CONTAMINATION ASSESSMENT OF TOXIC ELEMENTS IN THE SOIL WITHIN AND AROUND TWO DUMPSITES IN LAGOS, NIGERIA.

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ABSTRACT

This study assessed some contamination indices of trace elements in the soil within and around two dumpsites in Lagos, Southwestern Nigeria. This was with a view to assessing the degree of soil contamination. Thirty samples were collected from the two dumpsites, dried, disaggregated and sieved to <75um fraction for analysis of trace elements using aqua-regia digestion and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The soil generally showed background to minimum enrichment with arsenic, chromium, molybdenum and background to very high enrichment with cadmium, zinc, lead, Copper and nickel. Scandium, vanadium and strontium were only present in the active dumpsite with minimum enrichment while Lanthanum was present only in the abandoned dumpsite with background enrichment. The geo-accumulation index (Igeo) values for arsenic, chromium, molybdenum, manganese, lanthanum and arsenic, strontium, vanadium for active and abandoned dumpsites respectively were within background concentration. Chromium, scandium, molybdenum, nickel for active site and copper for the abandoned site fell in the class of moderate pollution. Cadmium, lead and zinc ranged between moderate pollution to strong pollution for the abandoned site while copper, cadmium, lead and zinc fell within strong to extreme pollution for the active site. The grade of ecological risk indices (E_i) for Chromium and Zn indicated low risk and low to moderate risk respectively for both dumpsites. Soil from the active dumpsite showed that arsenic fell within considerable risk, copper (moderate risk), lead and cadmium (very high risk). Soil from the abandoned dumpsite showed low to very high risk with copper, considerable to very high risk with arsenic, moderate to very high risk with lead and very high risk with cadmium. The 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 indicated low to very high risk and very high risk respectively. The results of contamination degrees ranged between low and very high degree of contamination for both dumpsites.

Keywords: Soil, Dumpsites, Trace Elements, Contamination, Lagos

INTRODUCTION

Soil is not only a medium for plant growth or waste disposal but also a transmitter of many pollutants to surface water, ground water, atmosphere and food. Soil pollution may threaten human health not only through its effect on hygiene quality of food and drinking water, but also through its effect on air quality. Little attention has been paid to soil pollution compared to food in the past (Christopher and Thresse, 2010, Wong, 1996). Urban areas generally have high population density and intensive anthropogenic activities and pollution of heavy metal in both terrestrial and aquatic ecosystems is becoming a potential global problem. Lack of planning and facilities in the third world countries like Nigeria to detect and monitor soil, stream sediments and water quality could expose the citizens to heavy metal poison (Ochieng *et al.*, 2008; Sekabira *et al.*, 2010). Heavy metals like other metals, are natural constituents in both soil and stream sediments. Heavy metals can also be introduced into the environment anthropogenically from human activities such as industrial activities, agricultural activities, dumpsites, fossil fuel combustion and atmospheric deposition.

Disposal of waste in landfills is an integral part of waste management strategies around the world. Soils are usually regarded as the ultimate sink for heavy metals discharged into the environment (Banat *et al.*, 2005). Therefore the environmental problem of soil pollution by heavy metals has received increasing attention in the last few decades in both developing and developed countries throughout the world (Zhang *et al.*, 2007; Gong and Dang, 2008).This study intends to use pollution indices by heavy metals in soil samples within and around both an active and an abandoned dumpsites in Lagos Southwest Nigeria to assess the level of soil contamination.

Study Area

The study areas are Ojota and Isolo waste disposal sites which are both located within Lagos, Southwestern Nigeria. Ojota site is situated within latitudes 6" 36'N and 6" 37'N and longitudes 3" 23'E and 3" 24'E (Fig. 1) while Isolo disposal site is located within latitudes 6"30'N and 6"31'N and longitudes 3"15'E and 3" 16'E (Fig. 2). The Isolo site has been abandoned while Ojota site is still very active containing all kinds of wastes but dominantly domestic and municipal wastes. The topography ranges from 50-150 m above the sea level. Isolo and Ojota areas are drained by rivers Ogun and Iya-Alaro respectively with minor streams forming dendritic drainage pattern.

The Ojota and Isolo waste dumpsites are underlain by the Coastal Plain Sands and the Coastal Alluvium respectively. The formations are composed of fine-medium-coarse grained unsorted sands with intercalations of clay lenses. The topsoil at the Ojota dump site is composed of laterite and clay.

MATERIALS AND METHOD OF STUDY

Thirty composite surface soil samples (0-10 cm) were collected within the vicinity of the waste disposal sites and some distance away using hand auger and stored in properly labeled polyethylene bags.

This was to enable the monitoring of variations in metal concentrations in the soil samples away from the dumpsites. Some samples were also taken as control samples from far distance from the dumpsite (Figs. 1 and 2). The samples were air-dried at room temperature (21-27°C) for seven days and later oven-dried at 100°C for one hour to obtain a constant weight. The samples were mechanically ground and sieved to obtain < 2 mm fraction. A fraction of the soil was drawn from the bulk soil (< 2 mm fraction) and reground to obtain < 75μm fraction using a mortar

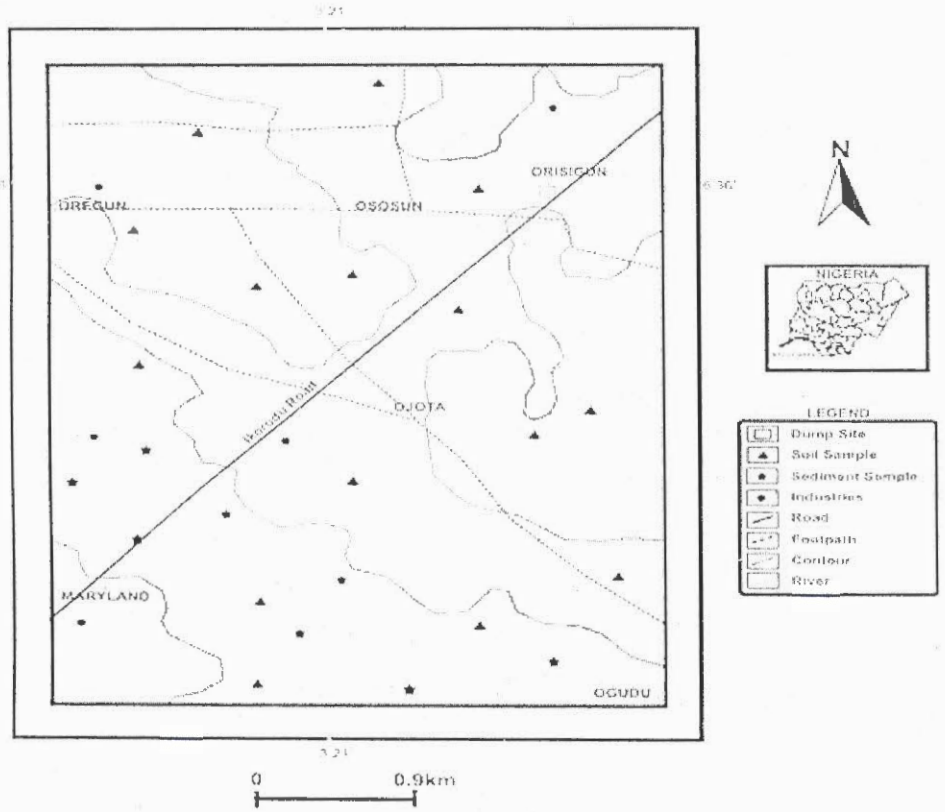


Fig.1. Ojota Waste Dumpsite Showing the Sample Locations

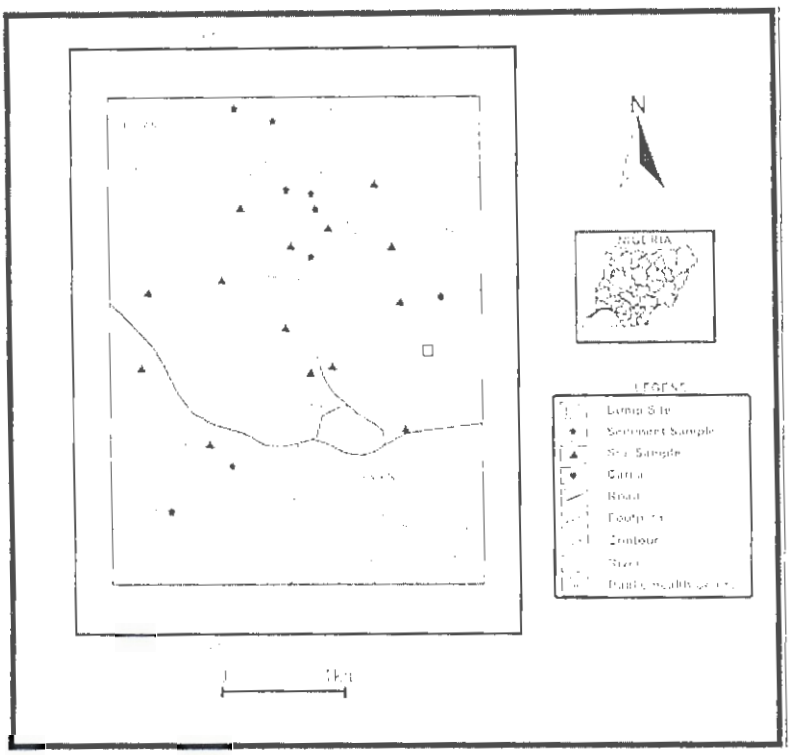


Fig. 2. Isolo Waste Dumpsite Showing the Sample Locations

and pestle and then digested using aqua-regia digestion method. Geochemical analysis of the soil samples was done at Actlabs, Canada using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The detection limit for most elements in solution is in the sub-ppb range.

The accuracy of the analytical methods was monitored by repeated analysis of standard reference materials (i.e. GSD-9 and NIM-G) together with batch of soil samples. These data gave satisfactory results with analytical values within ±1 10% for different elements using the certified ones (GSD-9) except K and P and within ±4% for K and P of the certified ones (NIM-G).

Evaluation of Data

Some quantitative indices were used to assess the heavy metal contamination and also to allow for ease of comparison between the determined parameters. These indices include Enrichment Factor (EF), Contamination Factor (CF) and Contamination Degree (CD), Geoaccumulation Index (Igeo), Ecological Risk Assessment (E r) and Potential Ecological Risk Index (RI) as discussed in Gong *et al.* (2008); Zoynab *et al.* (2008); Gong and Dang (2008), Rapant *et al.* (2008); Sekabira *et al.* (2010) and Saha and Hossain (2011).

The definitions and equations for the indices are stated below;

Enrichment Factor (EF)

As proposed by Simex and Helz (1981), EF was employed to assess the degree of contamination and to understand the distribution of the elements of anthropogenic origin from sites by individual elements in soil. Fe was chosen as the normalizing element while determining EF-values, since it is one of the widely used reference element (Loska *et al.* 2003; Kothai *et al.* 2009; Chakravarty and Patgiri, 2009; Seshan *et al.* 2010). The formula for Enrichment Factor is stated below while the classification is given in Table 4.

$$EF = \frac{C/Fe\ (sample)}{C/Fe\ (background)} \qquad \text{Equation (1)}$$

Where, C is the concentration of element "n". The background value is average crustal values (Taylor, 1964) in this case.

Geo-accumulation Index (Igeo)

As proposed by Mueller (1979), Igeo has been widely used to evaluate the degree of heavy metal contamination in terrestrial and aquatic environments and expressed as:

$$Igeo = \log 2 \frac{Cn}{1.5Bn}$$ Equation (2)

Where Cn and Bn are as defined above, while 1.5 is a factor for possible variation in the background concentration due to lithologic differences. Geo-accumulation index has seven classifications according to Mueller (1979) and as stated in Table 4.

Contamination Factor (CF) and Contamination Degree

The contamination factor (CF) or Enrichment Ratio (ER) and the degree of contamination (CD) were used to determine the contamination status of soil in the present study. The formula for contamination factor and Degree of contamination are stated below;

$$CF = \frac{Concentration\ of\ Heavy\ metal\ in\ sediments}{Concentration\ of\ background}$$ Equation (3)

$$CD = \sum CF$$ Equation (4)

The terminology suggested for describing the contamination factor (Cf) and Contamination degree (Hakanson, 1980) is shown in Table 4

Assessment According to Ecological Risk Assessment (E'r) and Potential Ecological Risk Index (RI)

United States Environmental Protection Agency (USEPA) in 1998 defined ecological risk assessment as a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stress.

The assessment of ecological risks of heavy metals in soil samples was done using the Ecological Risk Assessment E'r and Potential Ecological Risk Index (RI) proposed by Hakanson, 1980 and reported in Huaang *et al.*, 2011 while Grades of the Environment by Potential Ecological Risk Index were presented in Table 6.

An Ecological Risk Factor (Er) is to quantitatively express the Potential Ecological Risk of a given contaminant as suggested by Hakanson (1980). It is calculated as

$$E^{r} = Tr \cdot Cf$$ Equation (5)

where Tr is the toxic-response factor for a given substance (Table 7) and Cf is the contamination factor. The terminologies used to describe the risk factor is given in Table 4.

The soil analysis results were further subjected to statistical analysis to determine their environmental significance and three groups were identified.

RESULTS AND DISCUSSION

Geochemical Analysis Results

The summary of the results of trace elements in soil samples of both active (Ojota) and abandoned (Isolo) dumpsites as well as Average Crustal Values (ACV) (Taylor, 1964) are shown in Table 1. The ACV were used as background values for all the metals. Metal contents showed the following concentration ranges for abandoned and active dumpsites respectively in ppm: Pb 28-379 and 34-1057, Cd 0.06-2.3 and -0.5-4.9, Zn 21-1619 and 25-1626, Cr 30-89 and 40-125, Cu 16-85 and 13-498, As -2-16 and 5-16, Mo -1-4 and -1 -5, Mn 49-1673 and 70-1505. La was found only in the soil of abandoned site and the concentration ranged from 16-39 while Ni, Sr, Sc and V were found only in active soil with the following concentration ranges in ppm 14-61, 8-59, 8.4-23.2 and 44-110 respectively. The metals followed these trends Mn>Zn>Pb>Cr>Cu>La>As>Mo>Cd and Mn>Zn>Pb>Cu>V>Cr>Sr>Ni>Sc>As>Mo >Cd for abandoned and active dumpsites respectively (Table 1).

Based on the geochemical analysis results, the metals can be grouped into three.

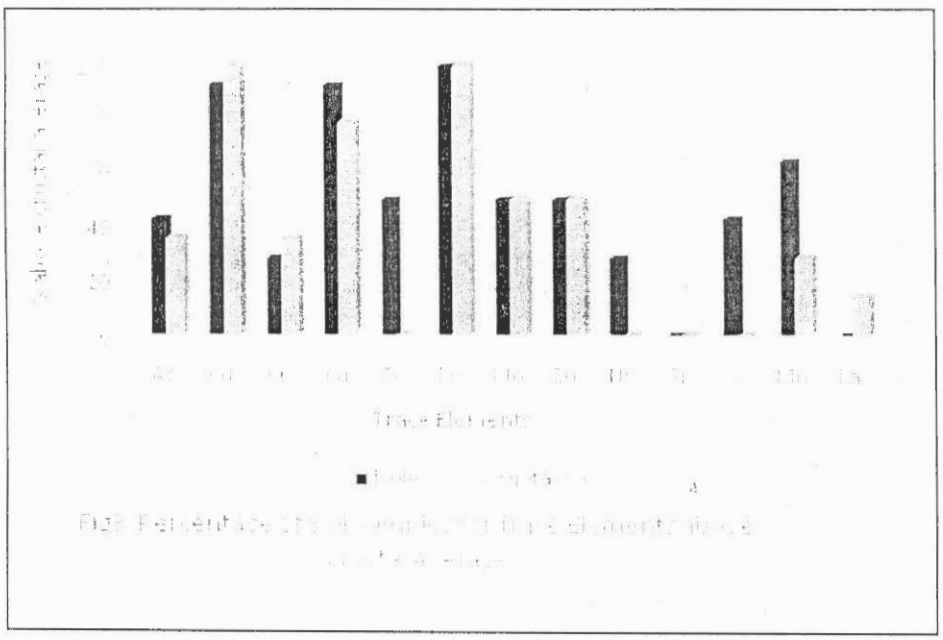
The first group includes Pb, Cd, Zn, Cr, Cu, As, Mo and Mn which were present in all the soil samples analyzed with high concentrations. The second group, which include Ag, Al, Co, Ni, Sb, Sc, Sr, Ti and V was only present in few samples that were within and close to the waste disposal

sites with concentration values higher than background values. The third group includes Bi and was present in all the samples with low concentration.

The geochemical results of abandoned and active dumpsites showed that Pb, Cd, Zn, Cr, As, Cu, Mn have concentration values higher than background values (average crustal values) in 100%, (100 and 92.9 %,), 50%, (35.7 and 28.6%), (78 and 92.9%), (28.57 and 64,3%), and (92.9 and 78.6%) respectively. Approximately 50% and 14.29% of abandoned soil samples showed higher values for Mo and La respectively while Sc, Ni and V in 50%, 28.6% and 42.9% of active soil samples were higher than background values respectively (Fig 3).

Table 1. Summary of Heavy Metals in Soil for the Two Dumpsites

Location		Pb	Cd	Zn	Cr	Cu	As	Mo	Mn	La	Sc	Sr	V
Ojota N= 15	Range	28-379	0.6-2.3	21-1619	30-89	16-70	BDL-16	BDL-4	70-1505	ND	8.4-23.2	8-59	44-110
	Mean	96.57	1.3	226.57	56.64	40.29	7.29	2.14	704.4	ND	12.36	30.14	80.35
	Median	50	1.2	105	61	42	8	3	782	ND	1.5	25.5	82
	St dev.	101.01	0.51	423.6	19.2	20.39	6.5	1.56	405.9	ND	3.78	15.2	16.29
Isolo N= 15	Range	34-1057	BDL-4.9	25-1625	41-125	13-498	5-16	BDL-5	49-1673	16-39	ND	ND	ND
	Mean	157.64	1.52	288.07	59.07	105.07	9.93	2.29	480	28.29	ND	ND	ND
	Median	39.5	1.3	118.5	52.5	46.5	10	2.5	296.5	28.5	ND	ND	ND
	St dev.	272.44	1.18	429.63	22.26	126.1	3.43	1.72	492.7	6.81	ND	ND	ND
Control		30	1.1	36	59	25	5	2	590	25	ND	ND	ND
Average Shale Conc.		20	0.3	95	90	45	6	1.5	1000				
Crustal Average		12.5	0.15	70	100	50	1.8	1.5		36	11	167	82



Correlation Coefficient and Factor Analyses

Using the Statistical Package for Social Sciences (SPSS) computer package (SPSS Inc. Released 2007), the Pearson correlation analysis revealed three groups for the significant metals. The first group include Cd, Cr, Cu, Pb, Mo and Zn which showed positive correlation of >0.5. The second group include As and Mn which showed positive correlation of <0.5 while the third group include Sc which showed negative correlation with other metals (Table 2). Metals with positive correlations are likely from the same origin or sources which is most likely dumpsites in this case, since they are toxic in nature.

This is also confirmed by R- mode factor analysis which revealed three groups of related elements and presented in Table 3.

Factor1: (Pb, Cr, Cu, As and Mo). This accounted for about 35.34% of the total variance in the data matrix with Eigenvalue of 3.18 which is the most significant. The source of these metals are more likely to be from leachates from the waste disposal sites.

Factor 2: (Cd, Zn and Mn). This accounted for about 25.04% of the total variance of the variables with an Eigenvalue of 2.25. The elements also showed positive correlation and mostly likely to be from the same source with those in group 1.

Factor 3. (Sc). This is the least significant of all the factors. It accounted for 16.68% with Eigenvalue of 1.50. Its presence may be geogenic because it has negative correlation with all other metals.

Table 2. Correlation Coefficient of the Metallic Ions in Soil Samples

	As	Cd	Cr	Cu	Sc	Pb	Mo	Zn	Mn
As	1.0								
Cd	.04	1.0							
Cr	.01	.71	1.0						
Cu	.04	.90	.82	1.0					
Sc	-.42	-.49	-.01	-.35	1.0				
Pb	.14	.90	.87	.92	-.44	1.0			
Mo	-.48	.54	.57	.63	-.09	.56	1.0		
Zn	.14	.90	.82	.89	-.51	.98	.61	1.0	
Mn	.28	.31	-.12	.15	-.28	.12	.33	.13	1.0

Table 3. Summary Factor Analysis of Trace Elements in Soil

Trace Elements	Factor 1	Factor 2	Factor 3	Communality
Pb	.788		-.491	.864
Cd	-.290	.768		.681
Zn		.886		.789
Cr	.783	-.441	.224	.789
Cu	.536	.319	-.68	.851
As	.864		.135	.771
Mo	.820		,143	.699
Sc	.327		.732	.648
Mn	.342	.749	.405	.842
Eigen values	3.180	2.253	1.501	
%Variance	35.338	25.035	16.680	
Cumulative % Variance	35.338	60.373	77.053	
Factor 1 :	Pb-Cr-Cu-As-Mo			
Factor 2 :	Cd-Zn-Mn			
Factor 3:	Sc			

Contamination Indices in Soil

Enrichment Factor (EF)

The results of EF are presented in Table 5. Soil samples showed background or depletion to minimum enrichment by As, Cr and Mo with the following ranges 0.45-1.45 and -0.18-1.45, 0.6-2.05 and 0.49-1.46, -0.5-2.5 and -0.5-2 for both active and abandoned dumpsites respectively. The enrichment factors of Cd, Zn, Ni, Pb and Cu for both sites fell within background to very high enrichment. Sc, V and Sr were only present in active soil samples with minimum enrichment while La showed background enrichment only in abandoned soil samples. Soil with very high enrichment metals were found within and very close to the dumpsites.

Geo-accumulation Index (Igeo)

Calculated Igeo values are presented in Table 5. The Igeo values for As, Cr, Mo, Mn, La and As, Sr, V fell in class 'I' (Value = <1) indicating background concentration for soil samples of abandoned and active sites respectively. Cr, Sc, Mo, Ni for active site and Cu for abandoned site fell in the class of 2 (Value = 0-1) indicating slight pollution. Cd, Pb and Zn ranged between moderate pollution to strong pollution for abandoned site while Cu, Cd, Pb and Zn fell within strong to extremely pollution for active site. The samples with strong to extreme pollution were those within and very close to the dumpsite

which was the case for enrichment factor.

Contamination Factor (CF) and Contamination Degree

The contamination factor of Cr, Sc, Mo, Sr, V, Mn and Cu for all the samples from active dumpsite ranged from 0.3-0.89, 0.76-2.11, 0-2.67, 0.05-0.35, 0.54-1.34, 0.07-1.51 and 0.32-1.4 respectively which showed low contamination to moderate contamination. Cr and La in the soil samples from abandoned dumpsite also showed low to moderate contamination with the following ranges 0.41-1.25 and 0.44-1.08 respectively. Soil samples from active and abandoned sites showed low to very high contamination with Cd, As, Zn and Pb respectively (Tables 4 and 5). Abandoned dumpsite showed higher values of contamination factors for most metals when compared with active dumpsite (Table 4).

The result of contamination degree ranged between 8.59-87.91 and 6.97-161.62 for active and abandoned sites respectively and fell within moderate degree of contamination to very high degree of contamination and low contamination degree to very high degree of contamination respectively (Table 4).

Table 4. Classification of Contamination Indices (Simex and Helz (1981), Mueller (1979), Hakanson (1980) and USEPA (1998).

Enrichment Factor		Contamination Factor		Contamination Degree		Geo-accumulation Index	
Value	Interpretation	Value	Interpretation	Value	Interpretation	Value	Interpetation
≤ 1	background concentration	Cf < 1	Low contamination factor	Cd<7	low degree of contamination	<0 (class 1)	practically uncontaminated
1- 2	depletion to minimal enrichment,		Moderate contamination factor	7 ≤ Cd<14	moderate degree of contamination	0-1 (class 2)	uncontaminated to slightly contaminated
	moderate enrichment	3 ≤ Cf < 6	Considerable contamination faetor	14 ≤ Cd<21	high degree of contamination	2-3 (class 3)	moderately to highly contaminated
5 – 20	significant enrichment,	Cf ≥ 6	Very high contamination factor	Cd ≥ 21	very high degree of contamination	4-5 (class 4)	highly to very strongly contaminated
20– 40	very high enrichment					>5 (class 5)	very strongly contaminated
> 40	extremely high enrichment						

*Cf = Contamination Factor
*Cd= Contamination Degree.

Table 5. Results of Trace Elements Contamination Assessment and Ecological Risk in both Active and Abandoned Dumpsites

Location	Indices	Trace Elements												
		As	Cd	Cr	Cu	Sc	Pb	Mo	Zn	Ni	Sr	V	Mn	La
Ojota (Active)	EF	0.45-1.45	5-49	0.6-2.05	0.57-21.65	0.76-2.1	1.3-40.65	0.5-2.5	1.34-21.77	0.52-2.26	0.05-0.35	0.54-1.34	0.12-2.59	
	Igeo	0.30-0.97	-3.3-32.67	0.44-1.37	0.04-5.44	0.51-1.41	0.37-27.1	0.33-1.67	0.23-14.65	0.35-1.51	0.03-0.24	0.36-0.89	0.08-1.73	
	CF	0.8-89	4-15.3	0.3-0.89	0.32-1.4	0.76-2.11	2.24-30.32	0-2.67	0.3-23.3	0.96	0.05-0.35	0.54-1.34	0.07-1.51	
	Enr	16-88.9	120-460	0.6-1.78	1.6-7		11.2-157.6		0.3-23.1	4.8				
	CD	8.59-87.91												
	RI	133.7-732.4												
Ibeju (Abandoned)	EF	0.18-1.45	6-23	0.49-1.46	0.7-3.7		1.08-14.58	0.5-2	0.28-21.87				0.08-2.89	0.44-1.08
	Igeo	0	2-3.91	-1.6-0.04	-1.1-1.3		-0.48-3.28	0-0.42	-2.4-3.87				-4.1-0.74	-1.75--0.47
	CF	2.78-8.89	0-32.67	0.11-1.25	0.26-9.96		2.72-84.56	0-3.3	0.36-23.2				0.05-1.67	0.44-1.08
	Enr	27.78-88.89	0-980	0.82-2.5	1.3-49.8		13.6-422.8		0.36-23.2					
	CD	6.97-161.62												
	RI	43.86-1567.2												

Table 6: Grades of the Environment by Potential Ecological Risk Index (Ren *et al.*, 2007)

Grade	E'_r value	Grade of ecological risk of single metal	RI value	Grade of potential ecological risk of the environment
A	$E'_r < 5$	Low Risk (LR)	RI < 30	Low Risk (LR)
B	$5 \leq E'_r < 10$	Moderate Risk (MR)	$30 \leq RI \leq 60$	Moderate Risk (MR)
C	$10 \leq E'_r < 20$	Considerable Risk (CR)	$60 \leq RI \leq 120$	Considerable Risk (CR)
D	$20 \leq E'_r < 40$	High Risk (HR)	$RI \geq 120$	Very High Risk (VHR)
E	$E'_r \geq 40$	Very High Risk (VHR)		

Table 7: Pre-industrial Reference Level (kg/g) and Toxic Response Factor (Håkanson,1980)

Elements	Cd	As	Ni	Cu	Pb	Cr	Zn
Pre-industrial reference level	1	15		50	7	90	175
Toxic-response factor	30	10	5	5	5	2	1

Assessment According to Ecological Risk Assessment (E'r) and Potential Ecological Risk Index (RI)

E'r of Cr in the soil samples of both active and abandoned dumpsites ranged between 0.6-1.78 and 0.82-2.5 respectively which indicated low risk (LR) while Zn showed low to moderate risk for all the samples (Tables 5 and 6). Soil samples of active dumpsite showed that Cu ranged from 1.6-7.0 which showed low to moderate risk while As and Pb ranged from 16-88.89 and 11.2-151.6 respectively which indicated considerable risk to very high risk. Soil samples of abandoned dumpsite showed that E'r of Cu ranged from 1.3-

39.8 (low to very high risk), Pb ranged from 13.6-122.8 (moderate to very high risk) and As ranged from 27.78-88.87 (considerable to very high risk) Tables 5 and 6. Eri of Cd in the soil samples of active and abandoned dumpsites ranged from 120-460 and 0-980 and fell within very high risk and low to very high risk respectively (Tables 5 and 6).

The sum of all the six risk factors for abandoned and active sites were calculated in order to quantify the overall potential ecological risk of the trace elements and the results for the two dumpsites are presented in Tables 5 and 6. The RI for soil samples of active and abandoned dumpsites ranged from 133.7-732.4 and 43.86-156.2 and fell within very high risk and moderate to very high risk respectively (Table 5 and 6).

CONCLUSION

This study assessed various contamination indices of trace elements in the soil within and around active and abandoned dumpsites in Lagos, Southwestern Nigeria. Out of the thirty six trace and rare earth elements analysed from the soil samples only Pb, Cd, Zn, Cr, Cu, As, Mo and Mn were significant for both sites while V, Sc, Sr and La were only significant for active and abandoned dumpsites respectively. The results of both correlation and factor analyses showed that there is positive correlation between all the significant metals and this indicates the same source(s) or origin for metals which is likely anthropogenic and from various wastes of the two dumpsites. The abandoned dumpsite located at Isolo was mainly for the disposal of municipal and domestic wastes while the active dumpsite located at Ojota is more diversified with combinations of municipal, domestic and industrial wastes and this may be responsible for the presence of more significant metals present in the soil samples.

The results of contamination indices such as Enrichment Factor and Contamination Factor showed that soil samples of the two dumpsites fell within depletion to minimal enrichment with Mo, Cr, Ni, Sc, V, Sr, La and low to very high degree of contamination with As, Cd, Pb, Zn and Cu. Geoaccumulation index showed that soil samples were within background to moderate contamination with As, Cr, Mn, La, Mo, Sr and V while Cd, Pb, Zn and Cu were in the class of moderate to strong to extremely strong contamination for all the samples.

Calculated potential risk assessment for six toxic metals recognized generally also showed that soil samples were within low risk with Cr, low to moderate risk with Zn and Cu while As, Pb and Cd fell within low to considerable to very high risk in the soil samples of the study area.

Result of Contamination Degree showed that active and abandoned dumpsites fell within moderate degree of contamination to very high degree of contamination and low contamination degree to very high degree of contamination respectively. The sum of the six risk factors within and around soil of active dumpsite can be classified as very high risk while those of abandoned dumpsite fell within moderate to very high risk.

Generally the soil samples at both sites were contaminated with Pb, Cd, Zn, Sc, Mo and Cu with various degree of contamination. Soil samples from the abandoned dumpsite showed higher level of contamination than those of active dumpsite. This may be due to total decomposition as a result of abandonment for a long time without any treatment measure thus resulting in leachates plume that migrated from the dumpsite to the soil within and beyond the vicinity of the dumpsite. Also there were more significant metals present in the active dumpsites as a result of varieties of wastes.

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