Trace Metal Enrichment in Sediments from Otofure and Teboga Waste Dump Sites in Benin City, Nigeria

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Abstract

Analyses of lead, copper, chromium, cadmium, nickel, zinc and manganese contents in Otofure and Teboga waste dumps in Benin City, Nigeria were carried out to determine trace metal enrichment and distribution in the soils around the dump sites and environs. Results of analyses show that trace metal concentrations in the waste dumps were greater than those from the reference background sites by magnitude concentration differences of Pb (18.711 mgkg^{-1}), Cu (12.342 mgkg^{-1}), Cr (0.073 mgkg^{-1}), Cd (0.908 mgkg^{-1}), Zn (104.669 mgkg^{-1}), Ni (3.522 mgkg^{-1}), Mn (203.803 mgkg^{-1}) in Otofure area; and Pb (3.522 mgkg^{-1}), Cu (10.466 mgkg^{-1}), Cr (0.556 mgkg^{-1}), Cd (1.026 mgkg^{-1}), Zn (109.026 mgkg^{-1}), Ni (4.307 mgkg^{-1}) and Mn (161.349 mgkg^{-1}) in Teboga area. The calculated contamination/pollution (C/P) index values show that the dump sites were slightly polluted while the reference sites showed insignificant contamination. Analysis of enrichment factor shows that the dump sites are enriched in lead and zinc, and these decreased with distance away from the waste dump sites. The geochemical association of Cr–Cu–Zn in the soil among others shows their inclination towards anthropogenic sources. This study shows slight metal enrichment in lead and zinc content over other metals studied, but generally the average concentrations of trace metals were below international guideline values for environmental quality criteria.

Keywords: trace metals enrichment, waste dump, soil, Nigeria

1. Introduction

Soil (sediments) is the primary recipient of solid waste and also a reservoir of nutrients and water for plants, animals and even man (Nyle & Ray, 1999). Thus, its contamination and degradation has far reaching effects on the entire living components of the eco-system. Millions of tons of waste materials from variety of sources (industrial, domestic and agricultural) find their way into the soil, interacting with the soil systems and changing their physical and chemical properties (Piccolo & Mbagwu, 1997). Their accumulation has multiple effects on the usability and function of soil in the eco-system (Nielsen, 1997). Contamination of trace metals in the environment is of major interest because of their toxicity, persistence and threat to human life and the environment (Purves, 1985). Trace metal soil contamination is particularly problematic because they are not degraded in soils, as such cannot be permanently eliminated but can be locally reduced by redistribution in the eco-system or removed from circulation by immobilization (Baker, Reeves, & Hajar, 1994; Barabara, Stephen, & William, 2002). Human activities create waste and it is the way these wastes are handled that may constitute risks to the environment and public health. Municipal solid waste heaps have become landmarks in several major cities in Nigeria obstructing motor ways and threatening to cause disease epidemics and flooding (Iwegbue, Ismirimah, Igwe, & Williams, 2006). According to Isu (2005), 87% of Nigerian use unsanitary methods of solid wastes disposals which constitute nuisance, ugly sight, unpleasant air and creates a breeding ground for pest and diseases.

This study therefore seeks to evaluate the distribution of trace metals in sediments around Teboga and Otofure waste dump sites and environ with the view of assessing the potential effect of the waste dumps on the area.

1.1 Study Area

The study area is located between latitude $6^0 15^1$ N to $6^0 30^1$ N and longitude $5^0 30^1$ E to $5^0 45^1$ E (Figure 1). The geology constitute part of the Niger Delta sedimentary suite described by Kogbe (1989), Adaikpoh, Kaizer and Osakwe (2005), Akpoborie, Ekakite and Adaikpoh (2000) and Shortand Stauble (1965) among others. Climatic

conditions fall within the Rain Forest type and similar to other parts of Southern Nigeria. The climate is influenced by two prevailing air masses; the S.W. monsoon wind and the N.E. trade wind. The former prevails during the wet season and the latter during the dry season. The effects of the dry N.E trade winds are most noticeable from December to February when they usher in the dry and dusty harmattan. The annual rainfall is generally high ranging from 2000-2400 mm (Offiodile, 1992). The beginning and the end are usually marked by intense thunderstorms of short duration. The rainfall regime is double-peaked, the two periods of peak rainfall being June/July and September which are separated by a relative dry period in August. The average daily temperature of the area ranges between $30.50^{o}C$-$30.90^{o}C$ while relative humidity ranges between 60% - 80%.
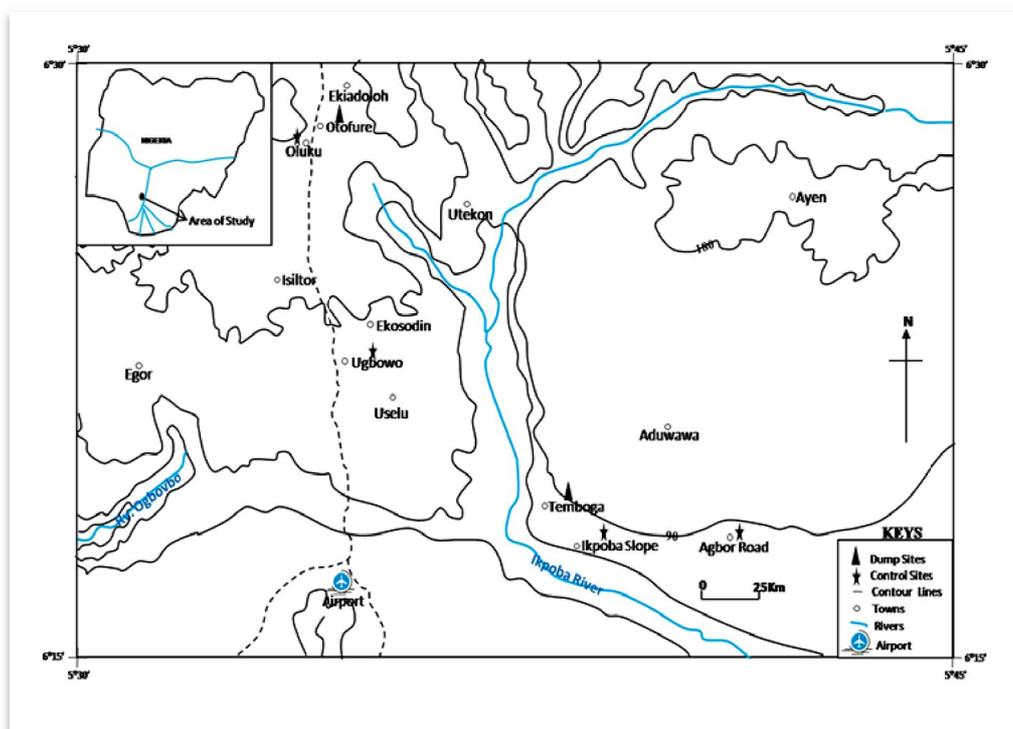
Figure 1. Map of study area

2. Method of Study

2.1 Sampling Method

Sediments samples were collected randomly due to poor accessibility, from locations around Otofure and Teboga waste dump sites at depth range of 0-30 cm, with the aid of a stainless steel iron and stored in black polythene bags for laboratory analysis.

2.2 Analysis Procedure

In the laboratory, the samples were first air-dried and later thoroughly homogenized using agate mortar and pestle and then subjected to analysis of their metal content using the atomic absorption spectrophotometric method. The metals determined were Zinc (Zn), Lead (Pb), Copper (Cu), Chromium (Cr), Cadmium (Cd), Nickel (Ni), Manganese (Mn). The partial extraction method was applied by weighing one gram of each sample into washed glass beakers, and the samples digested by adding 20 cm^3 of aqua-region (mixture of HCl and HNO_3 at a ratio of 3:1 and 10 cm^3 of 30% of hydrogen peroxide (H_2O_2) added. The H_2O_2 was introduced in small proportions to avoid any possible over flowing, which may lead to loss of materials (soil) from the beaker. These samples were then covered with watch glasses and heated over hot plate to about 90℃ (near boiling point). They were then filtered hot, so as to separate the insoluble solids. These solid parts were then rinsed with hot HNO_3 after which the final dilution was made with distilled de-ionized water. All the samples were then stored in plastic containers and refrigerator ready for the Atomic Absorption Spectrophotometry (AAS) method of analysis.

2.2.1 Enrichment Factor

The enrichment coefficient of the metals in the soil samples were qualified by the equation described by Loska and Wiechula (2003).

$$E_F = (C_1Me/C_{1n})/(C_2Me/C_{2n})$$

Where C_1Me = the examined metal content in the examined environment

C_2M_e = the examined content in the reference environment;

C_{1n} = the reference element content in the examined environment, and

C_{2n} = the examined reference element content in the reference environment.

A reference element is often a conservative one, such as the most commonly used element, Al, Fe, Mn, Sc and so on (Quevanviller, Lavigns, & Cortex, 1989; Yougming, Peixuan, Junji, & Posmentier, 2006; Nwajie & Iwegbue, 2007). In this study, manganese was applied as a reference element because of its natural abundance. It is pertinent to note that the enrichment coefficient is a convenient measure of geochemical trends and is used for comparison between areas over time. The enrichment coefficient gives an insight into differentiating an anthropogenic source from natural origin. An enrichment factor (EF) value close to unity indicates crustal origin while values greater than 10 points to a non-crustal source (Yougming et al., 2006). Five contamination categories are recognized based on enrichment coefficient value (Sutherland, 2000; Loska & Wiechula, 2003) (Table 1).

Table 1. Contamination Categories Based On Enrichment Factor (Ef) Values

Enrichment factor range	Significance
EF<2	Deficiency to minimal enrichment
EF = 2 – 5	Moderate enrichment
EF = 5 – 20	Significant Enrichment
EF = 20 – 40	Very high enrichment
EF > 40	Extremely high enrichment.

Sources: (Sutherland, 2000; Loska & Wiechula, 2003)

2.2.1 Contamination / Pollution Index

The contamination/pollution (C/P) index was derived by employing the contamination/pollution index as defined by Lacatusu, (2000).

C/P Index = Concentration of Metals in Soil/Target value)

The target (reference) values of metals were obtained using the standard table formulated by the Department of Petroleum Resources of Nigeria (DPR, 2002) for maximum allowed concentration of metals in soil (Table 2). A C/P index value greater than unity (1) defines a pollution range and when the value is less than unity defines contamination ranges (Table 3).

Table 2. Dutch Target Value, Australian, Environmental Impairment Variability and Canadian Environmental Quality Criteria

Metal	Assessment criteria				Remediation Criteria			DPR Target values
	DTV	AEIL	EC	CEQC	A	R/P	C/I	
Cd	0.8	3	3.0	0.5	4	4	8	0.8
Cr	100	400	-	20	750	250	800	100
Cu	36	100	140	30	150	100	500	36
Ni	35	60	75	20	150	100	500	35
Pb	85	60	300	25	375	500	100	85
Zn	140	20	300	60	600	500	1,500	146
Co	20	-	-	-	40	50	300	20
Mn[d]								437
Fe[d]								5000

[a] Dtv Dutch Target Value, AEIL Australian ecological investigation level EC European Communities. (EQC Canadian environment quality criteria).

[b] A Agricultural purposes, R/P residential/Parkland, C/I Industrial/Commercial.

[c] DPR Department of Petroleum Resources target values.

[d] Derived from selected global average (Alloway, 2005).

Table 3. Significance of interval of contamination/pollution (C/P) index value

C/P index	Significance
< 0.1	Very slight contamination
0.10-0.25	Slight contamination
0.26-0.50	Moderate contamination
0.51-0.75	Severe contamination
0.76-1.00	Very severe contamination
1.1-2.0	Slight pollution
2.1- 4.0	Moderate pollution
4.1-8.0	Severe pollution
8.1-16.0	Very severe pollution
>16	Excessive pollution

Source: Lacatusu (2000).

3. Results and Discussion

3.1 Result

The results of the geochemical analysis on soil samples obtained from the study area are presented in Table 4–11.

3.2 Discussion

The total mean concentration in mgkg[-1] and standard deviation of trace metals in soil samples from the study area and reference sites shows that manganese has the highest mean concentration of 139.401 mgkg[-1]. and chromium with the lowest of 0.484 mgkg[-1]. The mean concentrations of trace metals in the samples decrease in the following order of magnitude in mgkg[-1], Mn (139.401) > Zn (54.008) > Pb (24.814) > Cu (5.702) > Ni (3.009) > Cd (0.48) > Cr (0.219) (Table 6). From the range Table 7, trace metals in the samples shows lead (Pb) < 0.001 – 118.36 mgkg[-1], Copper (Cu) < 0.001 – 1.584 mgkg[-1], Zinc (Zn) 0.34 – 120.113mgkg[-1], Cadmium (Cd)

<0.001 – 1.584mgkg^{-1}, Zinc (Zn) 0.34 –120.113 mgkg^{-1}, nickel (Ni) 0.32 – 7.632 mgkg^{-1} and manganese (Mn) 38.20 – 294.302 mgkg^{-1}. It is observed that trace metal concentration in the study area is greater than those of the reference site by magnitude concentration difference of Pb (18.711 mgkg^{-1}) Cu (12.342 mgkg^{-1}), Cr (0.073 mgkg^{-1}) Cd (0.908 mgkg^{-1}), Zn (104.669 mgkg^{-1}), Ni (3.522 mgkg^{-1}), Mn (203.803 mgkg^{-1}) in Otofure area and Pb (80.316 mgkg^{-1}), Cu (10.446 mgkg^{-1}), Cr (0.556 mgkg^{-1}), Cd(102 mgkg^{-1}), Zn (109.026 mgkg^{-1}), Ni (4.307mgkg^{-1}), Mn (161.349 mgkg^{-1}) Teboga area (Table 7).

3.2.1 Contamination/Pollution Index

Assessment of the soil sample for trace metal pollution based on absolute metal content value provides inadequate information on the significance of the value obtained with the intrinsic soil feature and how the value is related to the maximum allowable limits for each. The presence of one metal can significantly affect the impact that another has on organisms (Iwegbue et al., 2010). This effect can be synergistic, additive and antagonistic (Eisler, 1993). Based on the limitation of (Iwegbue, Nwajei, & Overah, 2010) method, the Lacatusu (2000) method was used for this study. Based on these, the contamination/pollution index was calculated as the ratio between metals effectively measured by chemical analysis to the reference value (Table 3). Generally, standard used such as the Department of Petroleum Resources (2002) target value and the conversion formula (Lacatusu, 2000) for the C/P index vary from one country to another based on the chosen criteria. The calculated C/P index values were interpreted according to the scheme provided in Table 3.

3.2.2. Enrichment Factor (EFs)

Enrichment factor (EFs) can also be effective tools to differentiate a natural origin from an anthropogenic source. The calculated enrichment (EF) shows that Ni, Cr and Mn have enrichment factors close to unity, Pb and Zn were greater than 10, while Cu and Cd are lacking (Table 8). Observed concentrations of Ni, Cr and Mn are attributed to natural sources while Pb and Zn are due to anthropogenic sources (Yougming et al., 2006). Mean EFs decreased in this order Pb > Zn > Co > Mn > Ni > Cd = Cu which can also be seen as the degree of the overall contamination by trace metal in soil samples from the dump sites. Most sites have enrichment factor values in the deficiency to minimal enrichment domain except for Pb and Zn that have enrichment factor values in the extremely high enrichment category (Table 2). This implies that the dump sites are enriched in Pb and Zn. Trace metal concentration at the study area decreased with distance away from the waste dumps (Table 5).

Correlation matrix of the trace metal data indicates strong positive correlations $r^2 > 0.50$) between Pb with Cr – Ni, Cu with Cd – Zn – Ni - Mn, Cr with Ni, Cd with Zn – Ni – Mn, Zn with Ni – Mn and Ni with Mn. A weak positive correlation ($r^2 \leq 0.5$) was seen in Pb with Cu – Cd – Zn, Cu with Cr, Cr with Cd – Zn. The significant positive correlation within these metals reveal the common source of contamination from refuse dumped on the site which sinks into the soil of the study area.

Also indicated by same correlation matrix of the trace metal data is a strong positive correlation ($r^2 > 0.50$) between Pb and Cu – Ni – Mn, Cu and Zn, Cr and Ni – Mn, Zn and Ni, Ni and Mn while weak positive correlation ($r^2 \leq 0.50$) occurs between Pb and Cu, Cu and Ni – Mn, Cr and Zn with a very negative correlation between Cu and Mn (Table 12). The significant positive correlation within the metals also reveal their inclination toward anthropogenic sources but, the concentration of trace metal at the reference sites were minute compared to the waste dumps. In general, for both correlations, the geochemical association of Cr – Cu – Zn in the soil shows that these metals are deposited from anthropogenic sources, since there is no known geogenic source which can contribute to this type of association in the study area.

From the result of analysis, high levels of metals are observed in the dump sites with manganese (294.302/203.634mgkg^{-1}), lead (118.36mgkg^{-1}), zinc (115.201/103.750mgkg^{-1}), and manganese (257.765/167.053 mgkg^{-1}). The levels of metals obtained in this study were compared with both domestic and International guidelines (Table 3). The Dutch "target values" based on natural soil levels and on negligible risk concentration used in the Netherlands for soil protection (Lame & Leenaer, 1998) are similar to the Department of Petroleum resources targets values in Nigeria. However, other International guidelines for metals in soils include Canadian Soil Quality Criteria (CCME 1991), the Australian Ecological Investigation levels (EIL) and maximum concentration of toxic metal in soils permitted under the European community regulation (Kabata-Pendians & Pendias, 1992) are presented in Table 3 for comparison. It is pertinent to note that guidelines for re- development of contaminated land were not available for comparison. Hence, the Canadian soil quality criterion was used. These criteria are based on level above which remedial action is necessary before such lands can be used for agricultural, residential and/or industrial purpose.

3.2.2.1 Lead

The species of lead Pb vary considerably with soil type; it is mainly associated with clay minerals, Mn oxides, Fe and Al hydroxides and organic matter. In some soil types, Pb may be highly concentrated in calcium carbonate particles or in phosphate concentration and a baseline Pb value for surface soil (Gowd, Reddy, & Govil, 2010). The average content of Pb in the soil samples is 24.814 mgkg^{-1} and ranges from <0.001 to 118.36 mgkg^{-1} (Figure 2). The concentration magnitude of Pb shows that the soils is practically uncontaminated with Pb. Lead value for surface soil on the global scale has been estimated to be 25mg/kg and levels above this suggest an anthropogenic influence (Kabata-Pendias, 2004). The EF obtained for Pb ranges from 8.879-275-831 which indicate that the soils in the study area show significantly-extremely high enrichment. Similarly, the C/P index ranges from 0.0007-1.392 mgkg^{-1} and indicates that the sample ranges from very slight contamination to slight polution.
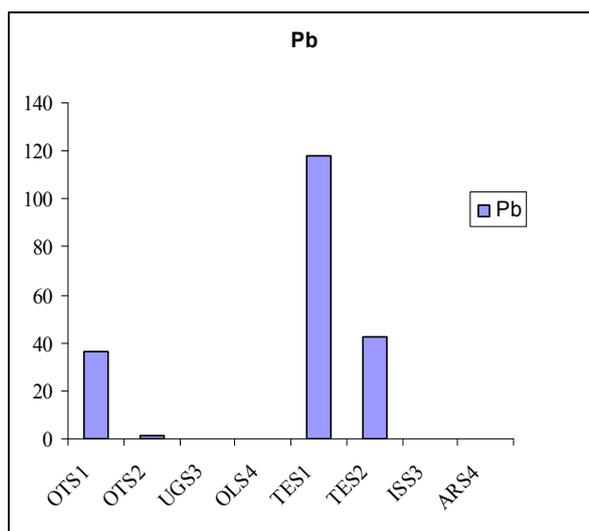
Figure 2. Chart showing concentration of Lead in the different sample locations

Lead concentration spanning between 47.15 and 155.07 mgkg^{-1} (Oyelola & Babatunde, 2008), and 1.41 – 109.9 mg/kg (Iwegbue et al., 2010), have been reported in soils of municipal waste dumps and other contaminated sites in Nigeria. The concentration found in the Otofure and Temboga area is similar for the range reported by Iwegbue et al. (2010) but was relatively higher than levels observed by Nwajei, Iwegbue and Okafor (2007).
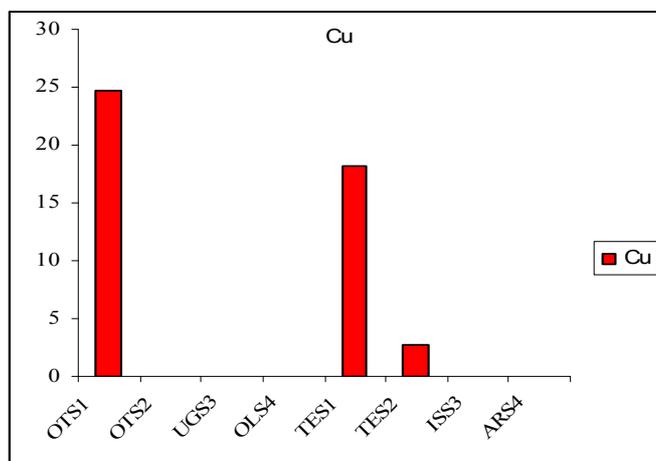
Figure 3. Concentration of Copper in the different sample locations

3.2.2.2 Copper

The normal threshold value prescribed in soil is 30 mgkg^{-1} and copper normally accumulates in the surface horizons, a phenomenon explained by the bioaccumulation of the metal and recent anthropogenic sources (Kabata-Pendias, 2004). The average copper content in the soil examined was 5.702 mg/kg and its concentration ranges were <0.001-24.684 (Figure 4). The EF obtained was nil pointing towards "Deficiency to minimal enrichment" in the soil. The C/P index obtained spanned from <0.001–0.686 indicating very slight contamination to severe contamination, hence from its low average concentration compared with CEQC standard, copper is of low concentration in the soil.
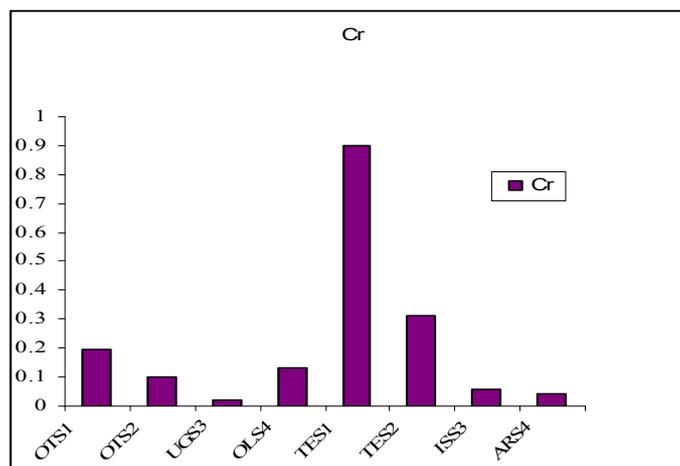
Figure 4. Chart showing concentration of Chromium in the different sample locations

3.2.2.3 Chromium

Chromium is a low mobility element, especially under moderately oxidizing and reducing conditions and near –neutral pH values. Cr^{+6} absorption decreased with increasing pH and Cr^{+3} adsorption increases with increasing pH. On the other hand, Cr^{+6} are toxic for biological systems. The average concentration is 0.219 mgkg^{-1} and ranges from 0.02-0.897 mgkg^{-1} in the soil samples collected (Figure 4). The EF revealed that the samples fell into the class of deficiency to minimal enrichment–moderate enrichment (0.302-3.554). The contamination/pollution index obtained for Cr ranged from 0.0016-0.002 indicative of a very slight contamination. The concentration of Chromium observed in the present day study is lower compared to value reported by Oyelola and Babatunde (2008).

3.2.2.4 Cadmium

The average Cadmium content in the soil examined is 0.484 mg/kg^{-1} and ranges from <0.001 – 1.584 mgkg^{-1} in the soil samples (Figure 5). The normal threshold value prescribed in soil for Cadmium is 0.5 mg/kg^{-1} (CCME, 1991). The EF is zero indicating deficiency to minimal enrichment of Cd in the soil similarly the C/P index ranges from <0.001 – 1.98 pointing at very slight contamination to slight contamination. The Cd concentration observed in this present study is similar to the concentration reported by Njoku and Ayoku (2007) in Owerri Southeastern Nigeria.
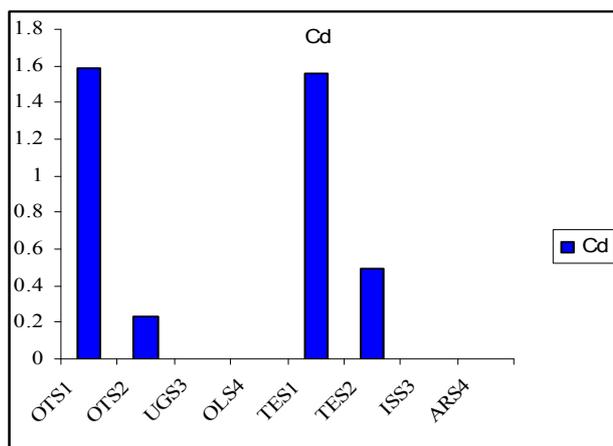
Figure 5. Chart showing concentration of Cadmium in the different sample locations

3.2.2.5 Zinc

Zinc belongs to a group of trace metals, which are essential for the growth of humans, animals and plants and are potentially dangerous for the biosphere when present in high concentrations. The main sources of pollution are industries and the use of liquid manure, composted materials and agrochemicals such as fertilizers and pesticides in agriculture (Gowd, et al., 2010). The average zinc concentration in the dump sites is 54.008 mgkg^{-1} (range 0.34-120.113 mgkg^{-1} (Figure 6). The EF indicates a range of 25.601-70.469 (Extremely high enrichment) and the C/P index ranges from 0.00233-0.789 which points at slight contamination to very severe contamination. From CCME, the threshold value for Zinc (60 mgkg^{-1}) compared with present study indicates low enrichment. The result from the Otofure and Teboga dump site were higher than levels from soils in northern Nigeria as reported by Eliagwu, Ajibola and Folaranmi (2007).
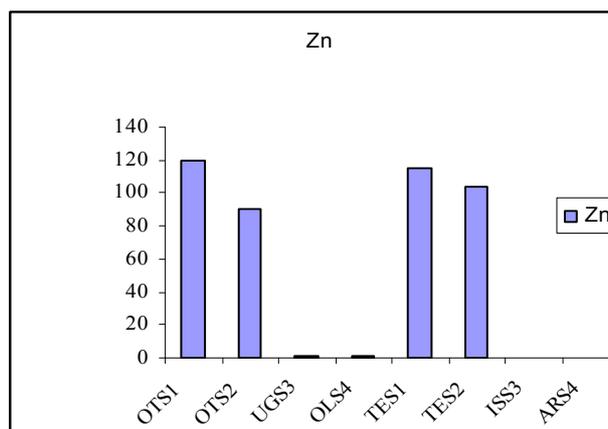
Figure 6. Chart showing concentration of Zinc in the different sample locations

3.2.2.6 Nickel

The Nickel content in dump site samples ranges from 0.32–7.632 mgkg^{-1} (Figure 7), with an average of 2.578 mgkg^{-1}. Nickel in soil is usually present in the organically bound form, which under acidic and neutral conditions increases its mobility and bio availability (Kabata – Pendias & Pendias 1999). The EF value ranges from 0.594–1.305 which falls under the deficiency to minimal enrichment category and the C/P index ranging from 0.0914–0.218 (very slight contamination–slight contamination).
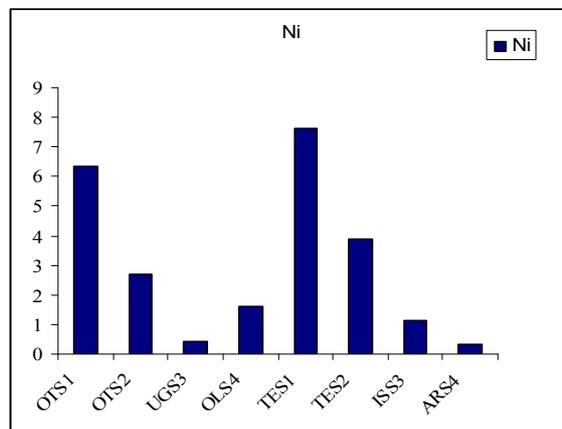
Figure 7. Chart showing concentration of Nickel in the different sample locations

3.2.2.7 Manganese

The average concentration of Manganese in the soils sample is 139.401 mgkg^{-1} and ranges from 38.20–294.302 mg/kg^{-1} (Figure 8). It has an EF of unity although indicating crustal origin and falls into the category of deficiency to minimal enrichment. The C/P value ranges from 0.0943 to 0.674 whose significance is very slight contamination severe contamination.
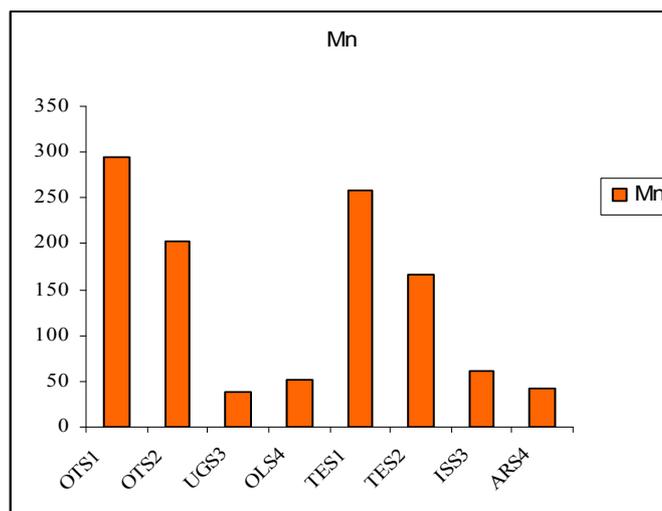
Figure 8. Chart showing concentration of Manganese in the different sample locations

Generally although the study shows slight metal enrichment in Pb and Zn content over other metal studied, the average concentration of trace metals were below international guide values (CEQC).

Table 4. Concentration in mgkg^{-1} of trace metals in soil samples from the studied sites (Otofure and Teboga) and reference sites (Oluku, Ugbowo, Ikpoba slope and Agbor road)

Sample Code	Pb	Cu	Cr	Cd	Zn	Ni	Mn
OTS1 (N=13)	36.281	24.684	0.194	1.584	120.113	6.361	294.302
OTS2 (N=10)	1.201	<0.001	0.102	0.232	90.665	2.703	203.634
MEAN (Z1) N=23	37.482±	24.684±	0.296±	1.816±	210.778±	9.064±	497.936±
	4.50	6.50	0.86	0.68	25.34	7.10	51.35
UG3S3 (N=9)	<0.001	<0.001	0.02	<0.001	0.61	0.42	38.20
OLS4 (N=11)	0.06	<0.001	0.13	<0.001	0.83	1.60	58.13
MEAN (Z2)	0.06±	<0.001±	0.15±	<0.001±	1.44±	2.02±	96.33±
N=20	3.15	0.00	0.08	0.00	0.37	0.15	5.44
TES1 (N=12)	118.36	18.204	0.897	1.560	115.201	7.632	257.765
TES2 (N=10)	42.442	2.728	0.314	0.492	103.750	3.901	167.053
MEAN (Z3)	160.802±	20.932±	1.211±	2.052±	218.951±	11.533±	424.818±
N=22	21.17	5.61	0.28	0.34	19.72	1.42	12.07
ISS3 (N=10)	0.13	<0.001	0.06	<0.001	0.56	1.14	60.90
ARS4 (N= 8)	0.04	<0.001	0.04	<0.001	0.34	0.32	41.22
MEAN (Z4)N=18	0.17±0.20	<0.001±0.0	0.10±0.06	<0.000.00	0.90±0.60	1.46±0.82	102.12±8.15
TOTAL SUM	198.514	45.616	1.757	3.868	432.069	24.077	1115.204
TOTAL AVE.	24.814	5.702	0.219	0.484	54.008	3.009	139.401
σ Standard Deviation	110.46	9.270	0.271	0.649	50.618	2.578	97.823

OTS1 = Otofure Waste dumps 1, OTS2 = Otofure Waste dumps 2, UG S3 = Ugbowo, OL S4= Oluku, TES1 = Teboga Dump Site 1, TES2 = Teboga Dump Site 2, ISS3 = Ikpoba Slope and ARS4 = Agbor Road.

Table 5. Range and total average concentration in mgkg^{-1} of soil samples

Trace metal	Range mgkg^{-1} (N=83)	Total average concentration (N=83)
Pb	<0.001 – 118.36	24.814 ± 110.46
Cu	<0.001 – 24.684	5.702 + 9.270
Cr	0.02 – 0.897	0.219 ± 0.271
Cd	<0.001 – 1.584	0.484 ± 0.649
Zn	0.34 – 120.113	54.008 ±50.618
Ni	0.32 – 7.632	3.009 ± 2.578
Mn	38.20 – 294.302	139.401 ± 97.323

Table 6. Observed difference in concentration magnitude between waste dump samples and reference background site

Sample site	Pb	Cu	Cr	Cd	Zn	Ni	Mn
Otofure dump site (N=23)	18.741	12.342	0.148	0.908	105.389	4.532	248.968
Ugbowo/ Oluku (N=20)	0.03	-	0.075	-	0.72	1.01	45.165
Difference (A)	18.711	12.342	0.073	0.908	104.669	3.522	203.803
Teboga Waste Dump (N=22)	80.401	10.466	0.606	1.026	109.476	5.767	212.409
Ikpoba slope and Agbor road (N=18)	0.085	-	0.05	-	0.45	1.46	51.06
Difference (B)	80.316	10.466	0.556	1.026	109.026	4.307	161.349

Table 7. Enrichment Factor of trace metal in soil samples from Otofure and Teboga waste dump sites.

Metal	OTOFURE I (N=13)	OTOFURE 2 (N=10)	TEMBOGA I (N=12)	TEMBOGA 2 (N=10)
Pb	185.595	8.879	275.831	152.617
Cu	-	-	-	-
Cr	0.397	0.302	3.554	1.919
Cd	-	-	-	-
Zn	25.601	27.928	50.711	70.469
Ni	0.967	0.594	1.305	0.816
Mn	1.000	1.000	1.000	1.000

Table 8. Comparison of Contamination/Pollution Index of metals in soils from the waste dumps and reference sites

Metals	OTS1 N=13	OTS2 N=10	UGS3 N=9	OLS4 N=11	TES2 N=12	TES2 N=10	ISS3 N=10	ARS4 N=8
Pb	0.424	0.014	-	0.0007	1.392	0.499	0.0015	0.00047
Cu	0.686	-	-	-	0.506	0.075	-	-
Cr	0.002	0.001	0.0002	0.0013	0.009	0.003	0.0016	0.0004
Cd	1.98	0.29	-	-	1.95	0.615	-	-
Zn	0.823	0.621	0.00418	0.0057	0.789	0.711	0.00383	0.00233
Ni	0.181	0.077	0.012	0.046	0.218	0.111	0.0326	0.00914
Mn	0.674	0.466	0.087	0.119	0.589	0.382	0.139	0.0943

OTS1 = Otofure Waste dumps 1, OTS2 = Otofure Waste dumps 2, UG S3 = Ugbowo, OL S4= Oluku, TES1 = Teboga Dump Site 1, TES2 = Teboga Dump Site 2, ISS3 = Ikpoba Slope and ARS4 = Agbor Road.

Table 9. The significance of interval of contamination/pollution (C/P) index ranges for the study area and reference sites are shown below

Sample Sites	Significance
Otofure Waste dumps 1 (OTS1)	Very slight contamination – slight pollution
Otofure Waste dumps 2 (OTS2)	Very slight contamination – severe contamination
Ugbowo (UG S3)	Very slight contamination
Oluku (OL S4)	Very slight Contamination- Slight Contamination
Teboga Dump Site 1 (TES1)	Very Slight contamination –slight pollution
Teboga Dump Site 2 (TES1)	Very slight contamination – very serve contamination
Ikpoba Slope (ISS3)	Very slight contamination – slight contamination
Agbor Road (ARS4)	Very slight contamination

Table 10. Correlation of trace metals in soil samples from otofure and teboga waste dump

	Pb	Cu	Cr	Cd	Zn	Ni	Mn
Pb	1.000						
Cu	0.400	1.000					
Cr	1.000	0.400	1.000				
Cd	0.400	1.000	0.400	1.000			
Zn	0.400	1.000	0.400	1.000	1.000		
Ni	0.800	0.800	0.800	0.800	0.800	1.000	
Mn	0.000	0.800	0.000	0.800	0.800	0.600	1.000

Table 11. Correlation of trace metal in soil from reference background sites

	Pb	Cu	Cr	Cd	Zn	Ni	Mn
Pb	1.000						
Cu	.447	1.000					
Cr	.800	.000	1.000				
Cd	-	-	-	-			
Zn	.000	.894	.400	-	1.000		
Ni	.600	.447	.800	-	.800	1.000	
Mn	1.000	-.447	.800	-	.000	0.600	1.000

4. Conclusion

From results of geochemical analysis, the Otofure and Teboga wastes dumps site show evidence of slight contamination although the study shows slight metals enrichment in Pb and Zn content over other metals studied. Risk assessment based upon soil quality guidelines limits proves that the soil does not have serious health risk with respect to humans. However, a proper and modern engineered disposal method should be adopted to reduce the concentration of the metal load in the waste materials before final disposal. Such method may include reducing the waste volume by pyrolysis and subsequently treating the metal waste chemically to remove the metal content, before final disposal by burial in a land fill site.

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