of naturally attenuated crude oi contaminated soil in Eneka, Rivers State, Nigeria.MSc thesis Postgraduate school, Niger Delta University, Wilberforce Isand, Bayelsa state, Nigeria.

Akinbile CO (2012). Environmental Impact of Landfill on Groundwater Quality and Agricultural Soils in Nigeria. Soil and Water Resource 7(1):18-26.

Amadi AN, Olasehinde PI, Okosun EA, Okoye NO, Okunlola IA, Alkali YB, Dan-Hassan MA (2012). A Comparative Study on the Impact of Avu and Ihie Dumpsites on Soil Quality in Southeastern Nigeria. American Journal of Chemistry 2(1):17-23.

Anikwe MAN, Nwobodo KCA (2001). Long term effect of municipal waste disposal on soil properties and productivity of sites used for urban agriculture in Abakaliki, Nigeria. Bioresource Technology 83:241-250.

Ben-Eledo VN, Kigigha LT, Izah SC, Eledo BO (2017a). Water quality assessment of Epie creek in Yenagoa metropolis, Bayelsa state, Nigeria. Archives of Current Research International 8(2):1-24.

Ben-Eledo VN, Kigigha LT, Izah SC, Eledo BO (2017b). Bacteriological Quality Assessment of Epie Creek, Niger Delta Region of Nigeria. International Journal of Ecotoxicology and Ecobiology 2(3):102-108.

Bhutiani R, Kulkarni DB, Khanna DR, Gautam A (2017). Geochemical distribution and environmental risk assessment of heavy metals in groundwater of an industrial area and its surroundings, Haridwar, India. Energy, Ecology and Environment 2(2):155-167.

Buteh DS, Chindo IY, Ekanem EO, Williams EM (2013). Impact Assessment of Contamination Pattern of Solid Waste Dumpsites Soil: A Comparative Study of Bauchi Metropolis. World Journal of Analytical Chemistry 1(4):59-62.

Guan Y, Shao C, Ju M (2014).Heavy metal contamination assessment and partition for industrial and mining gathering areas. International Journal of Environmental Research and Public Health 11:7286-7303.

Hakanson L (1980). An ecological risk index for aquatic pollution control.A sedimentological approach. Water Research 14:975-1001.

Isaac, RA, Kerber JD (1971). Atomic absorption and flame photometry. Techniques and uses in soil, plant, and water analysis. In Instrumental Methods for Analysis of Soil and Plant Tissue. Soil Science of America Agronomy Society of America Inc, Madison, Wisconsin, pp. 17-37.

Izah SC, Bassey SE, Ohimain EI (2018). Ecological risk assessment of heavy metals in cassava mill effluents contaminated soil in a

rural community in the Niger Delta Region of Nigeria. Molecular Soil Biology 9(1):1-11.
Izah SC, Aigberua AO (2017). Comparative Assessment of selected heavy metals in some common edible vegetables sold in Yenagoa metropolis, Nigeria. Journal of Biotechnology Research 3(8):66-71.
Izah SC, Bassey SE, Ohimain EI (2017a). Assessment of heavy metal in cassava mill effluent contaminated soil in a rural community in the Niger Delta region of Nigeria. EC Pharmacology and Toxicology 4(5):186-201.
Izah SC, Bassey SE, Ohimain EI (2017b). Assessment of pollution load indices of heavy metals in cassava mill effluents contaminated soil: a case study of small-scale cassava processing mills in a rural community of the Niger Delta region of Nigeria. Bioscience Methods 8(1):1-17.
Izah SC, Bassey SE, Ohimain EI (2017c). Geo-accumulation index, enrichment factor and quantification of contamination of heavy metals in soil receiving cassava mill effluents in a rural community in the Niger Delta region of Nigeria. Molecular Soil Biology 8(2):7-20.
Izah SC, Chakrabarty N, Srivastav AL (2016). A Review on Heavy Metal Concentration in Potable Water Sources in Nigeria: Human Health Effects and Mitigating Measures. Exposure and Health 8:285-304.
Izah SC, Angaye TCN (2016). Heavy metal concentration in fishes from surface water in Nigeria: Potential sources of pollutants and mitigation measures. Sky Journal of Biochemistry Research 5(4):31-47.
Izah SC, Ohimain EI (2015). Bioethanol production from cassava mill effluents supplemented with solid agricultural residues using bakers' yeast [Saccharomyces cerevisiae]. Journal of Environmental Treatment Techniques 3(1):47-54.
Jiang X, Lu WX, Zhao HQ, Yang QC, Yang ZP (2014). Potential ecological risk assessment and prediction of soil heavy-metal pollution around coal gangue dump. Natural Hazards and Earth System Science 14:1599-1610.
Kigigha LT, Nyenke P, Izah SC (2018). Health risk assessment of selected heavy metals in gari(cassava flake) sold in some major markets in Yenagoa metropolis, Nigeria. MOJ Toxicology 4(2):47-52.
Muller G (1969). Index of geo-accumulation in sediments of the Rhine River. GeoJournal 2(3):108-118.
Njoku C (2014). Effect of Waste Dumpsites on Water and Air Qualities in Abakaliki, Southestern Nigeria. International Journal of Plant and Soil Science 4(5):455-460.
Ogamba EN, Ebere N, Izah SC (2017). Heavy Metal Concentration in Water, Sediment and Tissues of Eichhorniacrassipes from Kolo Creek, Niger Delta. Greener Journal of Environment Management and Public Safety 6(1):001-005.
Ogamba EN, Izah SC, Oribu T (2015). Water quality and proximate analysis of Eichhorniacrassipes from River Nun, Amassoma Axis, Nigeria.Research Journal of Phytomedicine 1(1):43-48.
Oluseyi T, Adetunde A, Amadi E (2014). Impact Assessment of Dumpsites on Quality of Near-By Soil and Underground Water: A Case Study of An Abandoned and A Functional Dumpsite in Lagos, Nigeria. International Journal of Science, Environment and Technology 3(3):1004-1015.
Soliman NF, Nasr SM, Okbah MA (2015). Potential ecological risk of heavy metals in sediments from the Mediterranean coast, Egypt. Journal of Environmental Health Science and Engineering 13:70. DOI 10.1186/s40201-015-0223-x
Todorova Y, Lincheva S, Yotinov I, Topalova Y (2016). Contamination and Ecological Risk Assessment of Long-Term Polluted Sediments with Heavy Metals in Small Hydropower Cascade. Water Resource Management 30:4171-4184.
Tomlinson D, Wilson J, Harris C, Jeffrey D (1980). Problems in the assessment of heavy-metal levels in estuaries and the formation of a pollution index. Helgolander Meeresunters, 33:566-575
Xu ZQ, Ni SJ, Tuo XG (2008). Calculation of heavy metals toxicity coefficient in the evaluation of potential ecological risk index. Environmental Science and Technology 31:112-115.
Uzoekwe SA and Aigberua AO (2019).Heavy Metal Distribution and Assessment of Ecological Risk Assessment in Surface Waters and Sediments within the Flow Station in Kolo Creek, Nigeria. Journal of Chemical Society of Nigeria 44(5):809-824.
Nnaji JC, Uzoekwe SA (2018). Basic and Issues of the Environment. Mindex Publishing Company Ltd pp. 160.
Zhu H, Yuan X, Zeng G, Jiang M, Liang J, Zhang C, Yin J, Huang H, Liu Z, Jiang H (2012). Ecological risk assessment of heavy metals in sediments of Xiawan Port based on modified potential ecological risk index. Transactions of Nonferrous Metals Society of China 22:1470-1477.