Evaluation of Heavy Metals and Contamination Status of Soil around Abandoned and Active Nigerian Dumpsites

O. O. Afolabi [a*] and O. S. Eludoyin [b]

[a] *Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt, Nigeria.*
[b] *Department of Geography and Environmental Management, University of Port Harcourt, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Authors OOA and OSE designed the study. Author OOA performed the statistical analysis and wrote the first draft of the manuscript. Author OSE produced the study area map and review the drafted manuscript. Authors OOA and OSE managed the analyses of the study. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Aim: The study evaluated the heavy metals and contamination status of soil around active and abandoned waste dumpsites in Port Harcourt Metropolis, Nigeria.
Methodology: Five soil samples were collected at the topsoil (0-15cm depth) in a regular distance of 20m, 40m, 60m, 80m and 100m from the center of the dumpsites and control plot. The soil samples were analysed for heavy metals (Cu, Cr, Cd, Fe, Pb and Zn), pH and total Organic C (TOC) using standard laboratory analyses and contamination indices to determine the soil contamination status. Descriptive statistics involving mean and standard deviation were used for the data analysis.
Results: The mean concentrations of Cu, Cr, Cd, Fe, Pb and Zn in active dumpsite was 3.2616mg/kg, 0.3983 mg/kg, 0.2027 mg/kg, 6.5785 mg/kg, 2.6991mg/kg and 12.4111mg/kg respectively while that of the abandoned dumpsite are 1.3913mg/kg, 0.3693mg/kg, 0.0882mg/kg, 3.6235mg/kg, 0.4158mg/kg and 4.0140mg/kg respectively. Hence, the soil samples in both

Corresponding author: E-mail: omobolaji_afolabi@uniport.edu.ng;

dumpsites exceeded the allowable limit of World Health Organisation (WHO). The order of heavy metal concentrations in the dumpsites was Zn>Fe>Cu>Pb>Cr>Cd. The contamination factor of the heavy metals follows order: Pb > Cu > Cr > Zn > Fe for both dumpsites. The degree of contamination ranged from (1612.51 to 2286.83 for active dumpsite and 26.14 to 641.46 for abandoned dumpsite) indicating very high degree of contamination. Modified degree of contamination ranged from 46.09 to 381.14 for active dumpsite indicating "ultra-high degree of contamination" and 4.36 to 106.91 for abandoned dumpsite indicating high degree of contamination to ultra-high degree of contamination. Pollution Load Index ranged from (5.08 to 8.12 for active and 1.63 to 4.16 for abandoned dumpsite) indicating polluted soil with various heavy metals.
Conclusion: the concentration of heavy metals combined with the contamination indices revealed that the soils around the dumpsites are contaminated/polluted; hence, pose ecological and health-related risk.

ABBREVIATIONS

Pb	*Lead*	*PLI*	*Pollution Load Index*
Cu	*Copper*	*MDC*	*Modified Degree of Contamination*
Cr	*Cranium*	*WHO*	*World Health Organization*
Zn	*Zinc*	*USEPA*	*US Environmental Protection Agency*
Fe	*Iron*	*FEPA*	*Federal Environmental Protection Agency*
CF	*Contamination Factor*	*CCME*	*Canadian Council of Ministers of the Environment*
DCI	*Degree of Contamination Index*		

1. INTRODUCTION

Many urban and industrial cities of developing countries still using landfills system to accommodate their waste and due to the various socio-economic activities, wastes are generated in tons. Landfills system is most adopted due to its capacity to accommodate great amount of waste over a long period of time using simple disposal method such as burning and/or decomposition. Notwithstanding these benefits, landfills are regarded as major reservoir of heavy metals and organic compounds in the environment [1,2,3]. Hence, inefficient management of landfills waste has led to serious and several environmental and human impact, which has influence on the long term achievement of sustainable development [4].

Port Harcourt house many multinational companies and experiencing rapid urbanization and industrialization due to continuous influx of people from other parts of country and beyond. These have resulted in rapid impact on the environmental condition due to management of waste generated in the city. Many of the waste generated in the city are gathered to landfill sites located close to residential area and improperly disposed, leading to environmental degradation, poor soil quality and challenge on human health [5,6]. Soil at their natural state contain modest amount of heavy metals which are needed by plant for their wellbeing [7]. Heavy metals such as Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Iron (Fe) and Zinc (Zn) have been found in soil around landfill environment [8,9,10].

There have been several accomplished studies ascertaining the heavy metals contamination in Nigerian dumpsites. Oluwatuyi, *et al.*, [11] reported Zn, Fe, Mn and Ni concentrations to have exceeded the allowable limit of FEPA in their studied dumpsite while the sequence of concentration indicated that Fe > Mn > Zn > Ni > Cr. Bongoua-Devisme, *et al* [1] reported that the concentrations of Cr, Pb, Cd, Zn and Ni in the top layer soil around agricultural and industrial areas, and underground soil around dumpsite exceeded the allowable limit of CCME. Comparative assessment of heavy metals of a functioning and abandoned waste dumpsites conducted by Temiloluwa *et al.*, [12] indicated that both dumpsites concentrations exceeded the WHO allowable limit; hence, no significant difference in

the concentrations. Ideriah *et al*, [7] asserted that solid waste affect heavy metals concentration in soil and plant while attribute such as topography of the dumpsite, composition of waste and necessarily not the age of the dumpsite influence the concentration. Mekonnen, et al., [13] reported Cd, Zn, Pb and Cu in the soil had concentration higher than FEPA and USEPA standards. However, higher concentration of Pb, Cd, Mn, Ni and Cu was found at leachate sample of the study. The study of Makuleke and Ngole-Jeme [3] indicated higher concentration of heavy metal in the soil and plant around closed landfill area than the control site. The order of concentration of the heavy metal as indicated by the; Fe > Zn > Cu > Cr > Ni > Cd and posited that even though the landfill has been closed for more than 20 years. Dumpsite contamination assessment conducted by Afolagboye et al., [14] showed ecological risk index ranged of 4.37–505.55 which is an indication of low to considerable risk for the dumpsite. Odukoya [15] observed potential ecological risk (RI) for the abandoned and the active dumpsites ranged between 43.86 to 1567.2 and 133.7 to 732.4 which imply low to very-high risk and very-high risk respectively while contamination degrees ranged between low and very high degree of contamination for both dumpsites. Bello et al., [16] observed high level of contamination of heavy metals in dumpsite where the pollution load index averaged 2.113 and the degree of contamination index of 30.624. Demie [17] noted that the soils in their study were moderately contaminated by Cr and very highly contaminated by Pb, Ni, Cd and Co while the degree of contamination deduced highly contaminated soil.

The soil around the abandoned dumpsite has been subjected to various anthropogenic activities such as residential building and agricultural activities but how safe is the soil of the area for such activities. The study assessed the heavy metals load and contamination status of active and abandoned dumpsites soils in Port Harcourt Metropolis, Rivers State using various contamination indices.

2. MATERIALS AND METHODS

2.1 Study Area

The dumpsites are located within the Obio/Akpor Local Government Area of Rivers State, a maritime state in the southern geopolitical zone of Nigeria. It is located between latitudes 4°30'0"N and 5°30'0"N and longitude 6°30'0"E

and 7°30'0"E. The active site dumpsite is located along the Eagle Cement Factory off the Rumuolumeni road. The dumpsite is on the coordinate 4° 48'23.4"N and 6° 56'35.6" E. It's about 200m long and 150m wide with residential buildings and mechanic workshop scantly situated around the dumpsite. It is currently being used by the Rivers State Environmental Sanitation Authority as a dumpsite. The abandoned dumpsite is situated along Apirikom road off Rumuepirikom/Iwofe road at Rumuepirikom in Port Harcourt city. It is about 150m long and 100m wide located on the coordinate 4°49'37.1"N and 6°58'26.0"E. Although, the larger part of the dumpsite have been turned into residential area. It is an old refuse dump that has been abandoned for over 10 years. At the time of sampling, refuse were still there lightly but the placed was predominantly used by the scavengers as their abode and on-loading and off-loading point. The control site is a semi-forest land along the Rumuolumeni road after the Iwofe Police Station. The site is located on coordinate 4^{0}48'39.9"N and 6^{0}56'32.3"E. The location is about 1000m away from both dumpsites.

2.2 Collection of Soil Samples

With the aid of auger, the soils sample were collected within the depth of 0-15cm at a point distance of 20cm, 60m, 80m and 100m after a central point was identified at the dumpsites (Table 1 and Fig. 1). During the soil sample collection for each point, five soil samples were collected within the radius of the point and the soils were mixed together to form the composite soil sample for the point. The collected samples were bagged with polythene materials and air-dried afterwards. The dried soils were crumbled into fine particles and sieved through Aluminium sieve of 2mm mesh size and taking to laboratory for further soil analysis.

2.3 Determination of Soil Properties

Soil pH was analysed through $CaCl_2$ solutions using a Mettler Toledo Seven Easy pH Meter. Total Organic Carbon was analysed using the Walkley-Black Titrimetric Method. Digestion of soil samples was carried out through aqua-regia while the heavy metals of the digested soil were analysed using Atomic Absorption Spectrometer (Perkin-Elmer Aanalyst 200). The analyses were performed in the agronomy laboratory of the University of Ibadan, Ibadan, Nigeria.

2.4 Contamination Assessment of Heavy Metals

2.4.1 Contamination Factor (CF)

CF was utilized to estimate the extent of soil contamination with heavy metals. CF is express as;

$$CF = C_n/B_n \quad \text{......................... (1)}$$

Where C_n= Concentration of heavy metals in soil samples while B_n= Background value of heavy metals in natural state. The heavy metals are classified based on the CF according to Hakanson (1980) as shown in Table 1.

2.4.2 Pollution Load Index (PLI)

PLI is suitable for the comparison of extent pollution among sampled soils from different locations and at separate times. The PLI is express as;

$$PLI = \sqrt[n]{CF_1 * CF_2 * CF_3 * ....CF_n} \quad \text{...................... (2)}$$

Where PLI= Pollution Load Index, CF = Contamination factor, and n= number of elements. The PLI >1 indicates polluted, while PLI<1 indicates no pollution

2.4.3 Degree of Contamination Index (DCI)

DCI was utilized to estimate the sum of CF of the studied metals. DC is express as;

$$DCI = \sum_{i=1}^{n} CF \quad \text{..................................... (3)}$$

The DC of the heavy metals were classified according to Hakanson [18] in Table 2.

2.4.4 Modified degree of contamination (MDC)

As the name implies, it is the modification of DCI equation which is express as;

$$MDC = \frac{\sum_{i=1}^{n} CF}{n} \quad \text{.................................(4)}$$

Where n= Number of heavy metals. MDC is classified according to Abrahim and Parker [19] in Table 3.

Table 1. Classification contamination factor

Contamination Factor	Classification
CF<1	Low
1≤CF<3	Moderate
3≤CF<6	Considerable
CF≥6	Very high

Source: Hakanson [18]

Table 2. Classification contamination factor

Degree of Contamination	Classification
DC<1	Low
1≤DC<3	Moderate
3≤DC<6	Considerable
DC≥6	Very high

Source: Hakanson [18]

Table 3. Classification contamination factor

Modified degree of contamination (MDC)	Classification
MDC<1	Nil to Very Low Degree of Contamination
1.5 ≤ MDC < 2A	Low Degree of Contamination
2 ≤ MDC < 4	Moderate Degree of Contamination
4 ≤ MDC < 8	High Degree of Contamination
8 ≤ MDC < 16	Very High Degree of Contamination
16 ≤ MDC < 32	Extremely High Degree of Contamination
MDC ≥ 32	Ultra-High Degree of Contamination

Source: Abrahim and Parker [19] Afolagboye, et al., [14]

Table 4. Location of Sample points for Active dumpsite, abandoned dumpsite and Control

Plots	Sampling Distance (m)	Latitude	Longitude
Abandoned Dumpsite	20	4^{0}49'38.0"N	6^{0}58'26.5"E
	40	4^{0}49'38.2"N	6^{0}58'27.4"E
	60	4^{0}49'38.6"N	6^{0}58'28.7"E
	80	4^{0}49'39.5"N	6^{0}58'29.1"E
	100	4^{0}49'38.8"N	6^{0}58'30.0"E
Active Dumpsite	20	4^{0}48'20.6"N	6^{0}56'28.0"E
	40	4^{0}48'20.4"N	6^{0}56'27.0"E
	60	4^{0}48'20.9"N	6^{0}56'26.6"E
	80	4^{0}48'20.3"N	6^{0}56'25.8"E
	100	4^{0}48'20.4"N	6^{0}56'25.1"E
	Sample Points	Latitude	Longitude
	A	4^{0}48'35.8"N	6^{0}56'28.4"E
	B	4^{0}48'23.6"N	6^{0}56'21.5"E
	C	4^{0}48'27.5"N	6^{0}56'21.5"E
	D	4^{0}48'36.0"N	6^{0}56'27.4"E
	E	4^{0}48'34.7"N	6^{0}56'29.9"E

Fig. 1. A Section of Port Harcourt Metropolis showing the Locations of the Dumpsites

2.5 Data Analysis

Descriptive statistics was used to describe the mean value of the soil parameters in the active dumpsite, abandoned dumpsite and control plot. Tables and graphs were used for the presentation of results.

3. RESULTS AND DISCUSSION

3.1 Soil pH and Total Organic Carbon

From Table 5 and Figure 2, the soils were observed to be slightly acidic with a pH value

ranged from 6.22 to 6.59 at the abandoned dumpsite with a mean pH value of 6.44 while the pH value for the active dumpsite is observed to be moderately acidic with ranged from 5.57 to 5.92 with a mean pH value of 5.73. The pH of the control site ranged from 4.45 to 5.67 with a mean pH value of 4.82. The outcome indicated that the soils were acidic in nature. Similar pH range value was reported by Iwegbue *et al*., [20]. The pH reported by Abdalla et al., [21] from dumpsite indicated 7.85-8.60 which signify alkaline soil. TOC (Table 5 and Figure 3) of the active site ranged from 15.08mg/kg to 15.76mg/kg with a mean value of 15.47mg/kg. Abandoned site TOC

ranged from 10.85mg/kg to 11.96mg/kg with a mean value of 11.56mg/kg while the control site showed the lowest TOC ranged from 2.07mg/kg to 2.76mg/kg with mean value of 2.57mg/kg. TOC revealed the extent of decomposition of organic material and as shown that the active dumpsite has high TOC.
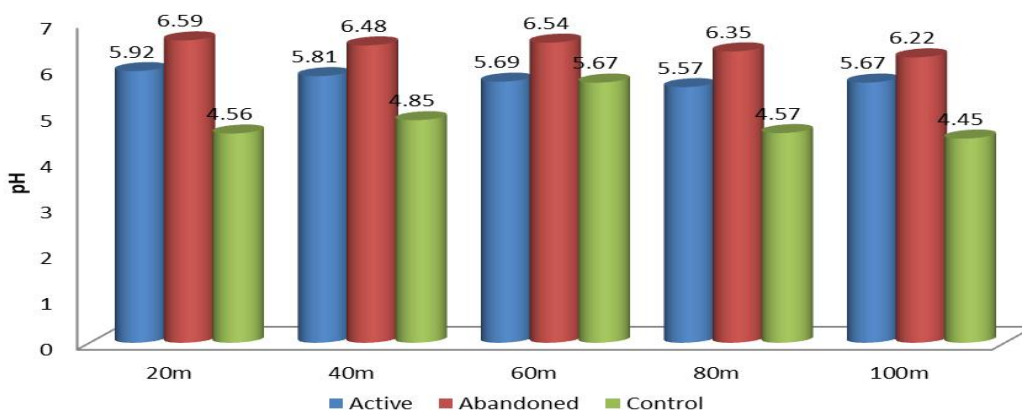
3. 2 Heavy Metal Concentrations

Six heavy metals elements including Cd, Cr, Cu, Fe, Pb and Zn in soil of active dumpsite, abandoned dumpsites and control were analysed in this study and the results are presented in Table 6.

Table 5. Mean values and standard deviations of pH and TOC in the dumpsites and control

Plots	Soil Properties	Sampling Distance (m)						
		20	40	60	80	100	Mean	SD
Active Dumpsite	pH	5.92	5.81	5.69	5.57	5.67	5.73	0.13
	TOC(mg/kg)	15.76	15.43	15.08	15.43	15.65	15.47	0.26
Abandoned Dumpsite	pH	6.59	6.48	6.54	6.35	6.22	6.44	0.15
	TOC(mg/kg)	11.96	11.75	11.76	11.49	10.85	11.56	0.43
Control	pH	4.56	4.85	5.67	4.57	4.45	4.82	0.50
	TOC(mg/kg)	2.71	1.76	3.67	2.65	2.07	2.57	0.73

SD: Standard Deviation

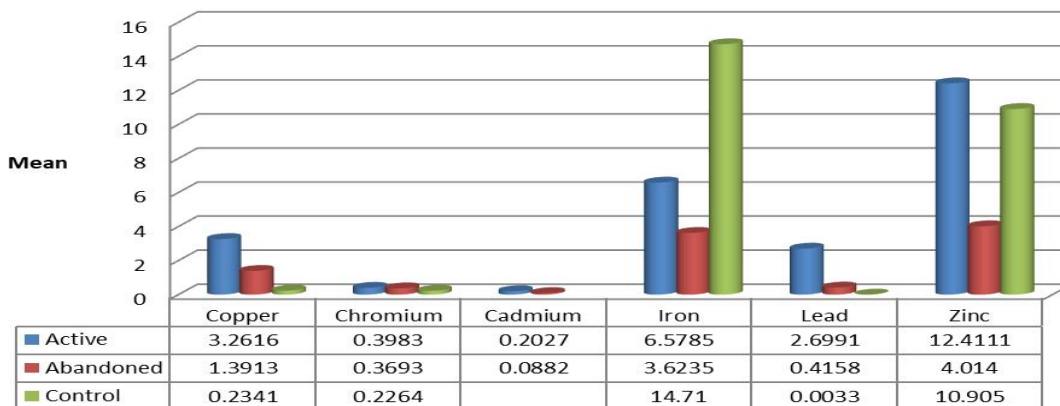**Fig. 2. pH of the Active Dumpsite and Abandoned Dumpsite**
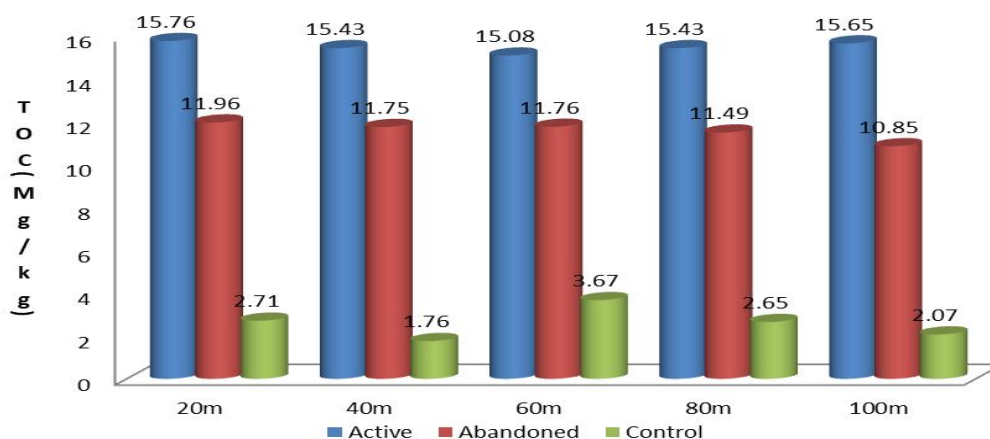
Fig. 3. TOC of the Active Dumpsites and Abandoned Dumpsites

Table 6. Heavy metal concentrations in the soil under the dumpsites and control site

Plots	Soil Properties (mg/kg)	Sampling Distance (m)						
		20	40	60	80	100	Mean	SD
Active Dumpsite	Cu	3.4712	3.3617	3.3571	3.1109	3.0071	3.2616	0.19
	Cr	0.4011	0.3982	0.4012	0.4119	0.3789	0.3983	0.02
	Cd	0.2807	0.0175	0.3415	ND	0.1712	0.2027	0.15
	Fe	6.8121	5.9771	6.9811	6.9453	6.1771	6.5785	0.47
	Pb	2.7241	2.7018	2.6975	2.6921	2.6801	2.6991	0.02
	Zn	12.3412	12.5671	12.7711	12.2011	12.1748	12.4111	0.25
Abandoned Dumpsite	Cu	1.7482	1.0298	1.9009	1.2956	0.9822	1.3913	0.42
	Cr	0.5764	0.3451	0.3125	0.3012	0.3112	0.3693	0.12
	Cd	0.0545	0.0310	0.008	ND	ND	0.0882	0.05
	Fe	3.4581	3.4134	3.6717	3.7567	3.8177	3.6235	0.18
	Pb	0.7578	0.5211	0.4908	0.1891	0.1201	0.4158	0.26
	Zn	4.7902	4.4621	4.0369	3.0377	3.7429	4.0140	0.68
	Sampling Points							
		A	B	C	D	E	Mean	SD
Control	Cu	0.2620	0.2617	0.1495	0.2157	0.2820	0.2341	0.05
	Cr	0.2240	0.1348	0.2346	0.2567	0.2820	0.2264	0.05
	Cd	ND	ND	ND	ND	ND		
	Fe	14.321	14.547	15.765	14.394	14.523	14.71	0.6
	Pb	0.0012	0.0014	0.0017	0.0104	0.0016	0.0033	0.004
	Zn	10.070	10.617	11.198	10.273	12.370	10.905	0.85

Key: Cu: Copper, Cr: Chromium, Cd: Cadmium, Fe: Iron, Pb: Lead, Zn: Zinc, ND: Not Detectable and SD: Standard Deviation

Fig. 4. Mean concentration of heavy metals of the Active Dumpsites, Abandoned Dumpsites and Control Site

Table 7. Mean concentration of heavy metals from all site against the permissible limit

Location	Heavy Metals (mg/kg)					
	Cu	Cr	Cd	Fe	Pb	Zn
Active Dumpsite	3.2616	0.3983	0.2027	6.5785	2.6991	12.4111
Abandoned Dumpsite	1.3913	0.3693	0.0882	3.6235	0.4158	4.0140
Control Site	0.2341	0.2264	ND	14.523	0.0033	10.905
Allowable Limit (WHO)	2.0	0.05	0.003	0.005	0.01	3.0

The concentration of Pb of the active site ranged from 2.6801 to 2.7241 mg/kg (Table 6 and Fig. 3), with an average value of 2.6991 mg/kg, while that of the abandoned site ranged from 0.1201 to 0.7578 mg/kg (Table 6), with an average value of 0.4158 mg/kg were all greater than that of the control (0.0033 mg/kg). The level of Pb reported in the study is lower than the value reported by Awokunmi *et al.* [22] for dumpsite and Eludoyin and Ogbe [23] for automobile workshop. Human are exposed to Pb through inhalation, ingestion and skin absorption while the metal is regarded dangerous with no biological function and with adverse impact on children [24,22]. The Pb values reported therein exceeded the allowable limit set by WHO for active and abandoned dumpsites while the control site is within the permissible limit (Table 7).

The concentration of Fe of the abandoned site ranged from 3.4134 to 3.8177 mg/kg, with an average value of 3.6235 mg/Kg, while that of the active site ranged from 6.1771 to 6.9811 mg/kg, with an average value of 6.5785 mg/kg were all less than that of the control (14.71 mg/Kg). The reported values of Fe for this study was lower when compare with that reported by Okeyode & Rufai, [25] from different dumpsites and Nwajei and Iwegbue [26] for automobile body-parts markets. Iwegbue *et al*., [20] reported Fe range value of 1746.4-2839.4 from soil subjected to Cassava processing activities. The Fe of the control site is within the anthropogenic iron range of 14.7% to 47.5%, though Fe has been reported at elevated levels in Nigerian soils [20,27]. The values of Fe reported in this study were higher than the allowable limit set by WHO for all the sites.

The concentration of Cd of the abandoned site ranged from 0.008 to 0.0545 mg/kg, with an average value of 0.0882 mg/kg, while that of the active site ranged from 0.0175 to 0.3415 mg/kg, with an average value of 0.2027 mg/kg. The Cd concentration of the control site was negligible or not detected. The reported Cd values of this study were lower to the one reported for Cassava processing mill [20], dumpsite [28,15,16], automobile workshop [23]. High concentration of Cd can lead to neurotoxin and hypertension, as well as mutagenic, liver or kidney dysfunction in the human system [29]. Cd was undetected at the control site; however, other values exceeded the allowable limit of WHO.

The concentration of Cu of the abandoned site ranged from 0.9822 to 1.9009 mg/kg, with an average value of 1.3913 mg/kg, while that of the active site ranged from 3.0071 to 3.4712 mg/kg, with an average value of 3.2616 mg/kg were all greater than that of the control site (0.2341 mg/kg). The reported Cu of this study was lower in concentration as compared with Cu reported by Oluseyi et al., [30], Bello *et al*., [16], Shittu et al., [31] and Afolagboye *et al*., [14] for dumpsites. Awokunmi, *et al,* [22] reported that bio-degradable waste introduced metallic Cu into soil at levels greater than natural loads. The reported values exceeded the WHO allowable limit except at the control site (Table 7).

Table 8. Contamination Index of Heavy Metals

Plots	Sampling Distance	Contamination Factor						DCI	MDC	PLI
		Cu	Cr	Cd	Fe	Pb	Zn			
Active Dumpsite	20	13.25	1.79	-	0.48	2270.08	1.23	2286.83	381.14	7.95
	40	12.85	2.95	-	0.41	1929.85	1.18	1946.06	324.34	8.12
	60	22.45	1.71	-	0.44	1586.77	1.14	1612.51	268.75	7.89
	80	14.42	1.6	-	0.48	258.86	1.19	276.55	46.09	5.09
	100	10.66	1.34	-	0.43	1675.06	0.98	1688.47	281.41	6.23
Abandoned Dumpsite	20	6.67	2.57	-	0.24	631.5	0.48	641.46	106.91	4.16
	40	3.94	2.56	-	0.23	372.21	0.42	379.36	63.23	3.25
	60	12.72	1.33	-	0.23	288.71	0.36	303.35	50.56	3.32
	80	6.01	1.40	-	0.26	18.18	0.29	26.14	4.36	1.63
	100	3.48	1.10	-	0.25	75.06	0.30	80.19	13.37	1.85

Key: DCI= Degree of Contamination Index, MDC=Modified Degree of Contamination, PLI= Pollution Load Index

The concentration of Cr of the abandoned site ranged from 0.3012 to 0.5764 mg/kg (Table 6), with an average value of 0.3693 mg/Kg, while that of the active site ranged from 0.3789 to 0.4119 mg/kg, with an average value of 0.3983 mg/kg were all greater than that of the control site (0.2264 mg/Kg). Iwegbue et al., [20] reported 3.7-29.5mg/kg in the soil around cassava milling area which is higher than the present study. Also, the Cr values reported in this study are lower than those reported for dumpsites [32,31,14]; however, the value was higher than those reported for dumpsites [33,11]. The values of Cu reported in this study exceeded the WHO acceptable limit.

The concentration of Zn in abandoned site was higher than all other metals with concentration ranged from 3.0377 to 4.7902 mg/kg, with an average value of 4.0140 mg/kg, while that of active site ranged from 12.1748 to 12.7711 mg/kg, with an average value of 12.4111 mg/kg were all greater than that of control site (10.905 mg/kg) were all greater than that of the control site (10.905 mg/kg). Eludoyin and Ogbe [23] reported 73.6mg/kg of Zn in the soil of automobile workshop while Iwegbue et al., [20] reported 21.9-97.3 mg/kg of Zn in the soil around cassava milling area. The reported Zn values for this study were lower than those reported for dumpsites [25,32,14,11]. The values of Zn reported for all sites exceeded the WHO allowable limit. According to Awokunmi, et al., [22], Zn is introduced into the environment through automobile oil, rubber and Zn-containing waste.

Series of anthropogenic activities have it influence on the concentration level of heavy metals in the soil as was observed in the dumpsites studied. The concentration of heavy metals obtained from the study can be arranged in a descending order (highest to the lowest in terms of contamination);

Active dumpsite: Zn > Fe > Cu > Pb > Cr > Cd; Abandoned dumpsite: Zn > Fe > Cu > Pb > Cr > Cd and Control site: Fe > Zn > Cu > Cr > Pb > Cd

3.3 Contamination Assessment

The results of the contamination assessment indices such as CF, DC, MDC and PLI were presented in Table 8.

The CF of the Cu, Cr, Fe, Pb and Zn for the active dumpsite was 10.66-13.25, 1.34-1.79, 0.41-0.48, 258.86-2270.08 and 0.98-1.23 respectively while the CF of the heavy metals for abandoned dumpsite was 3.48-6.67, 1.10-2.57, 0.24-0.25, 18.18-75.06 and 0.29-0.48 for Cu, Cr, Fe, Pb and Zn respectively. Based on CF classification, heavy metal such as Cu and Pb deemed "very high contamination", Cr and Zn are "moderate contamination" while Fe was deemed "low contamination" in the active site. The CF classification of abandoned dumpsite showed that Pb is deemed "very high contamination", Cr and Zn are "moderate contamination" while Cu was deemed "considerable high" and Fe was deemed "low contamination". The CF of the heavy metals follows order: Pb > Cu > Cr > Zn > Fe for both dumpsites.

The DC ranged from 1612.51 to 2286.83 which indicated very high degree of contamination at the active dumpsite while DC ranged from 26.14 to 641.46 indicating very high degree of contamination at the abandoned dumpsite. MDC ranged from 46.09 to 381.14 for active dumpsite which indicated "ultra-high degree of contamination" and 4.36 to 106.91 for abandoned dumpsite indicating high degree of contamination to ultra-high degree of contamination. The PLI value ranged from 5.08 to 8.12 for active dumpsite which indicated polluted soil while the PLI value of abandoned dumpsite ranged from 1.63 to 4.16 indicating polluted soil with various heavy metals.

4. CONCLUSION

The study concluded that the heavy metals in the soil of the active and abandoned dumpsites were all above the WHO allowable limit except for the Cu in the abandoned dumpsite. Metals in the soil sample of the control site were within WHO allowable limit except for Cr, Fe and Zn. The high value of CF, DC and MDC indicated that the soil of the dumpsites poses ecological risk especially for heavy metals such as Cu and Pb; hence, the CF of the heavy metals follows order: Pb > Cu > Cr > Zn > Fe for both dumpsites. The soil from the dumpsites are deemed polluted based on the PLI value and possess ecological and health-related issue in human.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bongoua-Devisme A, Bi EB, Kassin K, Balland-BolouBi C, Gueable, Y. Assessment of heavy metal contamination degree of municipal open-air dumpsite on surrounding soils: Case of dumpsite of Bonoua, Ivory Coast. Int J Eng Res Gen Sci. 2018; 6

2. Vongdala N, Tran, HD, Xuan TD, Teschke R, Khanh TD. Heavy metal accumulation in water, soil, and plants of municipal solid waste landfill in Vientiane, Laos. Int J Env Res and Pub Hlth. 2019;16:22.

3. Makuleke P, Ngole-Jeme VM. Soil heavy metal distribution with depth around a closed landfill and their uptake by datura stramonium. Applied and Environmental Soil Science; 2020.
Avaialble:https://doi.org/10.1155/2020/887 2475

4. Ferronato N, Torretta V. Waste Mismanagement in Developing Countries: A Review of Global Issues. International Journal of Environmental Research and Public Health. 2019;16:1060.
DOI:10.3390/ijerph16061060
Avaialble:www.mdpi.com/journal/ijerph

5. Essien OE, Hanson RO. Municipal solid waste dumpsite pollution on physico-chemical properties of dumpsite and surrounding soils; 2013.

6. Ukwaba SI, Ikpe AE, Orhorhoro EK. Adoption of a landfill system in nigeria and the role of municipal solid waste segregation on its performance. Nig Res J Eng Env Sci. 2018;3(1):280-286

7. Ideriah TJK, Harry FO, Stanley HO, Igbara JK. Heavy metal contamination of soils and vegetation around solid waste dumps in Port Harcourt, Nigeria. Journal of Applied Science and Environmental Management. 2010;14(1):101-109

8. Akpan IO, Akpanidiok AU. Heavy metal status of municipal waste in Calabar metropolis using atomic absorption spectrophotometric technique. Journal of Nigerian Environmental society. 2006;3:119-125.

9. Ukpaka CP, Pele A. Elemental analysis of soil characteristics due to municipal solid waste in Port Harcourt City. International Research Journal of Engineering Science, Technology and Innovation. 2012;1(5): 130-141.

10. Gebre DG, Debelie HD. Heavy metal pollution of soil around solid waste dumping sites and its impact on adjacent community: The case of Shashemane open landfill, Ethiopia. Toxicological & Environmental Chemistry. 2018;5:169–178.

11. Oluwatuyi OE, Ajibade FO, Ajibade TF, Adelodun B. Total concentration, contamination status and distribution of elements in a Nigerian State dumpsites soil. Environmental and Sustainability Indicators. 2020;5:100021

12. Temilola O, Oluwatoyin A, Emmanuel A. Impact assessment of dumpsites on quality of near-by soil and underground water: a case study of an abandoned and functional dumpsite in Lagos, Nigeria. International Journal of Science, Environment and Technology. 2014;3:1004–1015.

13. Mekonnen B, Haddis A, Zeine W. Assessment of the effect of solid wastedumpsite on surrounding soil and river water quality in Tepi Town, Southwest Ethiopia. J Env and Pub H; 2020.

14. Afolagboye LO, Ojo OA, Talabi AO. Evaluation of soil contamination status around a municipal waste dumpsite using contamination indices, soil quality guidelines, and multivariate statistical analysis. SN Applied Sciences. 2020;2:1864.

15. Odukoya AM. Contamination assessment of toxic elements in the soil within and around two dumpsites in Lagos, Nigeria. Ife J. of Sci. 2015;17(2):351-361.

16. Bello S, Zakari, YI, Ibeanu IGE, Muhammad BG. Evaluation of heavy metal pollution in soils of Dana Steel limited dumpsite, Katsina State, Nigeria using Pollution load and degree of contamination indices. Ame J Eng Res. 2018;4(12):161-169.

17. Demie G. Analyzing soil contamination status in garage and auto mechanical workshops of Shashemane City: implication for hazardous waste management. Environmental System Research. 2015;4:15

18. Hakanson L. Ecological risk index for aquatic pollution control A sedimentological approach. Water Resour. 1980;14:975–1001.

19. Abrahim GMS, Parker RJ. Assessment of heavy metal enrichment factors and the degree of contamination in marine sediments from Tamaki Estuary, Auckland, New Zealand. Environ Monit Assessement. 2008;136:227–238

20. Iwegbue CMA, Bassey FI, Tesi GO, Nwajei GE, Tsafe AI. Assessment of heavy metal contamination in soils around cassava processing mills in sub-urban areas of Delta State, Southern Nigeria. Nigerian J Bas and App Sci. 2013;21(2):96-104.

21. Abdallah SA, Uzairu A, Kagbu JA, Okunola OJ. Assessment of heavy metals bioaccumulation by Eleusine indica from refuse dumpsites in Kaduna Metropolis, Nigeria. J Environ Chem Ecotoxicol; 2012.

22. Awokunmi EE, Asaolu SS, Adefemi SO, Gbolagade, AY. Contributions of municipal solid waste to heavy metal concentration in soil near Oke Ese dumpsite, Ilesha, Osun state, Nigeria. International Journal of Environmental Protection. 2015;5(1):44-51. DOI:10.5963/IJEP0501007

23. Eludoyin OS and Ogbe OM. Assessment of Heavy Metal Concentrations in Pawpaw (Carica papaya Linn.) around Automobile Workshops in Port Harcourt Metropolis, Rivers State, Nigeria, J Health Pollution. 2017;14:48-61

24. Adelekan BA and Abegunde KD. Heavy Metals Contamination of Soil and Groundwater at Automobile Mechanic Villages in Ibadan, Nigeria," International Journal of the Physical Sciences. 2011;6(5):1045-1058.

25. Okeyode IC, Rufai AA. Determination of elemental composition of soil samples from some selected dumpsites in Abeokuta, Ogun state, Nigeria, using atomic absorption spectrophotometer. International Journal of Basic & Applied Sciences. 2011;11(06):55.

26. Nwajei GE, Iwegbue CMA. Trace metal concentrations in the vicinity of Uwelu motor spare parts market, Benin City, Nigeria. J chem soc Nig. 2007;32(2):283-286.

27. Adefemi SO, Ibigbami OA, Awokunmi EE. Level of heavy metals in some edible plants collected from selected dumpsites in Ekiti State, Nigeria," Global Advance Research Journal of Environmental Sci. and Toxicology. 2012;1(5):132-136.

28. Amadi AN, Olasehinde PI, Okosun EA, Okoye NO, Okunlola IA, Alkali YB, Dan-Hassan MA. A comparative study on the impact of Avu and Ihie dumpsites on soil quality in Southeastern Nigeria. American Journal of Chemistry. 2012; 2(1): 17-23. DOI: 10.5923/j.chemistry.20120201.0

29. World Health Organisation. Report on Water, Sanitation and Hygiene links to health. Geneva: WHO; 2004.

30. Oluseyi T, Adetunde O, Amadi E. 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. 2014;3(3): 1004-101.

31. Shittu OS, Ayodele OJ, Ilori AOA et al. Heavy metal contamination of a dumpsite environment as assessed with pollution indices. Int J Agric Biosyst Eng. 2018; 12:1–7.

32. Oketola AA, Akpotu SO. Assessment of solid waste and dumpsite leachate and topsoil. Chem Ecol. 2015;31:134–146.

33. Arinze IE, Igwe O, Una CO. Analysis of heavy metals' contamination in soils and water at automobile junk markets in Obosi and Nnewi, Anambra State, South eastern Nigeria. Arab J Geosci. 2015;8: 10961–10976.