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Heavy Metal Contamination of Otofure Dumpsite Environment near Benin City Edo, Nigeria

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Abstract

This study characterized some indices of heavy metals in the soils of Otofure waste dumpsite environment near Benin City, Edo State in Southern Nigeria, in order to ascertain the level of heavy metal contamination of one of the several sites receiving municipal solid wastes daily. Six samples were collected at the dumpsite (DS) and the adjoining upland positions (US). The samples were air-dried, crushed and sieved through a 2mm sieve and pre-treated using standard methods before determining the heavy metal concentrations in Atomic Absorption Spectrophotometer (Bulk Scientific 210 VGP) according to the method of the Association of Analytical Chemists. Various pollution indexes were computed using the analytical data obtained. The computed Enrichment factor (EF) showed that Mn. Fe, and cu had no enrichment at the top and subsurface of the dumpsite. However, there was a significant Zn enrichment and enrichment with Ni and V at the topsoil; and Extreme enrichment with Cr, Cd, and lead of the soil at the dumpsite. Also, the soil Contamination factor (CF) indicated a moderate contamination of iron (Fe), manganese (Mn) and copper (Cu), Very High contamination of zinc (Zn), chromium (Cr), cadmium (Cd), lead (Pb), nickel (Ni) and vanadium (V). Pollution Load Index (PLI) showed that Otofure dumpsite is heavily polluted (PLI > 1) by heavy metals in general. Geoaccumulation Index (Igeo) showed that soils of Otofure dumpsite were unpolluted to moderately polluted for manganese (Mn) and copper (Cu), heavily polluted for zinc (Zn), Heavily to Extremely polluted for chromium (Cr), cadmium (Cd), lead (Pb), and nickel (Ni), and Extremely polluted for chromium (Cr), cadmium (Cd), lead (Pb) and vanadium (V). The potential ecological risk index (PERI) showed slight pollution for manganese (Mn), zinc (Zn) and copper (Cu), a very strong pollution for chromium (Cr), and an extremely strong pollution for lead (Pb), nickel (Ni) and cadmium (Cd). The risk index (RI) for Otofure dumpsite indicated a very strong risk or level D pollution for the higher elevation around the Otofure dumpsite environment that could pose human health risks if crops from that environment is ingested. This result thus suggest the need for a gradual shift from surface municipal waste dumping of solid wastes to well-engineered and managed recycling/sanitary landfill

in Edo State and Nigeria in order to prevent heavy metal pollution of lands and possibly groundwater where shallow aquifers exist.

Keywords: Heavy Metals; Waste Dumpsite; Otofure; Edo-Nigeria; Land Pollution; Soil Pollution; Solid Waste

Introduction

Waste management has become increasingly complex due to the increase in human population, industrialization and technological innovations which produce enumerable benefits plus the associated consumption-related waste streams resulting thereof. The processes that control the fate of wastes in the soil is complex and many of them are poorly understood [1]. Issues such as nutrients and other chemicals release rates, leaching of nutrients and metals through macro pores as suspended solids, and sludge organic matter effects on the sorption and degradation are often not understood by many researchers. The leaching of hydrophobic organics, long term bioavailability, and fate of metals fixed by soil organic matter need to be studied to gain a better approach in groundwater pollution handling [2]. Toxic chemicals that have high concentrations of nitrate and phosphate derived from the waste in the soil can filter through the dump and contaminate both the ground and surface water. Insects, rodents, snakes, scavenger birds, dust, noise, or bad odour are some of the aesthetic problems associated with sanitary landfills. Emissions of methane (CH_4) and carbon IV oxide (CO_2) and leachate contamination of ground water and soil are the environmental issues connected with the landfill [1].

Open dumps are the oldest and most common way of disposing solid wastes, and although in recent years thousands of them have been closed, many are still being used [3]. The frequently used municipal solid waste disposal methods include: composting, sanitary landfill, and pyrolysis, reuse recovery and recycling [4].

Municipal solid waste generally constitutes both the degradable and non-degradable substances which find their way into the underground water resources and soil strata. Though all natural resources have their own importance in the environment, soil has a major role to play. Ever since life existed, soil played a vital role in the growth of microbes useful for the nutrient cycling to make available all the essential nutrients required for the plant growth and nourishment [5].

Microorganisms in waste dumpsites use waste constituents as source of nutrients thereby detoxifying the materials as their digestive processes breakdown complex organic molecules into simpler less toxic molecules. In addition the soil organic matter helps in maintaining soil quality. Ekundayo noted that soil provide a suitable natural environment for biodegradation of wastes and therefore serve as a sink for the adsorption and absorption of ions and as a medium for the restoration of vegetation and normal land use [6]. Misuse of the soil by various anthropogenic activities will result in drastic impacts in the near future that are damaging to the ecosystem and the environment on the whole. Although solid waste can be an asset when properly managed, it poses the greatest threat to life and health due to its potential of contaminating terrestrial, aquatic and aerial environments. This contamination of surface water, groundwater, soil and air is associated with wide range of human health and ecological impacts thereby contributing to the degradation of vital natural resources [7].

The dumpsites in most developing countries are usually unlined shallow hollow excavations arising from abandoned burrow-pits and quarry-sites without any environmental impact assessment studies [8]. Eventually these waste dumpsites with waste heaps become a potential threat to the soil and the underground water resources due to the leachate percolation in the course of time. The leachate from open dumps and landfills contain both chemical and biological constituents. Million tons of solid wastes from different sources like industrial, agricultural, commercial, and residential; pave their way onto the soil interfering with the natural activity of the soil [5].

Several wastes from different sources find the way into the environment and finally end up in the dump sites posing severe contamination of soil due to the heterogeneity. Soils serve as a natural sink for the pollutants released from both natural and man-made sources [5]. Though the municipal solid waste in developing countries like India is mostly food wastage, the decomposition of the organic matter will change the physicochemical properties of the soil affecting the underlying groundwater sources through leachate percolation [5]. Assessment of soil pollution becomes

difficult when contaminants belong to different sources and their products are variably distributed [9]. Solid waste pollutants serve as an external force affecting the physicochemical characteristics of soil ultimately contributing towards the poor production of vegetation [10]. The disturbances of higher intensity sometimes endanger the survival of some species and yield to low richness. Therefore it is utmost important to understand the soil geology and chemistry to assess the impact of the pollutants released onto the fertile layer [11]. The primary objective of this study was to assess the nature and extent of heavy metals contamination of the surface waste dumpsite environment using different pollution indices.

Methodology

Study Site: This study was conducted at the Otofure Dumpsite in the suburb of Benin City, Edo, Nigeria. It is operated by the Waste Management Board of the Ministry of Environment of the state Government. This surface municipal waste dumpsite as is commonly the case in Nigeria is a final disposal site of municipal solid wastes from residence in Benin City metropolis. It is a former burrow pit for lateritic sand for construction that was later converted. Cassava (*Manihot utilisima*) is grown at the upland section of the dumpsite, with several small sheds used by scavengers who collect recyclable materials for sale at the periphery. The lower section (downslope) receives daily supplies of solid waste.

Sample Collection

The soil samples were collected from two locations each during the dry season at three depths (0-15cm, 16-30cm and 30-45cm) with a soil auger at the downslope (DS) and upslope (US) positions of the dumpsite. About 500g of soil sample from each and placed in labeled ziploc bags. A hand-held GPS (Garmin model eTrexHcSerier) was used to obtain the geographic coordinates of each sampling location. Samples collected were placed in a cooler and taken to the laboratory for analysis. Sample preparation: The soil samples collected were air-dried at 25°C-27°C for a period of 72 hours. The samples were crushed and sieved through a 2mm sieve and packed in a well labeled Ziploc bags for

Heavy metals were determined in the Laboratory for Ecotoxicology and Environmental Forensics, University of Benin, Benin City. Sample digestion and the determination of the heavy metal concentration in the digested samples were carried out by the method of the Association of Analytical Chemists, (AOAC, 2000). Heavy metal analysis was carried out using Atomic Absorption Spectrophotometer (AAS Bulk Scientific 210 VGP). The equipment was first calibrated using buck certified atomic absorption standards for the respective heavy metals to obtain calibration curve. Reagent blank was first run at intervals of every ten sample analysis to eliminate equipment drift. All samples were analyzed in duplicates for reproducibility, accurate check and precision. Quantitative indices were used in this study to assess the heavy metal concentration which was aimed at ease of comparison between the determined parameters. These assessment indices were determined below.

Enrichment Factor

Soil Enrichment factor or EF was determined according to Simex and Helz [12]. EF was determined to assess the degree of contamination and to understand the distribution of the elements of anthropogenic origin from sites by individual elements in soil. In this instance, Iron (Fe) was chosen as the normalizing element while determining EF values, since it is one of the widely used reference element [13-16]. EF values close to 1.0 indicate crusted origin; those less than 1.0 suggest a possible mobilization or depletion of metals, whereas EF>1.0 indicates that the element is of anthropogenic origin in Nweke and Ukpai [16-18]. The formula for computing the enrichment factor is expressed as:

Enrichment Factor = (X /Fe) soil / (X /Fe) background

Where: X = Individual heavy metal concentration in the soil (mg/kg)

F=Fe concentration in the soil (mg/kg)

According to Sutherland (2000), five categories are generally recognized on the basis of enrichment factor (EF).

EF < 2: depletion of mineral enrichment or no enrichment

2≤EF<5: moderate enrichment

5≤EF<20: significant enrichment

20≤EF<40: very high enrichment

EF>40: extremely high enrichment

Contamination Factor (CF) and Pollution Load Index (PLI): Pollution severity and its variation were determined with the use of pollution load index. PLI was calculated according to Hakanson [19]. This concentration factor is the quotient obtained by dividing the concentration of each metal. Assessed as the ratio obtained by dividing the concentration of each metal in the soil by baseline or background value (concentration in uncontaminated soil):

$$CF_{metal} = C_{metal/} C_{background}$$

The pollution load index is obtained as concentration factor. According to Hakanson, CF values were interpreted as follows [19]:
If CF < 1: low contamination.
1 < CF > 3: moderate contamination.
3 < CF < 6: considerable contamination.
CF > 6: very high contamination.

While PLI can be expressed as

$$PLI\ of\ a\ study\ area = n\sqrt{C_f^i 1 \times C_f^i 2 \times C_f^i\ 3 \times C_f^i \ldots \times C_f^i n}$$

For assessing the level of heavy metal pollution this empirical index provides a simple, comparative means. When PLI > 1, it means that a pollution exists; otherwise, If PLI < 1, there is no metal pollution in Nweke and Ukpai, [16].

Geo accumulation index (Igeo): Igeo was calculated according to Ihenyen, Igeo has been widely used to evaluate the degree of heavy metal contamination in terrestrial and aquatic environments [20, 21]. It is expressed by Muller, (1969) and Boszke, et al, as [22]:

$$Igeo = Log2\ (C_n / 1.5\ B_n)$$

Where Cn is the measured concentration of the metal (n) in the sample and Bn is the geochemical background concentration of the metal, n. the factor 1.5 is used to minimize the effects of possible variations in the background values which may be attributed to lithological variations in soils. Igeo consists of seven classes (0 to 6), indicating various degrees of enrichment above the background values and ranging from unpolluted to very highly polluted as expressed by Muller, and Boszke, et al. [20, 21].

Class 0 (practically unpolluted): Igeo ≤ 0
Class 1 (unpolluted to moderately polluted): 0<Igeo<1
Class 2(moderately polluted): 1<Igeo<2;
Class 3 (moderatelyto heavily polluted): 2<Igeo<3;
Class 4 (heavily polluted):3<Igeo<4;
Class 5 (heavily to extremely polluted):4<Igeo<5;
Class 6 (extremely polluted):5>Igeo
(Source: Nweke and Ukpai, (2016)

Potential Ecological Risk Index (PERI)

The potential ecological risk index method of Hakanson, was used to evaluate heavy metal contamination from the perspective sedimentology reflected in equation below and was adopted to evaluate the heavy metal pollution in the soils and also to associate ecological and environmental effects with their toxicology and the toxic-response factor T_{ri} of Cu, Zn, Cd, Mn, Fe and Pb. An ecological risk factor (*Er*) is quantitatively expressed as the potential ecological risk of a given contaminant [19].

$$Er = Tr \cdot Cf$$

Where *Tr*is the toxic-response factor for a given substance and *Cf*is the contamination factor. The following terminologies are used to describe the ecological risk factor: *Eri*<40, low potential ecological risk; 40≤*Eri* <80, moderate potential ecological risk; 80≤*Eri* <160, considerable potential ecological risk; 160≤*Eri* <320, high potential ecological risk; and *Eri*≥320, very high ecological risk. The potential ecological risk index (RI) was in the same manner as degree of contamination defined as the sum of the risk factors.

$$RI = \sum_{i=1} Er$$

Where *Er i* is the single index of ecological risk factor, and m is the count of the heavy metal. The following terminologies are used for the potential ecological risk index as given by Hakanson; *RI<150*, low ecological risk; *150≤RI<300*, moderate ecological risk; and *RI>600*, very high ecological risk [19].

E^i_R	Pollution Degree	RI	Risk level	Risk Degree
EiR< 30	Slight	RI< 40	A	Slight
30≤EiR< 60	Medium	40 ≤ Ri< 80	B	Medium
60≤EiR<120	Strong	80≤Ri< 160	C	Strong
120≤EiR< 240	Very Strong	160≤RI 320	D	Very strong
EiR≥ 240	Extremely strong	RI≥ 320	-	-

Table 1: Adjusted Grading Standard of Potential Ecological Risk of Heavy Metals in Soil.
E^i_R is the potential ecological risk index of a single element; RI is a comprehensive potential ecological risk index.

Statistical Analysis

All statistical tests were carried out using Microsoft Excel software. All the data obtained were subjected to descriptive analysis. Data analyses for EF, CF, PLI, Igeo and PERI were done by adopting their models into Microsoft excel (2003).

Results

Table 2 and Figure 1 shows the enrichment factor (EF) in the study area. The table below indicates a depletion of Fe, Mn, and Cu in all the sample points as EF for Fe, Mn and Cu was < 2. There is a very high enrichment for Zn at DS at the soil surface (0-15cm) as EF for Zn was 20≤EF<40 while a significant enrichment of Zn was recorded at other sampled depths as EF for Zn was 5≤EF<20 except for US depth of 31-45cm which indicated a moderate enrichment as EF for Zn was 2≤EF<5. Cr and Pb had very high enrichment at all depths as EF was 20≤EF<40. There was an extremely high enrichment of Cr and Pb at all depths in the downslope position of the Otufure dumpsite as EF for Cr and Pb as EF>40. Similarly, there was an extremely high enrichment of Cd in all the sampled depths as EF value for Cd exceeded 40 except for the 31-40cm depth at the upslope (US) position of the dumpsite (EF for Cd 20≤EF<40).There was a significant enrichment of Ni at US depth of 16-30cm and 31-45cm as EF for Ni was 5≤EF<20, while a very high enrichment was recorded in other sampled depths as EF for Ni was 20≤EF<40. There was also an extremely high enrichment of V at DS depth of 0-15cm and 16-30cm as EF for V is EF>40. There was a very high enrichment for V at DS depth of 31-45cm, US depth of 0-15 cm and 16-30cm as EF for V was 20≤EF<40. Also, there was a significant enrichment of V at US depth of 31-45cm as EF for V was 5≤EF<20.

Enrichment factor across the Locations/depth						
HM*	**DS1**	**US1**	**DS1**	**US1**	**DS1**	**US1**
	(0-15cm)	(0-15cm)	(16-30cm)	(16-30cm)	(31-45cm)	(31-45cm)
Fe	1.23	0.4	1.1	0.32	0.95	0.23
Mn	1.96	0.65	1.76	0.49	1.52	0.38
Zn	20.59	6.77	18.53	5.34	15.94	3.87
Cu	1.78	0.73	1.75	0.59	1.43	0.48
Cr	68.63	30.13	63.75	26.26	50.89	21.41
Cd	106.67	46.83	99	40.67	79.17	33.25
Pb	65.58	28.75	60.92	25	48.67	20.38
Ni	39.61	23.58	36.44	18.67	31.44	14.03
V	49.86	29.68	45.86	23.5	39.59	17.68
* Heavy Metals						

Table 2: Soil Enrichment factor (EF) of Otofure Waste Dump Environment

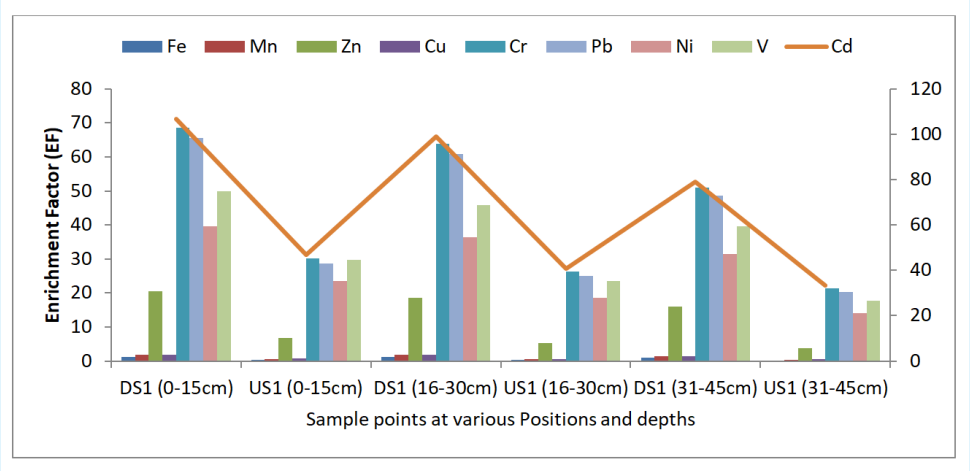

Figure 1: Enrichment factor across the sample depths of Otofure Dump site environment.

Table 3 shows the concentration factor of the study site. Low contamination of Fe, Mn, and Cu was observed in all the US points at all depths as CF < 1, while all the DS points at all depth recorded a moderate contamination for Fe, Mn and Cu as CF was 1 < CF > 3. There was a considerable contamination of Zn at US depths of 16-30 cm, and 31-45cm while other sample depths recorded values >6, thus reflecting very high contamination. There was a very high contamination of Cr, Cd, Pb, Ni and V (CF ≥ 6) in all the sampled depths. The PLI value across all the study areas in adopting Tomlinson, et al. indicates that all the sampled areas are polluted (PLI > 1) as shown in Table 3 under the PLI values. The result from the contamination factor further explains the status of contamination of the dumpsite observed from EF above. Figure 3 shows the spatial variation for the various heavy metals adopted for pollution load index (PLI). The trends observed across all sample points at across all depths were different indicating the pollution status>1. However, it is observed that soils collected at the center of Otofure dumpsite was far higher than soils collected from the adjoining upslope land nearby.

Concentration Factor										
Location	**Fe**	**Mn**	**Zn**	**Cu**	**Cr**	**Cd**	**Pb**	**Ni**	**V**	**Pollution**
Load Index										
DS1(0-15cm)	1.23	1.96	20.95	1.78	68.53	106.67	65.58	39.61	49.86	16.35
US1 (0-15cm)	0.4	0.65	6.77	0.73	30.13	46.83	28.75	23.58	29.68	6.92
DS1 (16-30cm)	1.1	1.76	18.53	1.75	63.75	99	60.92	36.44	45.86	15.08
US1 (16-30cm)	0.32	0.49	5.33	0.59	26.26	40.67	25	18.67	23.5	5.64
DS1 (31-45cm)	0.95	1.52	15.94	1.43	50.86	79.17	48.67	31.44	39.59	12.6
US1 (31-45cm)	0.23	0.38	3.87	0.48	21.41	33.25	20.38	14.02	17.68	4.37

Table 3: Soil Concentration Factor and the Pollution Load Index of Otofure Dumpsite.

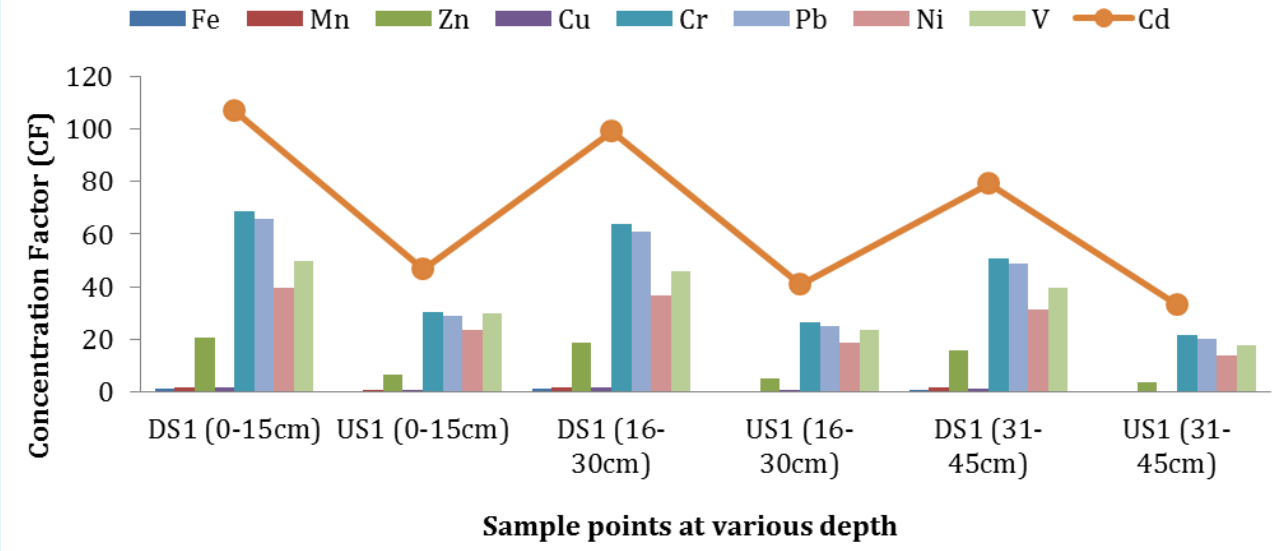

Figure 2: Soil Concentration factor across the Otofure Dumpsite Environment at various depths.

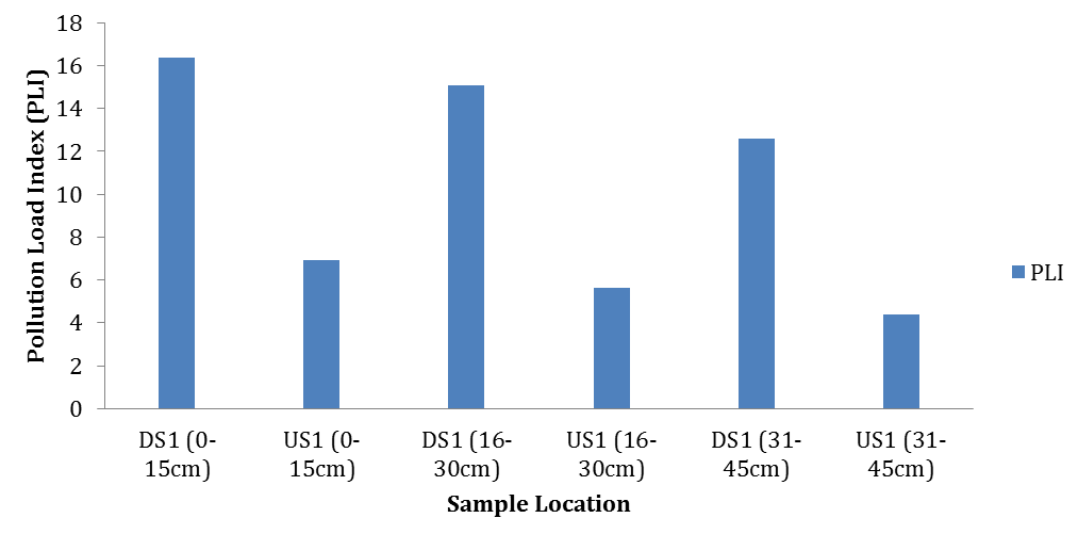

Figure 3: PLI values across the sample points at various depths of Otofure Dumpsite Environment.

Table 4 shows the summary of Igeo of heavy metals contamination in Otofure dumpsite. The soils of Otofure dumpsite falls within the seven classes based on Muller's interpretation. The soil sample obtained from all the sampled depths in relation to Fe shows negative values of heavy metal contamination and this means that the soil was practically unpolluted (Igeo ≤ 0), while the soil sample obtained for Mn and Cu from US depth and DSdepth of 31-45cm also recorded negative values of metal contamination and was practically unpolluted (Igeo ≤ 0).The soil sample obtained from other DS and US depths for Mn and Cu were unpolluted to moderately polluted (0<Igeo<1). In relation to Zn, the soil sample obtained from US depth of 16-30cm and 31–45cm were moderately polluted (1<Igeo<2), while the soil samples obtained at US depth of 0-15 cm was moderately to heavily polluted (2<Igeo<3).The soil sample obtained from all DS depths for Zn were heavily polluted (3<Igeo<4). In relation to Cr and Pb, the soil samples obtained from the US depth at 31-45cm were heavily polluted (3<Igeo<4). In relation to Cr, Cd and Pb, the soil samples collected for US depths at 0-15cm and 16-30cm were heavily to extremely polluted (4<Igeo<5), while the soil samples obtained for Cr, Cd and Pb from all sampled DS depths were extremely polluted (5>Igeo). The soil sample obtained for Ni was similar to V as all the DS depths were heavily to extremely polluted (4<Igeo<5) while all the US for Ni and V at all sampled depths were heavily polluted (3<Igeo<4) except for US for V with a depth of 0-15cm which was heavily to extremely polluted (4<Igeo<5) (Figure 4).

Geoaccumulation Index (*Igeo*)						
HM	**DS1**	**US1**	**DS1**	**US1**	**DS1**	**US1**
	(0-15cm)	(0-15cm)	(16-30cm)	(16-30cm)	(31-45cm)	(31-45cm)
Fe	-0.29	-1.89	-0.44	-2.24	-0.66	-2.7
Mn	0.38	-1.2	0.23	-1.57	0.02	-1.97
Zn	3.78	2.17	3.63	1.83	3.41	1.37
Cu	0.24	-1.05	0.22	-1.34	-0.07	-1.63
Cr	5.52	4.33	5.41	4.13	5.08	3.84
Cd	6.15	4.96	6.04	4.76	5.72	4.47
Pb	5.45	4.26	5.34	4.06	5.02	3.76
Ni	4.72	3.97	4.6	3.64	4.39	3.23
V	5.05	4.31	4.93	3.97	4.72	3.56

H/M – Heavy Metal

Table 4: Igeo of Heavy Metal Contamination in the Study Areas.

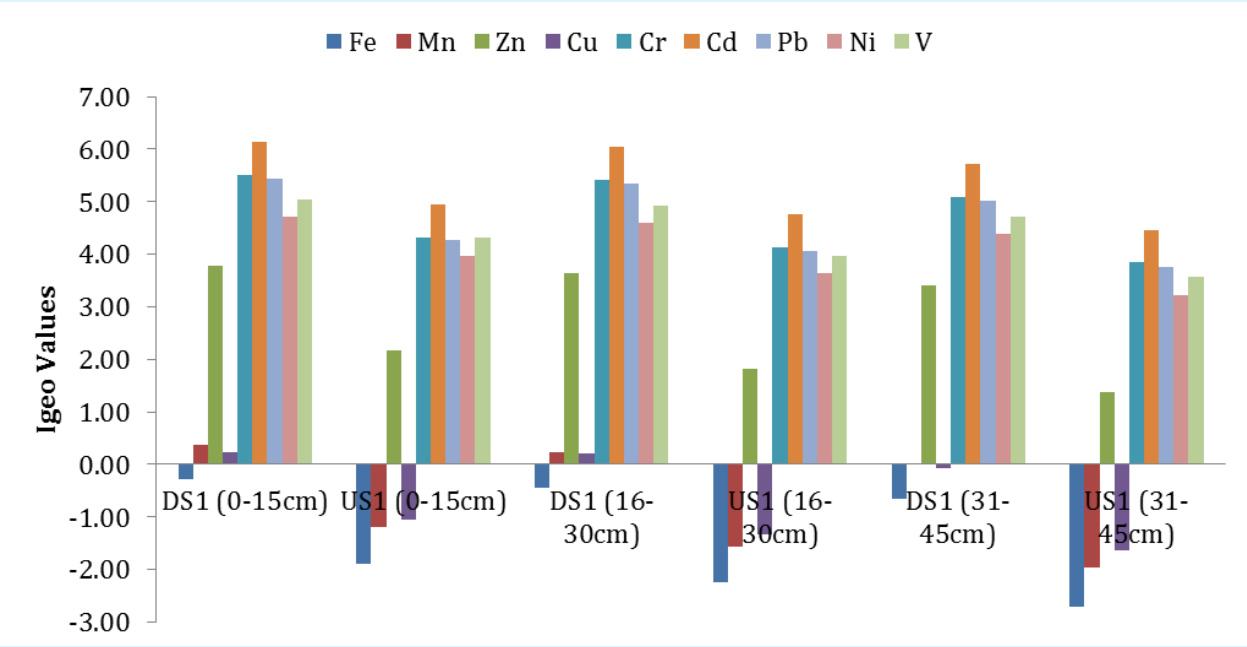

Figure 4: Igeo values Across the Sample points at Various Depths of Otofure Dumpsite Environment.

Five pollution degree and four risk levels were recognized in relation to the potential ecological risk index and will be used in assessing the soils obtained from Otofure dumpsite in Benin City. Table 5 shows the potential ecological risk index for the various heavy metals determined. There was a slight pollution of Mn, Zn and Cu (E^i_R<30) across all the sampled depths. In relation to Cr, medium pollution (30≤EiR< 60) exists at US depth of 16-30 cm and 31-45cm, a strong pollution (60≤EiR<120) exist at US depth of 0-15cm and DS depth of 16-30cm and 31-45cm while a very strong pollution for Cr exists (120≤EiR< 240) at DS depth of 0-15cm. There was a strong pollution (60≤EiR<120) for Pb at US depth of 31-45cm while other sampled depth for US indicated a very strong pollution (120≤EiR< 240). Pb concentration across all sample DS depths indicated extremely strong pollution degree (E^i_R ≥240). There was a very strong pollution of Ni (120≤EiR< 240) across all the US depths while an extremely strong pollution degree (E^i_R ≥240) exist for Ni at all DS depths. Cd concentration across the sampled depths indicated extremely strong pollution degree (E^i_R ≥240). There was a very strong risk degree or level D (RI≥ 320) across Otofure dumpsite in Benin City (Figure 5).

T^i_R	Mn	Zn	Cu	Cr	Pb	Ni	Cd	RI
EiR	1	1	5	2	5	5	30	-
DS1 (0-15cm)	1.96	20.95	8.9	137.26	327.9	198.05	3200.1	3894.76
US1 (0-15cm)	0.65	6.77	3.65	60.26	143.75	117.9	1404.9	1737.88
DS1 (16-30cm)	1.76	18.53	8.75	127.5	304.6	182.2	2970	3613.34
US1 (16-30cm)	0.49	5.33	2.95	52.52	125	93.35	1220.1	1499.74
DS1 (31-45cm)	1.52	15.94	7.15	101.72	243.35	157.2	2374.1	2901.98
US1 (31-45cm)	0.38	3.87	2.4	42.82	101.9	70.1	997.5	1218.97

Table 5: Potential Ecological Risk Index.

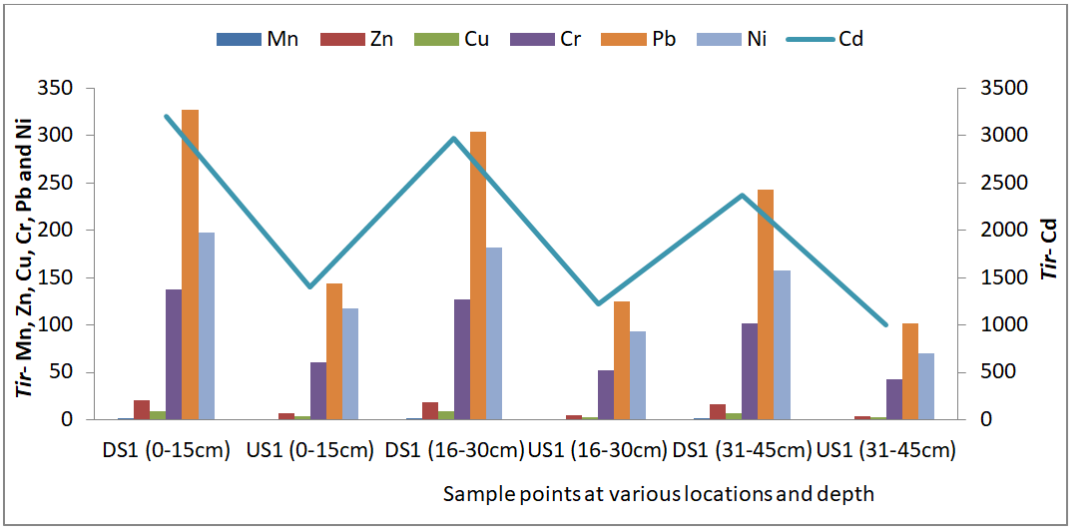

Figure 5: PERI Values across the Sample points at Various Depth of the Study Area.

Discussion and Conclusion

Enrichment factor (EF) showed high enrichment for Zinc (Zn), very high enrichment for chromium (Cr), lead (Pb) and nickel (Ni), an extremely high enrichment for chromium (Cr), lead (Pb), cadmium (Cd) and vanadium (V). Contamination factor (CF) indicated a moderate contamination for iron (Fe), manganese (Mn) and copper (Cu), very high contamination for zinc (Zn), chromium (Cr), cadmium (Cd), lead (Pb), nickel (Ni) and vanadium (V). Pollution load Index (PLI) showed that Otofure dumpsite is polluted (PLI > 1) by heavy metals. Geoaccumulation Index (Igeo) showed that soils of Otofure dumpsite were unpolluted to moderately polluted for manganese (Mn) and copper (Cu), heavily polluted for zinc (Zn), heavily to extremely polluted for chromium (Cr), cadmium (Cd), lead (Pb), and nickel (Ni), and extremely polluted for chromium (Cr), cadmium (Cd), lead (Pb) and vanadium (V). Potential ecological risk index (PERI) showed slight pollution for manganese (Mn), zinc (Zn) and copper (Cu), a very strong pollution for chromium (Cr), and an extremely strong pollution for lead (Pb), nickel (Ni) and cadmium (Cd). The risk index (RI) for Otofure dumpsite indicated a very strong risk or level D for Otofure dumpsite. Thus, it is possible to ascertain that the activities of man carried out in Otofure dumpsite are relatively detrimental to the soil which has shown to increase the level of metals in the soil.

Various studies have shown that heavy metals such as Zn, Pb, Cd and Ni, amongst others are responsible for certain diseases that have lethal effects on man and animals, and due to their accumulation and long-time retention by plants and animals, these metals are very dangerous. The findings from this study indicate high level of Zn, Cd, Pb, Ni and V mostly from a depth of 0-15cm in the soil for both downslope and upslope. Thus, it is possible to ascertain that the activities of man carried out in Otofure dumpsite are relatively detrimental to the soil which has shown to increase the level of metals in the soil. There is a need to assess the heavy metal concentration of plants grown around the dumpsite in Benin City.

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