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**Assessment of Some Heavy Metals in Soil Samples from some Waste  
 Dumpsites in Kano Metropolis, Nigeria Using INAA Technique**

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**ABSTRACT**

Investigations were carried out to determine the presence of some heavy metals in some selected dumpsites in Kano metropolis, Nigeria. Soil samples were collected from five different sampling locations. The samples were prepared in the laboratory according to standard methods and Instrumental Neutron Activation Analysis (INAA) was adopted in the analysis of the data using Nigeria Research Reactor – 1 (NIRR -1). The following heavy metals; Mn, Zn, Fe, Cr, V, As, Co, Rb, Cs, Lu, Ta, and Th were identified in the samples at various levels of concentration. The results of the analysis indicated that, there was gradual decrease in concentration with depth (reading obtained with samples at 20-30cm depth were higher than that obtained with samples at 50-60cm depth at all sampling locations). The results of the analysis also showed the presence of Zn, Fe, Cr, Co, Rb, Lu, Ta and Th were found to be higher concentration while V, As, and Cs in lower concentration. Enrichment index and Geo-accumulation index were also determined in order to estimate how much the soil is impacted (naturally and anthropogenic) with heavy metals and evaluate the degree of metal contamination or pollution respectively. The Enrichment index of Mn, Zn, Fe, Cr, V, As, Co, Rb, Cs, Lu, Ta, and Th were calculated and found to be lower (not enriched) in the samples except Co, Cr, Zn, in YK, Lu, Ta, Th, in YL also Lu, Ta, Th, in GG and RJ were found to be extremely high enrichment. Also, the Geo accumulation index calculated shows that the soil sample were from strongly uncontaminated to moderately contaminated materials. The results indicate that there is need for assessing more elements to establish comprehensive Data in the study area.

**Keywords:** Heavy metals, Soil, Dumpsite, Enrichment index and Geo-accumulation index

## 1.0 INTRODUCTION

Waste handling facilities are lacking in many highly populated areas in most developing and underdeveloped countries due to cost and lack of enforcement of relevant enactment. Poor regional and urban planning, lack of enforcement of relevant laws and edicts on waste disposal, lack of organized landfill sites contribute to the presence of dumpsites within living areas in developing nations, has resulted in the discharge of household sewage, industrial wastes and refuse into the environment untreated (Abdus-Salam *et al.*, 2011). Similarly, the recent population and industrial growth has led to increasing production of domestic, municipal and industrial wastes, which are indiscriminately dumped in landfill and water bodies without treatment (Ogunyemi *et al.*, 2003). Solid waste management constitutes one of the most crucial health and environmental problems facing administration and management of African cities. This is because even though these cities are using 20-50 percent of their budget in solid waste management, only 20-80

percent of the waste is collected. The uncollected or illegally dumped wastes constitute a disaster for human health and the environmental degradation (Achankeng, 2003). Most of old landfills and dumpsites existed in developing countries became a threat for human health for the next decades, unless appropriate measures are taken. Most developing countries follow the practice of open dumping of solid wastes causing environmental and health risks (Kurian *et al.*, 2003; Njagi, 2013).

Some of the environmental problems arising from poor disposal of solid waste include health hazards, soil and water pollution, repulsive sight and offensive odor. The resultant of these is the degradation of our environmental quality (Abdus-Salam, Ibrahim and Fatoyinbo, 2011). Most dumpsites are located within the vicinity of living communities and wetlands. The dumpsites are often not lined nor basement prepared for selective adsorption of toxic substances. Therefore, it is prone to release of pollutants to

nearby water and to the air through leachates and dumpsite gases respectively (Alimba, Bakare and Latunji, 2006).

In line with the above statement, the emergence of industrial and municipal solid waste into our environment has contributed greatly to the increase in levels of heavy metals in soil and plants on these dumpsite will constitute a serious threat to the health of people domesticating within such areas ( Adefemi and Awokumi, 2009). Wong *et al.* (2003) showed that heavy metals are potentially toxic to crops, animals, and humans when contaminated soils are used for crop production. Pollution of the biosphere with heavy metals, induced by industrial, agricultural, and domestic activities, poses serious problems for safe use of agricultural lands (Fytianos *et al.*, 2001). Most studies of metal leaching in soil columns or field investigations conclude that trace metals are strongly bound to topsoil (Sukkariyah *et al.*, 2005).

In some dumpsites, wastes are burnt in the open and ashes abandoned at the sites, with no regard to environmental implications. This poses a direct safety threat because of the danger of explosion. The burning of wastes gets rid of the organic

materials and oxidizes the metals, leaving the ash richer in metal contents. After the processes of oxidation and corrosion, these metals get dissolved in rain water and are then leached into soil from where they are picked up by growing plants thereby entering the food chain (Harrison and Chirgawi, 1989; Benson and Ebong, 2005). Excess heavy metal accumulation in soils is toxic to humans and other animals. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer. Acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact, but is possible. Chronic problems associated with long-term heavy metal exposures are: i) Lead – mental lapse. ii) Cadmium – affects kidney, liver, and GI tract. iii) Arsenic – skin poisoning, affects kidneys and central nervous system (USDA and NRCS, 2000). That is why this study was initiated with an objective of investigating the concentration levels of heavy metals in soil samples from the selected waste dumpsites and estimating how much the soil is polluted/impacted (naturally and anthropogenic) with heavy metal, in order to reduce the possible transfer of metals into plants, human and livestock in the study area.

**Table 1: The geographical location of sample point using GPR Reader**

Place	Sam ple code	Dep th in cm	Coordin ates N E	Elevat ion in m
'Yantag waye	YT1	20- 30c m	11° 57' 3" 8° 29' 59"	472.2
	YT2	50- 60c m	11° 57' 3" 8° 29' 59"	472.2
'Yankusa	YK1	20- 30c m	11° 54' 28" 8° 28' 28"	439.4
	YK2	50- 60c m	11° 54' 28" 8° 28' 28"	439.4

### 2.1. Sample Collection

Soil samples were randomly collected at a depth of about 20 – 30cm and 50 – 60cm using auger from each of these five dumpsites. The soil samples were packed in plastic containers,

'Yanlem o	YL1	20- 30c m	11°54' 50" 8° 33' 8"	473.5
	YL2	50- 60c m	11°54' 50" 8° 33' 8"	473.5
Ranji	RJ1	20- 30c m	12°1' 26" 8° 34' 10"	466.3
	RJ2	50- 60c m	12°1' 26" 8° 34' 10"	466.3
Gyadi Gyadi	GG1	20- 30c m	11° 58' 0" 8° 32' 34"	470.3
	GG2	50- 60c m	11° 58' 0" 8° 32' 34"	470.3

### 2.0 MATERIALS AND METHODS

properly sealed and labeled for easy identification. It was transported to the environmental laboratory at Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Nigeria, for analysis.

## 2.2 Sample Preparation

The collected Soil samples were crushed and converted into powder (sieved to tiny bits of 38µm) (Kogo *et al.*, 2009; Abdullahi *et al.*, 2013). 0.152g of the samples were wrapped in polythene then placed in a vial of 7cm<sup>3</sup>. The polythene and rabbit capsules containing the samples were cleaned by soaking in 1:1 HNO<sub>3</sub> (Nitric acid) and then washed with de-ionized water in order to eliminate any contamination prior to short and long irradiations on the reactor neutron source. A similar procedure is adopted for Standard Reference Materials (SRM) IAEA Lichen 336 which will also be weighted and packed together with the sample for short and long irradiations. The purpose of the SRM is for quality control of the experimental procedure (Abdullahi *et al.*, 2013 and Yamusa *et al.*, 2013).

## 2.3 Sample Analysis

To analyze the data, two irradiation schemes were adopted based on the half-life of the product radionuclide. For elements leading to short lived activation product, the prepared samples were irradiated at a thermal flux of 1.0x10<sup>11</sup>ncm<sup>-2</sup> in an outer irradiation channel B4, for element leading to long lived activation product, samples were irradiated at a thermal flux of 5.0x10<sup>11</sup>ncm<sup>-2</sup> for 6 hours in the inner irradiation channel as reported by Jonah *et al.* (2006). Following the short-lived irradiation regime the first-round counting was done for 10mins (i.e. S1) after a waiting time of 2-5mins. The second round of counting was carried out 10mins following the irradiation regime (i.e. S2) after a waiting period of 3-4 hours. In long irradiation regime, the first counting was done for 30mins, after a waiting time of 4-5 days and the second counting was carried out for 60mins after a cooling time of 10-15 days. Finally, the identification of gamma-ray of product radionuclide through their energies and quantitative analysis of the concentration of

each of the elements in the samples were obtained by using the gamma-ray spectrum analysis software, "Winspan 2003" (Butu and Iguisi, 2013).

## 2.4 Enrichment Index

A common approach to estimate how much the soil is impacted (naturally and anthropogenic ally) with heavy metal was to calculate the Enrichment Factor (EF) for metal concentrations above un-contaminated background levels (Fagbote and Olanipekun,

$$EF = \frac{\left(\frac{C_{Metal}}{C_{normalizer}}\right)_{soil}}{\left(\frac{C_{metal}}{C_{normalizer}}\right)_{Control}} \quad 1.0$$

Where C<sub>metal</sub> and C<sub>normalize</sub> are the concentrations of heavy metal and normalize in soil and in unpolluted control.

## 2.5 Geo Accumulations Index (I<sub>geo</sub>)

Index of Geo-accumulation (I<sub>geo</sub>) has been used widely to evaluate the degree of metal contamination or pollution in terrestrial, aquatic and marine environment (Tijjani and Onodera, 2009). The I<sub>geo</sub> of a metal in soil was calculated with formula (Medolla *et al.*, 2008; Fagbote and Olanipekun, 2010):

$$I_{geo} = \log_2 \left[ \frac{C_{metal}}{1.5 \times c_{metal (control)}} \right] \quad 2.0$$

C<sub>metal</sub> Is the concentration of the heavy metal in the enriched sample and C<sub>metal (control)</sub> is the concentration of the metal in the unpolluted sample or control. the factor 1.5 is introduced to minimize the effect of the possible variations in the background or control values which may be attributed to lithogenic variations in the soil (Medolla *et al.*, 2008; Fagbote and Olanipekun, 2010).

### 3.0 RESULTS AND DISCUSSIONS

#### 3.1 Heavy Metal Concentrations

Table 2 presents the results of heavy metals concentration levels of soil at some selected five waste dumpsites at various depths. The results indicate significant variation in heavy metal levels in soil.

**Table 2: Heavy Metals Concentrations**

<b>SAMPLE ID/ HEAVY METALS</b>	<b>YK 1 (20-30) cm depth Mean (ppm)</b>	<b>YK 2 (50 -60) cm depth Mean (ppm)</b>	<b>YL 1 (20-30) cm depth Mean (ppm)</b>	<b>YL 2 (50 -60) cm depth Mean (ppm)</b>	<b>GG 1 (20-30) cm depth Mean (ppm)</b>	<b>GG 2 (50 -60) cm depth Mean (ppm)</b>	<b>RJ 1 (20-30) cm depth Mean (ppm)</b>	<b>RJ 2 (50 -60) cm depth Mean (ppm)</b>	<b>YT 1 (20-30) cm depthMean (ppm)</b>	<b>YT 2 (50 -60) cm depth Mean (ppm)</b>
<b>Mn</b>	326	291	382	288	446	322	327	294	3926	1376
<b>Zn</b>	294	138	55.0	52.1	603	245	348	290	523	BDL
<b>Fe</b>	37070	25820	20730	18870	28410	10940	21640	18050	106000	48160
<b>Cr</b>	44930	18980	77.2	57.2	39.3	19.9	158	18.9	993	175
<b>V</b>	39.7	37.3	31.0	30.3	34.4	16.3	26.5	17.8	74.6	73.3
<b>As</b>	3.39	2.30	0.86	0.79	1.51	0.79	BDL	BDL	7.53	BDL
<b>Co</b>	307	242	4.88	3.01	3.31	7.74	4.23	3.47	14.2	6.00
<b>Rb</b>	62.3	56.3	88.1	74.2	71.2	97.4	138	132	BDL	BDL
<b>Cs</b>	1.56	1.21	1.80	1.34	2.30	0.98	2.29	2.27	BDL	BDL
<b>Lu</b>	0.27	BDL	13.4	12.3	9.11	5.02	18.5	11.7	BDL	BDL
<b>Ta</b>	2.00	BDL	46.9	46.5	29.9	20.3	32.1	29.7	BDL	BDL
<b>Th</b>	9.72	8.98	30.9	17.5	16.4	13.7	23.6	20.5	21.3	16.2

BDL= Below Detection Limit.

Table 2 showed that, the concentration levels obtained for manganese range from 288ppm to 3926ppm and decreased down at all dumpsites. The permissible value for the concentration of Manganese (**Mn**) in soil was 200 to 9000ppm (Eddy *et al.*, 2004). Thus, the concentrations values are within the safety limit.

The concentration levels of Zinc (**Zn**) were detected at all samples, except YT2 (50-60 cm depth) which was below the detection limit, range from 52.1ppm to 603 ppm and were decreased down with depth. The highest concentrations were obtained at GG1 (20-30 cm depth) with 603 ppm, YT1 (20-30 cm depth) with 523 ppm, RJ1 (20-30 cm depth) with 348 ppm, YK1 (20-30 cm depth) with 294 ppm, RJ2 (50-60 cm depth) with 290ppm, GG2 (50-60 cm depth) with 245 ppm and YK2 (50-60 cm depth) with 138 ppm (Table 2). These values obtained were higher than the results (10-30ppm) obtained at soil dumpsites by (Eddy *et al.*, 2004; Njagi, 2013), (2.3-5.0ppm) by (Ademola, *et al.*, 2014) and the global average value for soil 70ppm by (Kataba and Pendias, 1992; Licht *et al.*, 2006). This shows that waste at these dumpsites contain significant amount of zinc. Though, Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms. Nevertheless, higher concentrations of zinc can be toxic to the organism. (Nazir *et al.*, 2015).

The levels of Iron (**Fe**) concentration range from 10940ppm to 106000ppm and the highest concentrations of Iron were found at YT1 (20-30cm depth) with 106000ppm, YT2 (50-60cm depth) with 48160ppm and YK1 (20-30cm depth) with 37079ppm as indicated in Table 2. These values were higher than the results (3699ppm) found in dumpsites soil by (Awokunmi *et al.*, 2010), (15 to 250ppm) (Okeyode and Rufa'I, 2001 and Ademola *et al.*, 2015) and global average value for soil 36000ppm (Koljone *et al.*, 1992; Licht, *et al.*, 2006). Though, the Iron concentration is higher in some samples sites. This might be due to the indiscriminate disposal of waste containing Iron at the dumpsites. However, it has been confirmed that natural soil contains significant concentration of iron and suggested that the pollution of the environment by iron cannot be

conclusively linked to waste materials alone but other natural source of iron must be taken into consideration (Ademoroti, 1996; Aluko *et al.*, 2003; Eddy, 2004).

The concentration levels of Chromium (**Cr**) range from 18.9 ppm to 44930ppm and were decreased with depth at all dumpsites as presented in Table 2. It can be deduced from the Table that the highest concentrations levels were obtained at YK1 (20-30 cm depth), with 44930 ppm, YK2 (50-60cm depth) with 18980 ppm, YT1 (20-30cm depth) with 993 ppm and YT2 (50-60cm depth) with 175ppm. Thus, these values were higher than the maximum permissible level of soil in EU (180ppm), UK (6.4ppm), USA (400ppm) (Hong *et al.*, 2014), 100ppm (USEPA 1992; Abdullahi *et al.*, 2013) and global average value for soil 71ppm (Kataba and Pendias, 1992; Licht, *et al.*, 2006). This could be attributed to the industrial activity taking place around the locations. Eddy (2004) reported that Automobiles, electronic, leather waste introduced metallic chromium into the soil.

Vanadium (**V**) range from 16.3ppm of GG2 (50-60cm depth) to 74.6ppm of YT1 (20-30cm depth) as shown in Table 2. These concentrations vary and decreased down at all dumpsites, of which all the values does not exceed the global average value for soil (87ppm) (Kataba and Pendias, 1992; Licht, *et al.*, 2006) and 100ppm as the average concentration by (Njagi, 2013).

Arsenic (**As**) was found in the range of 0.79ppm to 7.596 ppm at all sampling points of the dumpsites, except RJ1(20-30cm depth), RJ2 (50-60 cm depth) and YT2 (50-60cm depth) which were below the detection limit and the concentrations decreased with depth (Table 2). These values were found to be lower than global average value for soil 7.83ppm (Kataba p. and Pendias, 1992; Licht, *et al.*, 2006), and 1-50ppm as reported in soil bearing by (USEPA, 1992; Abdullahi *et al.*, 2013).

The range of concentration levels of Cobalt (**Co**) was 3.0 ppm to 370ppm and the concentration levels were decreased with depth at all dumpsites except at Gyadi Gyadi dumpsites as it can be seen in Table 2. The highest concentration were found at YK1 (20-30cm depth) with 307ppm, YK2 (50-60cm depth) with 242ppm and YT2 (50-60cm depth) with 14.2ppm. The values obtained were

higher than the results found 4.17 ppm by (Butu and Iguisi, 2013) and the global average value for soil 8.15ppm by (Kataba and Pendias, 1992; Licht *et al.*, 2006). This also could be attributed to industrial activities and deposition of particular matter into the soil containing cobalt.

Table 2 showed that Rubidium (**Rb**) was detected in all samples, except at YT2 (50-60 cm depth) and YT1 (20-30 cm depth) which were below the detection limit, and range from 56.3ppm to 138ppm. The highest concentrations were found at RJ1 (20-30 cm depth) with 138ppm, RJ2 (50-60 cm depth) with 132ppm, GG2 (50-60 cm depth) with 97.4ppm and YL1 (20-30 cm depth) with 88.1ppm. These also were higher than the global average value for soil 77ppm by (Kataba and Pendias, 1992; Licht, *et al.*, 2006). This might be due to the presence of some minerals like lepidote, pollucite and carnallite and transporting materials (waste) containing Rubidium (Lenntech, 2016). There was a decrease in concentration with depth at all dumpsites except at Gyadi dumpsite which might be due to background concentration.

Cesium (**Cs**) was detected at all sampling points, except YT2 (50-60cm depth) and YT1 (20-30 cm depth) which were below the detection limit and range from 0.98ppm to 2.30ppm (Table 2). The levels of concentration of Cesium (Cs) were decreased down with depth at all dumpsites and were less than the values 3.7 ppm found by (Butu and Iguisi, 2013) and 2.54 ppm of the global average value for soil by (Kataba and Pendias, 1992; Licht *et al.*, 2006).

Lutetium (**Lu**) was detected at all sampling points, except YK2 (50-60 cm depth), YT1 (20-30 cm depth) and YT2 (50-60 cm depth) which were below the detection limit and range from 0.2ppm to 18.5ppm and were decreased in concentrations down with depth. The highest concentrations were obtained at RJ1 (20-30 cm depth) with 18.5ppm, YL1 (20-30 cm depth) with 13.4ppm, YL2 (50-60 cm depth) with 12.3ppm, RJ2 (50-60cm depth) with 11.7ppm, GG1 (20-30 cm depth) with 9.11ppm and GG2 (50-60 cm depth) with 5.02ppm (Table 2). These values were higher than the values 0.7 ppm obtained by (Butu and Iguisi, 2013) and 0.53ppm of the global average value for soil by (Kataba and Pendias, 1992; Licht *et al.*, 2006). This could be attributed to the industrial activities taken place and presence of some minerals like

xenotime, monazite and bastnasite around the locations ( Lenntech, 2016).

From Table 2, it can also be seen that Tellurium (**Ta**) was detected at all sampling points, except YK2 (50-60cm depth), YT1 (20-30cm depth) and YT2 (50-60cm depth) which were below the detection limit and range from 2.0ppm to 46.9ppm. There was decrease in concentration with depth at all dumpsites. All the values obtained were higher than the global average value for soil 1.59ppm (Kataba and Pendias, 1992; Licht *et al.*, 2006). This might be due to the disposal of industrials waste products and some particular matters around the dumpsites (Lenntech, 2016).

The levels of concentrations of Thorium (**Th**) were obtained at all sampling point and range from 8.98ppm to 30.9ppm as indicated in Table 2. All the values obtained were higher at all locations and were also higher than the global average value for soil 7.94ppm (Kataba and Pendias, 1992; Licht *et al.*, 2006). This could be due to geological settings of the area, Industrial activities, transportation of materials containing Thorium to the sampling sites and presence of some radioactive minerals that contribute the abundant of Thorium such as Monazite, Zirocon and Thorianite (Okeyede and Akanni, 2009; Innocent, 2014). There was a decrease in concentration with depth at all dumpsites.

### 3.2 Enrichment Factors and Geo-accumulations Index

Manganese (**Mn**) enrichment factor index was at deficiency to minimal enrichment at all sampling points except at YT1 (20-30cm depth) with (2.2222) which was at moderate enrichment, and the geo-accumulation index is negative at all sampling points in which the soils are not polluted, except at YTI (20-30cm depth) with (2.1251) and YT2 (50-60cm depth) with (0.6125) which indicated that, the soils are moderately to strongly polluted and unpolluted to moderately polluted respectively as presented in Table 3 when compared with range in Table 4.

Zinc (**Zn**) had significant enrichment at YK1 (20-30cm depth) with (5.8559), GG1 (20-30cm depth) with (10.9157), GG2 (50-60cm depth) with (11.5174), RJ1 (20-30cm depth) with (8.2704) and RJ2 (50-60cm depth) with (8.2628) and moderate enrichment at YT1 (20-30cm depth)

with (2.5375). While at other sampling points were at deficiency to minimal enrichment, except at YT2 (50-60cm depth) which was at below the detection limit and has geo-accumulation index of (2.5218) at GG1 (20-30cm depth) and (2.3164) at YT1 (20-30cm depth) indicated that the soils are from moderately to strongly polluted, YK1 (20-30cm depth) with (1.4854), GG2 (50-60cm depth) with (1.2224), RJ1 (20-30cm depth) with (1.7287) and RJ2 (50-60cm depth) with (1.4657) which also indicated the soils are moderately polluted and YK2 (50-60cm depth) with (0.3943), also indicated the soil is unpolluted to moderately polluted, while at others sampling points were unpolluted, except at YT2 (50-60cm depth) which was at below detection limit as shown in Table 3 when compared with range in Table 4.

The enrichment factor index for Iron (**Fe**) was at deficiency to minimal enrichment at all sampling points and has negative geo-accumulation index values at all sampling points which showed that the soils are not polluted except at YT1 (20-30cm depth) with (0.9730) which indicated the soil is unpolluted to moderately polluted as observed in Table 3 when compared with range in Table 4.

Chromium (**Cr**) had extremely high enrichment at YK1 (20-30cm depth) with (614.5511) and YK2 (50-60cm depth) with (372.7212) and moderate enrichment at RJ1 (20-30cm depth) with (3.7021) and YT1 (20-30cm depth) with (4.7499). While at others sampling points were below the detection limit and has the geo-accumulation index at YK1 (20-30cm depth) with (8.7207) and YK2 (50-60cm depth) with (7.4775) which indicates that the soils were very strongly polluted, YT1 (20-30cm depth) with (3.2209) strong polluted and YL1 (20-30cm depth) with (2.2261) moderately to strong polluted and also unpolluted to moderately polluted at RJ1 (20-30cm depth) with (0.5691) and YT2 (50-60cm depth) with (0.7165). While having negative values of geo-accumulation index at all sampling points which indicated that the soils are not polluted as can be seen in Table 3 when compared with range in Table 4.

Vanadium (**V**) were at deficiency to minimal enrichment at all sampling points and had negative geo-accumulation index values at all sampling point, means the soils are not polluted

as observed in Table 3 when compared with range in Table 4.

Arsenic (**As**) was at deficiency to minimal enrichment at all sampling points except at RJ1 (20-30cm depth), RJ2 (50-60cm depth) and YT2 (50-60cm depth) which were at below the detection limit and has negative geo-accumulation values at all sampling points which show that the soils are not polluted, except at RJ1 (20-30cm depth), RJ2 (50-60cm depth) and YT2 (50-60cm depth) which were at below the detection limit as indicated in Table 3 when compared with range in Table 4.

Cobalt (**Co**) had high enrichment at YK1 (20-30cm depth) with (36.5814) and extremely enrichment at YK2 (50-60cm depth) with (41.4004). While at other sampling points were deficiency to minimal enrichments and had geo-accumulation index of (4.6503) at YK1 (20-30cm depth) and (4.3071) at YK2 (50-60cm depth) which indicated the soils are strongly to very strongly polluted and (0.2161) at YT1 (20-30cm depth), indicated that the soil is unpolluted to moderately polluted, while at others sampling points were at unpolluted as observed in Table 3 when compared with range in Table 4.

Rubidium (**Rb**) had moderate enrichment at GG1 (20-30cm depth) with (3.0428), RJ1 (20-30cm depth) with (3.5745) and RJ2 (50-60cm depth) with (2.8519) while at others sampling points were at deficiency to minimal enrichment, except YT1 (20-30cm depth) and YT2 (50-60cm depth) which were at below the detection limit and has negative geo-accumulation index values at all sampling points which showed that the soils were not polluted, except at RJ1 (20-30cm depth) with (1.1948) indicated the soil is moderately polluted, RJ2 (50-60cm depth) with (0.1926) which indicated the soil is unpolluted to moderately polluted and YT1 (20-30cm depth) and YT2 (50-60cm depth) which were at below the detection limit as shown in Table 3 when compared with range in Table 4.

Cesium (**Cs**) had deficiency to minimal enrichment at all sampling points, except at YT1 (20-30cm depth) and YT2 (50-60cm depth) at which were below the detection limit and also had negative geo-accumulation index values at all sampling points which showed the soils are not polluted except at YT1 (20-30cm depth) and YT2

(50-60cm depth), which were at below the detection limit as indicated in Table 3 when compared with range in Table 4.

Lutetium (**Lu**) had extremely high enrichment at YL1 (20-30cm depth) with (40.3025), YL2 (50-60cm depth) with (48.2347), RJ1 (20-30cm depth) with (58.0686) and RJ2 (50-60cm depth) with (44.0286), very high enrichment at GG1 (20-30cm depth) with (21.7808) and GG2 (50-60cm depth) with (31.1682) and deficiency to minimal enrichment at other sampling points except YT1 (20-30cm depth) and YT2 (50-60cm depth) which were at below the detection limit and has very strongly polluted at YL1 (20-30 cm depth) with (15.4717), strongly to very strongly polluted at RJ1 (20-30 cm depth) with (4.5404) and YL2 (50-60 cm depth) with (4.0751), strongly polluted at RJ2 (50-60 cm depth) with (3.8794) and GG1 (20-30 cm depth) with (3.5184), moderately to strong polluted at GG2 (50-60 cm depth) with (2.6587) and YK1 (20-30 cm depth) with (-1.5579) which showed the soil is not polluted, except at YK2 (50-60 cm depth), YT1 (20-30 cm depth) and YT2 (50-60 cm depth) which were at below the detection limit as observed in Table 3 when compared with range in Table 4.

The enrichment factor for Tellurium (**Ta**) at YL1 (20-30cm depth) with (56.2738), YL2 (50-60cm depth) with (50.7878) and GG2 (50-60cm depth) with (42.0130) were extremely high and at GG1 (20-30cm depth) with (23.8289), RJ1 (20-30cm depth) with (33.5856) and RJ2 (50-60cm depth)

with (37.2550) were at very high enrichment, while at others sampling points were at below the detection limit and has strongly to very strongly polluted at YL1 (20-30cm depth) with (4.2975) and YL2 (50-60cm depth) with (4.2852), strongly polluted at GG1 (20-30cm depth) with (3.6481), GG2 (50-60cm depth) with (3.0894), RJ1 (20-30cm depth) with (3.7505) and RJ2 (50-60cm depth) with (3.6384) and YK1 (20-30cm depth) with (-0.2539) which showed the soil is not polluted, except at YK2 (50-60cm depth), YT1 (20-30cm depth) and YT2 (50-60cm depth) which were at below the detection limit as shown in Table 3 when compared with range in Table 4.

Thorium (**Th**) had significant enrichment at YL1 (20-30cm depth) with (6.7584) and GG1 (20-30cm depth) with (5.6779) and moderate enrichment at YL2 (50-60cm depth) with (4.2048), GG2 (50-60cm depth) with (2.6173) and RJ1 (20-30cm depth) with (4.9447), while at others sampling points were at deficiency to minimal enrichment and has unpolluted to moderately polluted at YK1 (20-30cm depth), YL2 (50-60cm depth), GG1 (20-30cm depth), GG2 (50-60cm depth), RJ1 (20-30cm depth), RJ2 (50-60cm depth), YT1 (20-30cm depth) and YT2 (50-60cm depth) with values (0.3010),(0.5552),(0.2020),(0.4615), (0.9866),(0.7834), (0.4438) and(0.8387) respectively and moderately polluted at YL1 (20-30cm depth) with (1.3754), while unpolluted at YK2 (50-60cm depth ) with (-0.2931) as indicated in Table 3 when compared with range in Table 4.

Table 3 shows the results of the Enrichment factor (EF) and Geo-accumulations Index which were calculated from the concentrations of the Metals in the sampling points in the study area.

**Table 3: Enrichment Factors and Geo-accumulations Index**

SAMPLE ID	YK 1(20-30cm depth)		YK 2 (50-60cm depth)		YL 1(20-30cm depth)		YL 2 (50-60cm depth)		GG 1(20-30cm depth)	
	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>
Mn	0.5276	-1.4651	0.6762	-1.6289	1.1056	-1.2363	0.9157	-1.6439	0.9419	-1.0129
Zn	5.8559	1.4854	1.9145	0.3943	1.3645	-0.9329	1.4199	-1.0110	10.9157	2.5218
Fe	1.0000	-0.5427	1.0000	-1.0645	1.0000	-1.3812	1.0000	-1.5169	1.0000	-0.9266
Cr	614.5511	8.7207	372.7212	7.4775	1.8883	2.2261	1.5369	-0.8968	0.7014	-1.438
V	0.4432	-1.7168	0.6667	-1.8068	0.6188	-2.0737	0.6644	-2.1067	0.5010	-1.9236
As	0.4205	-1.7927	0.4096	-2.3523	0.1907	-3.7716	0.1925	-3.8940	0.2444	-2.9594
Co	36.5814	4.6503	41.4004	4.3071	1.0398	-1.3249	0.7046	-2.0219	1.3365	-1.8849
Rb	0.7857	-0.8906	1.0194	-1.0367	1.9869	-0.3907	1.8384	-0.6384	3.0428	-0.6979
Cs	0.4626	-1.6548	0.8563	-1.2882	1.2307	-1.0818	1.0065	-1.5076	1.1474	-0.7282
Lu	0.4947	-1.5579	BDL	BDL	40.3025	15.4717	48.2347	4.0751	21.7808	3.5184
Ta	1.2215	-0.2539	BDL	BDL	56.2738	4.2975	50.7878	4.2852	23.8289	3.6481
Th	1.5768	0.3010	1.1888	-0.2931	6.7584	1.3754	4.2048	0.5552	5.6779	0.2020

Key: ( I<sub>geo</sub> = index of geo-accumulation, EF = enrichment factor and BDL = below detection limi

SAMPLE ID	GG 2 (50-60cm depth)		RJ 1 (20-30cm depth)		RJ 2 (50-60cm depth)		YT 1(20-30cm depth)		YT 2 (50-60cm depth)	
	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>	EF	I <sub>geo</sub>
Mn	1.7659	-1.4829	0.9067	-1.4601	0.9773	-1.6141	2.2222	2.1251	1.7143	0.6125
Zn	11.5174	1.2224	8.2704	1.7287	8.2628	1.4657	2.5375	2.3164	BDL	BDL
Fe	1.0000	-2.3033	1.0000	-1.3193	1.0000	-1.5809	1.0000	0.9730	1.0000	-0.1651
Cr	0.9223	-2.4200	3.7021	0.5691	0.5309	-2.4944	4.7499	3.2209	1.8425	0.7165
V	0.4432	-1.7168	0.6667	-1.8068	0.6188	-2.0737	0.6644	-2.1067	0.5010	-1.9236
As	0.3320	-3.8941	BDL	BDL	BDL	BDL	0.3266	-0.6413	BDL	BDL
Co	1.2034	-0.6594	1.0352	-1.5311	0.7083	-1.8168	0.5917	0.2161	0.5503	-1.0268
Rb	1.6029	-0.2459	3.5745	1.1948	2.8519	0.1926	BDL	BDL	BDL	BDL
Cs	1.2696	-1.9589	1.7825	-0.7470	1.4998	-0.7344	BDL	BDL	BDL	BDL
Lu	31.1682	2.6587	58.0686	4.5404	44.0286	3.8794	BDL	BDL	BDL	BDL
Ta	42.0130	3.0894	33.5856	3.7505	37.2550	3.6384	BDL	BDL	BDL	BDL
Th	2.6173	0.4615	4.9447	0.9866	5,1494	0.7834	1,5251	0.4438	0.8908	0.8387

Table 4 shows the range for Enrichment factor and Geo-accumulation index for ease of reference.

**Table 4. Enrichment factor ( EF ) and Geoaccumulation index (I<sub>geo</sub>) Ranges**

<b>Enrichment factor ( EF )</b>
EF <2 is deficiency to minimal enrichment
EF 2-5 is moderate enrichment
EF 5-20 is significant enrichment
EF 20-40 is very high enrichment
EF > 40 is extremely high enrichment
<b>Geo-accumulation index (I<sub>geo</sub>)</b>
I <sub>geo</sub> < 0 means unpolluted
0 ≤ I <sub>geo</sub> <1 means unpolluted to moderately polluted
1 ≤ I <sub>geo</sub> <2 means moderately polluted
2 ≤ I <sub>geo</sub> <3 means moderately to strongly polluted
3 ≤ I <sub>geo</sub> <4 means strongly polluted
4 ≤ I <sub>geo</sub> <5 means strongly to very strongly polluted
I <sub>geo</sub> ≥ 5 means very strongly polluted

Source: Sutherland, (2000) and Huu and Damme,( 2010) in Fagbote and Olanipekun (2010).

#### 4.0 CONCLUSION

The method adopted in the analysis of this study is Instrumental Neutron Activation Analysis (INAA) using Nigeria Research Reactor – 1 (NIRR -1). The following heavy metals; Mn, Zn, Fe, Cr, V, As, Co, Rb, Cs, Lu, Ta, and Th were identified in the samples at various levels of concentration. The results of the analysis indicated that, there was gradual decrease in concentration with depth (reading obtained with samples at 20-30cm depth were higher than that obtained with samples at 50-60cm depth at all sampling locations) which showed solid wastes have contributed to the levels of these heavy metals in all studied dumpsite soil. The findings of this study have shown that heavy metals such as Zn, Fe, Cr, Co, Rb, Lu, Ta and Th are found to be in higher concentration while Mn, V, As, and Cs are in lower concentration. The study also reveals that the enrichment and geo-accumulation

index showed that these studied dumpsite soils are becoming enriched and polluted by heavy metals ( Zn, Cr, Co, Lu, Ta and Th) and continuous use of these study areas as dumpsites may lead to heavy metal build up in soils to toxic levels. Hence, this creates a sound alarm to all human, plant and livestock in study area.

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