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GEOGENIC AND ANTHROPOGENIC SOURCES OF HEAVY METALS CONTAMINATION OF SOILS FROM SELECTED DUMPSITES IN JOS, PLATEAU STATE, NIGERIA

AUTHORS:
S. C. Odewumi[1,*] and B. P. Omoniwa[2]

AFFILIATIONS:
[1,2]Department of Science Laboratory Technology, University of Jos, Jos, Nigeria

***CORRESPONDING AUTHOR:**
Email: sholaodewumi@yahoo.com

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Abstract

Heavy metal contamination in Yantrailer, Tina, and Maternity dumpsites soils within Jos was investigated. Twelve samples were collected at two different sampling points at depths of 40 cm and 80cm in each sampling point. The samples were air-dried and subjected to X-ray fluorescence (XRF) analysis to determine their elemental composition. XRF analysis detected the presence of Molybdenum (Mo), Zirconium (Zr), Strontium (Sr), Rubidium (Rb), Uranium (U), Thorium (Th), Lead (Pb), Arsenic (As), Zinc (Zn), Tungsten (W) and Copper (Cu). The higher value of Zr (394.396-499.054 mg/kg) at 80 cm depth than the Zr value (406.581-444.142 mg/kg) at 40 cm from Yantrailer suggests a geogenic contamination source. Higher values of Zr (915.985-935.203mg/kg) at 80 cm depth than its value (663.403-746.535 mg/kg) at 40 cm depth from Tina dumpsite indicates a geogenic contamination source. The higher value of Zr (594.659-654.508 mg/kg) at 40 cm depth than its value (521.707-565.414 mg/kg) at 80 cm depth from the maternity dumpsite indicates an anthropogenic contamination source. Higher values of Mo, Zr, U, and Th at 80 cm depth than at 40 cm depth from Yantrailer and Tina dumpsites indicate geogenic sources while higher values of Zr, Th, Sr, and Zn at 40 cm depth than at 80 cm depth from maternity dumpsites suggest anthropogenic contamination sources. The higher concentrations of Sr and Zn at 40 cm depth than at 80 cm depth from Yantrailer and Tina dumpsites indicate anthropogenic contamination sources. The soils underlying the dumpsites in the study area have been contaminated with heavy metals from anthropogenic and/or geogenic sources. The anthropogenic sources could be associated with the decomposition of domestic and industrial wastes which have eventually been leached into the underlying soils while geogenic sources of contamination could be associated with weathering and dispersion of heavy metals from underlying mineralization and parent rocks.

1.0 INTRODUCTION

Soil contamination is the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive material, or disease-causing agents, which have adverse effects on plant growth and animal health. Studies on the effects of unlined waste dumps on the host soil and underlying shallow aquifers have shown that soil and groundwater systems can be polluted due to poorly designed waste disposal facilities [1]. Depending on the topography, hydrology condition, and the rock type within the locality, leachates can travel several metres of vertical and horizontal distances, thereby polluting soils, rocks, surface water, and groundwater [2]

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Anthropogenic soil contaminations are contaminations that occur due to human activities at the surface of the soil. Examples include the burning of fossils, fuels, deforestation, mining, sewage and refuse disposal, pesticides, fertilizers, etc. [3]. Geogenic soil contaminations are contaminations that come from the soil due to geological activities like leaching, weathering, and volcanism. Anthropogenic and geogenic activities have burdened the soil with heavy metals [4]. According to [5], heavy metals emitted from anthropogenic origins including mining activities are highly mobile in the soil environment with increased potential to cause ecological and human health complications compared to those of geogenic origins. According to [6], toxicity sets in when the heavy metal content in the soil exceeds the natural background level. This may cause ecological destruction and deterioration of environmental quality, influence yield and quality of crops as well as the atmosphere, and health of animals through food chains.

The existence of heavy metals in soils is attributed to both anthropogenic and geogenic (particularly lithogenic) factors. The main human activities resulting in environmental contamination are mining and smelting, industrial activities, agricultural practices, fossil fuel combustion, waste disposal, transportation, etc. and they have been discussed in numerous reports and publications [7]. Refuse dumpsites are located in different areas in Jos due to the increase in population [7]. Dumpsite wastes are commonly burnt to get rid of the organic matter while ashes obtained are rich in metal contents due to the non-segregation of the wastes at the dumpsites [8] [9]. Invariably, the burnt ashes are not just from the organic sources but also from the metal constituents of the dumpsites. The burnt ashes are leached into the soil, thereby contaminating the environment such as soils, surface water, and groundwater [10] [11] [12]. The present study focuses on the determination of heavy metal contaminations of soils from three dumpsites located at Yantrailer, Tina, and Maternity junction within the Jos metropolis.

2.0 MATERIALS AND METHODS

The present study was carried out in three solid waste dumpsites located at Tina, Yantrailer, and Maternity within the Jos metropolis as shown in Figure 1. A total of twelve (12) samples were collected from the three dumpsites at depths of 40 cm and 80 cm from two different sampling points from each of the three dumpsites:

i. Four (4) soil samples were collected from Yantrailer dumpsite on latitudes 09° 54’ 24.6’’ to 09° 55’ 24.6’’ N and longitudes 008° 54’ 45.9’’ to 008° 54’ 46.2’’ E,
ii. Four (4) soil samples were collected from Tina dumpsite on latitudes 09° 55’ 18.8’’ to 09° 55’ 19.1’’ N and longitudes 008° 54’ 44.3’’ to 008° 54’ 44’’ E, and
iii. Four (4) soil samples were collected from Maternity along Ola hospital dumpsite on latitudes 09° 55’ 23.7’’ to 09° 55.2’ 23.5’’ N and longitudes 008° 54’ 41.4’’ to 008° 55’ 42.8’’ E.

The soil samples were taken at two different depths of 40 cm and 80 cm at the three dumpsites using a soil auger. The samples were placed in different labeled sample bags. The depth of each of the sampling points was measured using a measuring tape. The samples were shipped from the dumpsites to the laboratory for analysis. The samples were air-dried at room temperature to remove moisture for two weeks. Five grams of the ground samples were measured using an analytical balance and packaged into different sample bags for XRF analysis as previously reported [13][14][15] [16].

A total of twelve (12) soil samples were subjected to XRF analysis at the Department of Science Laboratory Technology, University of Jos, Nigeria. The soil samples were analyzed for the concentrations of Mo, Zr, Sr, Rb, U, Th, Pb, As, Zn, W, Cu, Ni, Fe, Mn, Cr, Nb, V Ti, Ca, and K. The values of heavy metals from the three dumpsites have been subjected to statistical analysis using Microsoft Excel. The geological setting of part of the Jos Plateau has been previously reported [17]. The values of heavy metals from the dumpsites will be compared with standards from regulatory bodies such as [18] [19] [20] and [21].

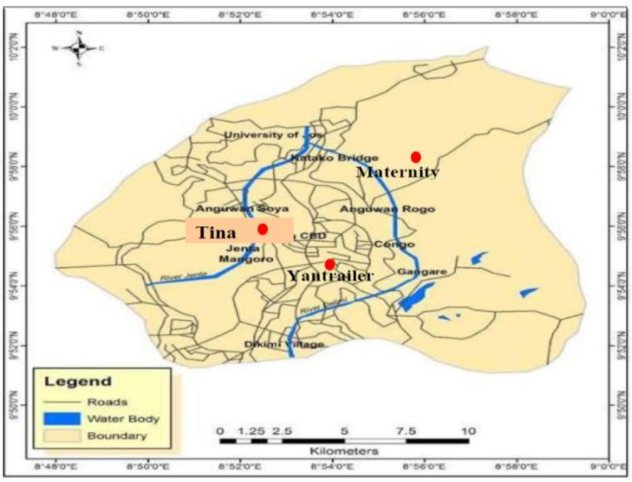

Figure 1: Location map of the study area (Maternity, Yantailer, and Tina) within Jos North Metropolis (Modified after [7])

3.0 RESULTS AND DISCUSSION

Table 1 represents the concentrations of metals at the Yantrailer, Tina, and Maternity dumpsites within the Jos metropolis at 40 cm depth. The concentrations of the metals were compared with background reference level [18] [19], the threshold value [20], and the permissible limit [21]. The Mo levels at the Yantrailer, Tina, and Maternity dumpsites were significantly elevated ($p < 0.05$) compared to the background reference value but significantly reduced ($p < 0.05$) compared to the threshold and permissible limits. The Maternity dumpsite had a significantly elevated ($p < 0.05$) Mo concentration than both the Yantrailer and Tina dumpsites. The Mo level at the Tina and Yantrailer dumpsites did not differ significantly ($p > 0.05$) (Table 1). The concentrations of Zr at the Yantrailer, Tina, and Maternity dumpsites were significantly elevated ($p < 0.05$) compared to the threshold and permissible limits. The Maternity dumpsite had a significantly increased ($p < 0.05$) Zr level than the Yantrailer dumpsite but a lower ($p < 0.05$) Zr level than the Tina dumpsite (Table 1). The Sr levels at the Yantrailer, Tina, and Maternity dumpsites were significantly reduced ($p < 0.05$) compared to the background reference and permissible limit. The Yantrailer dumpsite had a significantly elevated ($p < 0.05$) Sr level when compared to the Tina and Maternity dumpsites. The Sr levels at both the Tina and Maternity dumpsites did not differ significantly ($p > 0.05$) (Table 1).

The concentrations of U at the Yantrailer, Tina, and Maternity dumpsites were significantly increased ($p < 0.05$) compared to the permissible limit whereas the U levels at the Yantrailer, Tina, and Maternity dumpsites did not differ significantly ($p > 0.05$) (Table 1). The concentration of Rb at Tina dumpsite was significantly raised ($p < 0.05$) compared to the background reference and permissible limit. The Rb level at the Yantrailer and Maternity dumpsites did not differ significantly ($p > 0.05$) from the background reference but was elevated significantly ($p < 0.05$) compared to the permissible limit. The Rb level at the Tina dumpsite was elevated significantly ($p < 0.05$) in comparison to its level at the Maternity dumpsite (Table 1).

The Th concentration at the Yantrailer, Tina, and Maternity dumpsites was raised significantly ($p < 0.05$) compared to the permissible limit. The Yantrailer dumpsite had a significantly increased Th concentration ($p < 0.05$) in comparison to the Tina dumpsite. The level of Th at the Maternity did not differ significantly ($p > 0.05$) from those atthe Yantrailer and Tina dumpsites (Table 1). The level of Pb at the Tina and Maternity dumpsites was reduced significantly ($p < 0.05$) compared to the background reference, threshold limit, and permissible limit. At the Yantrailer dumpsite, the Pb level did not differ significantly ($p > 0.05$) from that at the background reference but was reduced ($p < 0.05$) compared to the threshold and permissible limits. The level of Pb at the Yantrailer dumpsite was significantly elevated ($p < 0.05$) than at both the Tina and Maternity dumpsites while the Pb level at the Maternity dumpsite was raised ($p < 0.05$) compared to that at the Tina dumpsite (Table 1).

The As level at the Yantrailer dumpsite was raised significantly ($p < 0.05$) in comparison to the background and threshold limit but reduced ($p < 0.05$) when compared to the permissible limit. As levels at both the Tina and Maternity dumpsites were beyond detectable limits (Table 1). Zn concentration at the Yantrailer and Maternity dumpsites was raised significantly ($p < 0.05$) compared to the background reference and permissible limit but lower ($p < 0.05$) than the threshold limit. At the Tina dumpsite, the Zn level was elevated significantly ($p < 0.05$) above the permissible limit but lower ($p < 0.05$) than both the background reference and threshold limit. Yantrailer dumpsite had a significantly raised ($p < 0.05$) Zn level compared to both the Tina and Maternity dumpsites while the Maternity dumpsite had a higher ($p < 0.05$) Zn concentration than the Tina dumpsite (Table 1).

The level of W at the Yantrailer, Tina, and Maternity dumpsites was not significantly different from the permissible limit (Table 1). The level of Cu at the Yantrailer dumpsite was significantly elevated ($p < 0.05$) above the background reference and the permissible limit but lower ($p < 0.05$) than the threshold limit. The Cu level at the Tina and Maternity dumpsites was significantly reduced ($p < 0.05$) below the background reference, threshold limit, permissible limit, and Yantrailer dumpsite level. The Cu levels at both Tina and Maternity dumpsites did not differ significantly ($p > 0.05$) (Table 1).

The Ni level at the Yantrailer, Tina, and Maternity dumpsites was elevated significantly ($p < 0.05$) above the background reference but lower ($p < 0.05$) than both the threshold and permissible limits. Ni level at the Tina dumpsite was significantly raised ($p > 0.05$) compared to both the Yantrailer and Maternity dumpsites while the Ni level at the Maternity dumpsite was reduced significantly ($p < 0.05$) below that at the Yantrailer dumpsite (Table 1). Background reference, threshold limit, and permissible limit for Fe are not available. There is no significant difference ($p >0.05$)

in the Fe concentration at the Yantrailer and Maternity dumpsites while both had a significantly elevated ($p < 0.05$) Fe level than the Tina dumpsite (Table 1).

The Mn level at the Yantrailer and Maternity dumpsites did not significantly differ ($p > 0.05$) from the background reference. Mn level at the Yantrailer, Tina, and Maternity dumpsites was raised significantly ($p < 0.05$) above the permissible limit but reduced ($p < 0.05$) below the threshold limit. The Yantrailer dumpsite had a significantly increased ($p < 0.05$) Mn level than the Tina dumpsite (Table 1). The Cr level at the Yantrailer, Tina, and maternity dumpsites was significantly raised ($p < 0.05$) above the background reference but reduced ($p < 0.05$) below the threshold limit. Cr level at the Yantrailer and Tina dumpsites was reduced significantly ($p > 0.05$) below the permissible limit and its level at the Maternity dumpsite (Table 1).

The levels of V at the Yantrailer, Tina, and Maternity dumpsites were significantly elevated ($p < 0.05$) above the permissible limit. The Tina dumpsite had a significantly decreased ($p < 0.05$) V level than the Maternity dumpsite (Table 1). The levels of Ti at the Yantrailer, Tina, and Maternity dumpsites were significantly elevated ($p < 0.05$) above the permissible limit. The Yantrailer dumpsite had a significantly decreased ($p < 0.05$) Ti level than the Maternity dumpsite (Table 1). The levels of Ca at the Yantrailer, Tina, and Maternity dumpsites were significantly raised ($p < 0.05$) compared to the permissible limit. The Yantrailer dumpsite had a significantly elevated ($p < 0.05$) Ca level than both the Tina and the Maternity dumpsites (Table 1). The levels of K at the Yantrailer, Tina, and Maternity dumpsites were significantly elevated ($p < 0.05$) above the reference background, threshold limit, and permissible limit. The K level at the Yantrailer, Tina, and Maternity dumpsites did not differ significantly ($p > 0.05$) (Table 1).

The levels of S at the Yantrailer, Tina, and Maternity dumpsites were significantly increased ($p < 0.05$) compared to the reference background, threshold limit, and permissible limit. The Yantrailer dumpsite had a significantly elevated ($p < 0.05$) S level than the Tina and Maternity dumpsites. The S level at the Tina and Maternity dumpsites did not differ significantly ($p > 0.05$) (Table 1). The levels of Nb at the Yantrailer, Tina, and Maternity dumpsites were significantly raised ($p < 0.05$) above the permissible limit. The Nb level at the Yantrailer, Tina, and Maternity dumpsites did not differ significantly ($p > 0.05$) (Table 1).

Table 2 represents the comparison of heavy metal concentrations from Yantailer, Tina, and Maternity dumpsites in Jos Metropolis with the background reference level, threshold limit, and permissible limit at 80 cm depth. The Mo level at the three dumpsites was significantly elevated ($p < 0.05$) above the background reference but lower than the threshold and permissible limits. The Mo levels at the three dumpsites did not differ significantly ($p > 0.05$) (Table 2). The Zr level at the three dumpsites was significantly elevated ($p < 0.05$) above the threshold and permissible limits.

The Zr level at the Tina dumpsite was significantly raised ($p < 0.05$) compared to the Yantrailer and Maternity dumpsites while its level at the Maternity dumpsite was higher ($p < 0.05$) than at the Yantrailer dumpsite (Table 2). The Sr level at the three dumpsites was significantly reduced ($p < 0.05$) below the background reference and the permissible limit. There was no significant difference ($p > 0.05$) in the Sr level at the Yantrailer and Tina dumpsites but their Sr levels were significantly elevated ($p < 0.05$) above that at the Maternity dumpsite (Table 2).

The U level at the Yantrailer and Tina dumpsites was raised significantly ($p < 0.05$) above the permissible limit. There is no significant difference ($p > 0.05$) in the U level at the Yantrailer and Tina dumpsites. U level at the Maternity dumpsite was beyond the detection limit (BDL) (Table 2). The Rb level at the Yantrailer and Tina dumpsites was elevated significantly ($p < 0.05$) above the background reference and permissible limit. There was no significant difference ($p > 0.05$) between the background reference and the Rb level at the Maternity dumpsite which was elevated significantly ($p < 0.05$) above the permissible limit (Table 2).

The Th level at the three dumpsites was significantly higher ($p < 0.05$) than the permissible limit. The Yantrailer and Tina dumpsites had a significantly raised ($p < 0.05$) Th level compared to the Maternity dumpsite (Table 2). The Pb level at the three dumpsites was reduced significantly ($p < 0.05$) below the background reference, threshold limit, and permissible limit. The Pb level at the Yantrailer and Tina dumpsites did not significantly differ ($p > 0.05$) but was significantly elevated ($p < 0.05$) compared to the level at the Maternity dumpsite (Table 2).

The As level at the three dumpsites was raised significantly ($p < 0.05$) above the background reference but lower ($p < 0.05$) than the permissible limit. While As level at the Yantrailer dumpsite was significantly higher ($p < 0.05$) than the threshold limit, its level at the Tina and Maternity dumpsites did not significantly differ ($p > 0.05$) from the threshold limit (Table 2). The Zn level at all the dumpsites was significantly raised ($p < 0.05$) above the permissible limit but reduced ($p < 0.05$) below the threshold limit. The Zn level at the Yantrailer dumpsite was significantly elevated ($p < 0.05$) above the background reference while its level at the Tina and Maternity dumpsites was lower than the background reference (Table 2).

The W level at the Yantrailer dumpsite was reduced significantly ($p < 0.05$) below the permissible limit while its level at the Tina dumpsite did not differ significantly ($p > 0.05$) from the permissible limit. The W level at the Maternity dumpsite was BDL (Table 2). The Cu level at the Yantrailer dumpsite was raised significantly ($p < 0.05$) above the background reference and the permissible limit but reduced ($p < 0.05$) below the threshold limit. The Cu level at the Tina and Maternity dumpsites was BDL (Table 2). The Ni levels at the Tina and Maternity dumpsites were elevated significantly ($p < 0.05$) above the background reference but reduced significantly ($p < 0.05$) below the threshold and permissible limits.

Table 1: Comparison of the Range of Heavy Metal Concentration (mg/kg) from Three Dumpsites with background reference level [18] and [19], threshold value [20], and permissible limit [21] at 40 cm Depth

Metals	Background reference	Threshold limit	Permissible limit	Yantrailer 40 cm	Tina 40 cm	Maternity 40 cm
Mo	3.00±0.00[a]	45.00±0.00[b]	45.00±0.00[b]	7.85±1.75[c]	8.70±0.07[c]	11.85±0.78[d]
Zr	NA	267.00±0.00[a]	5.00±0.00[b]	425.36±18.78[c]	704.97±41.57[d]	624.58±29.92[e]
Sr	175.00±0.00[a]	NA	200.00±0.00[a]	71.36±18.23[b]	39.16±15.30[c]	28.39±3.94[c]
U	NA	NA	3.00±0.00[a]	8.31±0.00[b]	9.08±0.00[b]	7.87±0.00[b]
Rb	68.00±0.00[a]	NA	7.00±0.00[b]	93.82±15.41[ac]	117.87±18.70[c]	62.65±2.48[a]
Th	NA	NA	7.00±0.00[a]	26.32±0.53[b]	16.18±3.33[c]	22.56±4.17[bc]
Pb	85.00±0.00[a]	530.00±0.00[b]	200.00±0.00[c]	81.64±3.25[a]	28.10±2.60[d]	41.16±1.08[e]
As	5.00±0.00[a]	6.83±0.00[a]	50.00±0.00[b]	10.83±1.75[c]	BDL	BDL
Zn	150.00±0.00[a]	5000.00±0.00[b]	50.00±0.00[c]	791.33±244.64[d]	97.06±29.78[e]	243.78±3.84[f]
W	NA	NA	83.00±0.00[a]	64.95±11.75[a]	74.76±16.63[a]	65.32±6.69[a]
Cu	36.00±0.00[a]	190.00±0.00[b]	36.00±0.00[a]	77.84±4.58[c]	21.02±0.00[d]	19.70±2.55[d]
Ni	29.00±0.00[a]	100.00±0.00[b]	50.00±0.00[c]	44.25±0.00[d]	46.88±0.00[e]	33.78±0.06[f]
Fe	NA	NA	NA	26976.53±111.74[a]	22622.66±2178.44[b]	26706.51±1621.57[a]
Mn	437.00±0.00[a]	1500.00±0.00[b]	50.00±0.00[c]	405.81±78.04[a]	239.00±13.05[d]	360.47±66.72[ad]
Cr	0.05±0.00[a]	3950.00±0.00[b]	100.00±0.00[c]	35.17±10.86[d]	49.00±3.11[d]	90.34±7.95[c]
V	NA	NA	0.31±0.00[a]	33.53±5.57[bc]	24.66±1.28[b]	56.87±19.91[c]
Ti	NA	NA	0.30±0.00[a]	1438.12±478.28[b]	1850.64±110.15[bc]	2770.92±660.91[c]
Ca	NA	NA	257.00±0.00[a]	23474.55±12602.95[b]	16151.67±798.41[c]	13038.60±45.82[c]
K	61.00±0.00[a]	120.00±0.00[b]	120.00±0.00[b]	5300.50±700.10[c]	8905.85±3151.84[c]	7566.07±2146.01[c]
S	25.00±0.00[a]	50.00±0.00[b]	50.00±0.00[b]	780.58±78.09[c]	295.61±48.88[d]	342.02±40.10[d]
Nb	NA	NA	0.12±0.00[a]	68.12±4.55[b]	69.51±14.66[b]	59.41±2.79[b]

NA: Not Applicable; BDL: Beyond detection limit; Values represent mean ± Standard error of mean (of 2 replicates). Values with different superscript letters across the row are significantly different at $p < 0.05$

Ni levels at the Tina and Maternity dumpsites did not differ significantly ($p > 0.05$) while its level at the Yantrailer dumpsite was BDL (Table 2). The Fe level at the Tina dumpsite was significantly elevated ($p < 0.05$) compared to those at the Yantrailer and Maternity dumpsites. The Fe level at the Yantrailer and Maternity dumpsites did not differ significantly ($p > 0.05$) (Table 2).

Mn level at all the dumpsites was significantly elevated ($p < 0.05$) above the permissible limit but lower ($p < 0.05$) than the background reference and the threshold limit. Mn level at the three dumpsites did not differ significantly ($p > 0.05$) (Table 2). The Cr levels at all the dumpsites were raised significantly ($p < 0.05$) above the background reference but were reduced ($p < 0.05$) below the threshold limit. Cr level at the Tina dumpsite did not differ significantly ($p > 0.05$) from the permissible limit but was significantly raised ($p < 0.05$) above its level at the Yantrailer and Maternity dumpsites (Table 2).The levels of V and Ti at all the dumpsites were elevated significantly ($p < 0.05$) above the permissible limit. V and Ti levels at the Tina and Maternity dumpsites did not significantly differ ($p > 0.05$) but were significantly raised ($p < 0.05$) compared to the level at the Yantrailer dumpsite (Table 2).

The Ca level at all the dumpsites was elevated significantly ($p < 0.05$) above the permissible limit. The Ca level at the Yantrailer dumpsite was significantly raised ($p > 0.05$) compared to its level at both the Tina and Maternity dumpsites. The Maternity dumpsite had a significantly raised ($p < 0.05$) Ca level in comparison to the Tina dumpsite (Table 2). The K level at all the dumpsites was significantly elevated ($p < 0.05$) above the background reference, threshold limit, and permissible limit.

The K level at the Tina dumpsite was significantly increased ($p < 0.05$) compared to its level at the Yantrailer and Maternity dumpsites. The Maternity dumpsite had a significantly elevated ($p < 0.05$) K level than the Yantrailer dumpsite (Table 2). The S levels at all the dumpsites were significantly raised ($p < 0.05$) compared to the background reference, threshold limit, and permissible limit. The S level at the Yantrailer dumpsite was significantly elevated ($p < 0.05$) above its level at the Tina and Maternity dumpsites while its level at the Maternity dumpsite was higher ($p < 0.05$) than at the Tina dumpsite (Table 2). The Nb level at the Tina dumpsite was BDL. The Nb level at the Yantrailer and Maternity dumpsite was significantly raised ($p < 0.05$) above the permissible limit. The Yantrailer dumpsite had a significantly elevated ($p < 0.05$) Nb level compared to the Maternity dumpsite (Table 2).

Table 2: Comparison of the Range of Heavy Metal Concentration (mg/kg) from Three Dumpsites with background reference level [18] and [19], threshold value [20], and permissible limit [21] at 80 cm Depth

Metals	Background reference	Threshold limit	Permissible limit	Yantrailer 80 cm	Tina 80 cm	Maternity 80 cm
Mo	3.00±0.00^{a}	45.00±0.00^{b}	45.00±0.00^{b}	10.00±0.00^{c}	13.16±3.72^{c}	7.20±2.71^{ac}
Zr	NA	267.00±0.00^{a}	5.00±0.00^{b}	424.23±74.83^{c}	925.59±9.61^{d}	543.56±21.85^{e}
Sr	175.00±0.00^{a}	NA	200.00±0.00^{b}	40.54±5.05^{c}	37.77±3.68^{c}	21.56±2.31^{d}
U	NA	NA	3.00±0.00^{a}	9.32±2.18^{b}	9.70±0.00^{b}	BDL
Rb	68.00±0.00^{a}	NA	7.00±0.00^{b}	78.76±1.20^{c}	149.31±4.82^{d}	65.55±1.71^{a}
Th	NA	NA	7.00±0.00^{a}	31.36±9.52^{b}	31.55±2.68^{b}	17.07±1.46^{c}
Pb	85.00±0.00^{a}	530.00±0.00^{b}	200.00±0.00^{c}	34.28±4.84^{d}	34.46±2.13^{d}	21.45±0.70^{e}
As	5.00±0.00^{a}	6.83±0.00^{b}	50.00±0.00^{c}	8.78±0.00^{d}	6.76±0.60^{b}	6.71±0.00^{b}
Zn	150.00±0.00^{ac}	5000.00±0.00^{b}	50.00±0.00^{c}	209.13±80.74^{a}	113.04±7.82^{ac}	94.28±22.78^{ac}
W	NA	NA	83.00±0.00^{a}	65.36±11.83^{b}	78.40±0.00^{ab}	BDL
Cu	36.00±0.00^{a}	190.00±0.00^{b}	36.00±0.00^{a}	43.61±0.50^{c}	BDL	BDL
Ni	29.00±0.00^{a}	100.00±0.00^{b}	50.00±0.00^{c}	BDL	42.75±0.00^{d}	43.06±1.85^{d}
Fe	NA	NA	NA	27279.86±472.77^{a}	43786.54±5498.17^{b}	28199.95±1411.64^{a}
Mn	437.00±0.00^{a}	1500.00±0.00^{b}	50.00±0.00^{c}	242.19±3.44^{d}	244.49±4.80^{d}	209.16±45.03^{d}
Cr	0.05±0.00^{a}	3950.00±0.00^{b}	100.00±0.00^{c}	44.30±8.08^{d}	110.03±2.62^{c}	63.73±0.29^{e}
V	NA	NA	0.31±0.00^{a}	22.42±8.15^{b}	52.88±16.65^{c}	50.92±10.94^{c}
Ti	NA	NA	0.30±0.00^{a}	1472.90±10.70^{b}	2383.82±743.70^{c}	2252.67±303.40^{c}
Ca	NA	NA	257.00±0.00^{a}	11328.16±495.19^{b}	2482.48±152.95^{c}	4448.76±167.93^{d}
K	61.00±0.00^{a}	120.00±0.00^{b}	120.00±0.00^{b}	5741.22±177.34^{c}	9029.98±908.13^{d}	6318.15±544.08^{e}
S	25.00±0.00^{a}	50.00±0.00^{b}	50.00±0.00^{b}	510.57±29.74^{c}	214.75±0.00^{d}	299.41±9.75^{e}
Nb	NA	NA	0.12±0.00^{a}	72.51±0.00^{b}	BDL	45.98±0.49^{c}

NA: Not Applicable; BDL: Beyond detection limit; Values represent mean ± Standard error of mean (of 2 replicates). Values with different superscript letters across the row are significantly different at $p < 0.05$

The concentrations of Sr from the three (3) dumpsites are lower than the background value of 175 mg/kg [22] and the permissible limit of 200 mg/kg [23]. The U concentrations from the three (3) dumpsites exceed the permissible value of 3 mg/kg [23]. Uranium has contaminated the soil from the three (3) dumpsites and is considered toxic to plants growing on the dumpsite and can threaten human life [24] [25]. The Th value of 18.391 - 26.721 mg/kg at 40 cm depth from the Maternity dumpsite is higher than the Th value of 15.608 - 18.526 mg/kg at 80 cm depth and this indicates an anthropogenic source of Th contamination. The values of Th are higher than the permissible limit of 7 mg/kg [23] and will be harmful to plants growing in the soil [26] [27]. The concentration of Cu from the Yantrailer dumpsite is higher than the background reference value of 36 mg/kg [22] and exceeded the permissible limit of 36 mg/kg [23] making Cu harmful to plants and could threaten human life [26] [27].

The presence and distribution of heavy metals in soils are influenced mainly by the parent material, the chemical and physical soil properties, the metal speciation, and the climatic conditions. The mineral content of the parent material is one of the most important factors for the amount of trace elements in soils, irrespective of classification or the amount of weathering [5]. This was observed in the present study where heavy metals in soils are suggested to be derived from geogenic sources. According to [1], contaminations from anthropogenic sources are usually moderate and referred to as 'Punctual" contamination. This is due to an identified source, often close to the contaminated soil. This kind of contamination could be due to industrial activities or the dumping of domestic wastes [7]. This was suggested to be anthropogenic sources in Jos area.

The higher values of Mo, Zr, U, and Th at 80 cm depth than the values obtained at 40 cm depth from Yantrailer and Tina dumpsites indicate geogenic sources which could be attributed to the decomposition of underlying rocks while higher values of Zr, Th, Sr and Zn at 40 cm depth than values obtained at 80 cm depth from maternity dumpsite suggest anthropogenic sources of contamination. The higher concentrations of Sr and Zn at 40 cm depth than the values at 80 cm depth from Yantrailer and Tina dumpsites indicate anthropogenic sources of contamination which could be attributed to the availability of metal-containing industrial and domestic wastes at the dumpsites which have eventually leached into the underlying soils. The report of [28] on dumpsite from Katsina showed that soils were contaminated from anthropogenic sources. The values of heavy metals in soils from dumpsites in Yenagoa were within permissible levels [29]. This is in contrast to the present study where the values of Zr, Zn, As, Th, and U from the three (3) dumpsites exceeded the background limit, threshold limit, and permissible limit. According to [30], the dumpsite from Abeokuta showed that Cu, Cr, Mn, and Zn accumulated at soil depths between 0–40 cm while Pb, Fe, and Ni were at depths above 40 cm. This is similar to the present study where soils were contaminated by Mo, Zr, U, and Th at 80 cm depth indicating geogenic sources while Zr, Th, Sr, and Zn at 40 cm depth indicated anthropogenic sources.

Heavy metals contaminations of soils from the dumpsites in Jos resulted from the decomposition of waste from anthropogenic sources resulting in leachate plumes that migrated from dumpsites to the soils. This is similar to the report of [31] on heavy metals contaminations on soils of Ewhare Dumpsite (Agbaro-Warri) that was linked to the decomposition of waste that migrated from the dumpsite to the soil. The higher concentrations of Sr and Zn at 40cm depth than the values at 80cm depth from Yantrailer and Tina dumpsites indicate anthropogenic sources of contamination which could be attributed to the availability of metal-containing wastes at dumpsites which have eventually been leached into the underlying soils. The reports of [32] and [33] on dumpsites from Ilesha show that concentrations of the selected heavy metals (Mn, Cd, Cr, Pb, and Fe) were lower than the WHO maximum permissible limit. This is in contrast to the results from the present study where the values of Zr, Zn, As, Th, and U from the three (3) dumpsites exceed the background limit, threshold limit, and permissible limit and could pose a serious threat to plant growing around the dumpsites.

According to [1] [34] [35] [36] [37] in the forest (uncultivated) area of Vari, Attica, geogenic source of contamination shows higher Co and Ni contamination at lower depths (10 – 25 cm) indicating that they were derived from the parent material, while for Cd, Zn, and Pb in the upper depth (0-10 cm) probably due to anthropogenic sources. This is similar to the present study where high values of Zr, Th, Sr, and Zn were obtained at 40 cm depth suggesting anthropogenic sources, and high values of Mo, Zr, U, and Th at 80 cm depth indicating geogenic sources. The present study is similar to the report of [11] [38] on dumpsites within the Gombe metropolis, northeastern Nigeria where the values of Rb, Zr, Cu, Zn, Fe, Mn, Pb, Sr, Ni, and As in the soil samples were higher than their values in control soil sample and was attributed to industrial and domestic wastes at the dumpsites. The high concentrations of Zn (67.281 - 1035.966 mg/kg) obtained from 40 cm and 80 cm depths in the soils underlying the dumpsites within Jos were higher than the soil grand mean worldwide values of Zn (64 mg/kg) reported by [6]. Zn is a very mobile and bioavailable metal, and the high contents in soil from dumpsites suggest anthropogenic sources. Thus, Heavy metal contamination of soils from dumpsites can be associated with the decomposition of domestic and industrial wastes indicating anthropogenic sources.

4.0 CONCLUSION

The higher values of Mo, Zr, U, and Th at 80 cm depth than the values obtained at 40cm depth from Yantrailer and Tina dumpsites indicate geogenic sources which could be attributed to the decomposition of underlying rocks while higher values of Zr, Th, Sr and Zn at 40cm depth than values obtained at 80 cm depth from maternity dumpsite suggest anthropogenic sources of contamination. The higher concentrations of Sr and Zn at 40cm depth than the values at 80cm depth from Yantrailer and Tina dumpsites indicate anthropogenic sources of contamination which could be attributed to the availability of metal-containing industrial and domestic wastes at the dumpsites which have eventually leached into the underlying soils. The values of Zr, Zn, As, Th, and U from the three dumpsites exceeded the background limit, threshold limit, and permissible limit and could pose a serious threat to plants growing around the dumpsites. The soils underlying the dumpsites in the study areas have been contaminated with heavy metals from anthropogenic and/or geogenic sources. The anthropogenic sources could be associated with the decomposition of domestic and industrial wastes while geogenic sources of contamination could be associated with weathering and dispersion of heavy metals from underlying mineralization and parent rocks.

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