Concentrations of Selected Heavy Metals in Soil in the Vicinities of Two Major Municipal Dumpsites in Minna, Nigeria

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Abstract
This study assesses the concentrations of lead, cadmium, nickel, copper and zinc, as well as some physico-chemical properties of surface soils in the vicinity of Gurusu and Kuyi dumpsites in Minna City, Nigeria, using standard analytical methods. The soil is generally sandy with a pH ranging from 5.20 (slightly acidic) to 8.67 (slightly alkaline). Organic matter content of the soil ranged from 1.0 to 12% while the Cation Exchange Capacity (CEC) ranged from 12 to 120meq/g. Range of mean concentrations (mg/kg) of heavy metals in Gurusu dumpsite were: Pb(0.71 - 19.51), Cd(2.22 - 2.80), Ni(23.55 - 45.39), Cu(16.74 - 50.37) and Zn(9.52 - 55.73), while that of Kuyi dumpsite were: Pb(37.35 - 54.29), Cd(4.19 - 4.67), Ni(2.83 -10.52), Cu(25.13 - 40.78) and Zn(1.05 - 22.42). The low clay contents, low organic matter and high Cation Exchange Capacity are capable of enhancing metal mobility. Generally, the concentrations of heavy metals in soil decreases with distance from the dump heap in both dumpsites and higher in the dumpsites than the control sites. This showed that the dumpsites were major contributors to the heavy metal build up in their vicinities and that the dumpsites were appreciably contaminated by these metals. The concentrations of the heavy metals, Pb and Cd, in soil samples of both dumpsites were found to be generally higher than the WHO permissive limit for agricultural soils. This calls for concern as these metals are highly toxic and of no known biochemical importance.

Keywords: Dumpsite, surface soils, heavy metals, cation exchange, contamination

1.0 Introduction

Heavy metals are naturally occurring in the earth but with increasing industrialization, anthropogenic activities contribute significantly to the rapid increase in concentration of heavy metals in the environment [1]. The contamination of the soil and water bodies by heavy metals is a persistent global issue and it poses a health threat to the immediate environment where the pollution has occurred [2]. Exposure of humans to heavy metals occurs through the dermal duct, inhalation or by ingestion [1]. Soil which is the topmost layer of the earth serves as a reservoir for numerous materials that could contaminate the environment and heavy metals constitute a major risk group because of their ability to accumulate in the tissues and organs of animals [3].

Heavy metals can directly influence human behavior by impairing mental and neurological functions, influencing neurotransmitter production and utilization, and altering numerous metabolic body processes. Systems in which toxic metal element could cause impairment and dysfunction include the blood, cardiovascular, eliminative pathways (colon, liver, kidneys and skin), endocrine (hormonal), energy production pathway, enzymatic, gastrointestinal, immune, nervous (central and peripheral), reproductive and urinary. The adverse effects of excess accumulation of heavy metals are well documented. Many cases of heavy metals burden are associated with industrial exposure, food and water contaminations [4].

In recent times, there had been a proliferation in the number of dumpsites and the amount of waste produced by many urban centers had been on the increase as a result of population growth and rapid industrialization [1]. In Nigeria, the use of dumpsites and surrounding soils as farmlands is a common practice as the soils are considered to be fertile because of the decayed and composted dumps [1]. Accumulation of heavy metals in agricultural soils and water bodies is hence of major concern due to issues regarding the safety of foods and water used for domestic purposes [5]. The burning of wastes as observed in many dumpsites destroys the organic compounds and oxidizes the metals which make them dissolvable in rain water. These metals can then be leached though the soil into surrounding water bodies and underground waters [5].

Even though several researches have been conducted to determine the concentrations of heavy metals in the dumpsite soils, however, there is need for continuous evaluation of the environment to avoid sudden cases of environmental contamination. Furthermore there exists paucity of data on the heavy metal contamination of the selected sites. The aim of this study is to assess the extent of accumulations of Pb, Cd, Ni, Cu and Zn in the surface soil in the vicinities of two major municipal dumpsites in Minna, the contributions of the dumpsites to the heavy metal burden in soil in their vicinities and the potential environmental health risks.

2.0 Materials and Methods

2.1 Study Sites

Gurusu (Figure 1) is located along Minna-Sarkin Pawa road on the outskirt of Minna City. It is geographically located within latitude of 09°38´ North and longitude of 06°38´ East. The settlers, predominantly Gwaris and Hausas, are farmers and most part of the land is used as farmlands for the planting of food crops and grazing of animals. The study area is a flat land with slight elevations and a few trees.

Kuyi (Figure 1) is located along Maikunle-Zungeru road. It is geographically located within latitude 09°39´ North and longitude 06°25´ East. The settlers, predominantly Gwaris and Fulanis, are also farmers and most part of the land is used as farmland for the planting of food crops and grazing of animals.

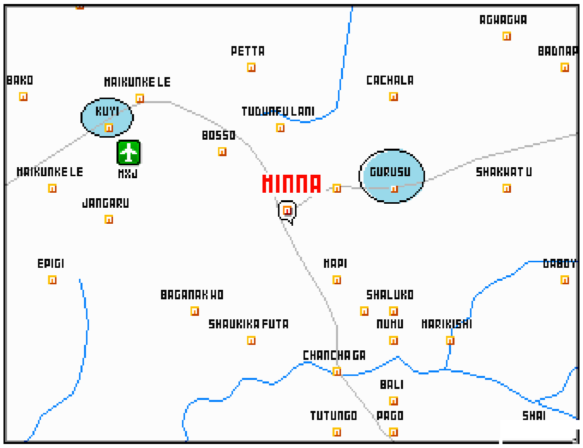

Figure 1: Map showing the location of study sites

The study area is a semi flat land with pits that continue to deepen as a result of the uncontrolled fetching of the earth by construction companies. Kuyi has a river that flows parallel to the dumpsite from the North to the East and it fills up to the brim during the raining season but dries up considerably during the dry season. The river is a source of water for livestock, irrigation and domestic uses. Other sources of water available in Kuyi are a hand dug well and a borehole.

2.2 Sample Collection

For each of the dumpsites (Plates I and II), twenty soil samples (five along each of the four cardinal points) were collected 50 m apart, starting from the edges of the dumpsites, at a depth of 0 – 20 cm. Samples were taken at 0 m (edge of the dump heap), 50 m, 100 m, 150 m and 200 m. Control samples were also collected at a distance of 700 m away from the dumpsite (Figure 2). The soil samples were thoroughly mixed to obtain a representative sample and then stored in pre-labelled polythene bags. The samples were air-dried for 3 days followed by grinding and sieving with 0.5 mm sieve to ensure homogeneity.

2.3 Determination of Physico-chemical Properties of Soil

The major physico-chemical properties of the soil capable of affecting heavy metal concentrations and mobility were determined. These include; pH, organic matter content, particle size distribution and cation exchange capacity (CEC).

Determination of Soil pH: The soil pH was determined using a pH meter (Model: EIL 7045/46 Kent, England) [3].

Determination of soil organic matter: Organic matter content of the soil was determined by weight loss on ignition method [3].

Plate I: Gurusu Dumpsite

Plate II: Kuyi Dumpsite

Determination of soil particle size distribution: The Bouyoucos hydrometer method was employed in the determination of soil particle size distribution [6].

Determination of cation exchange capacity: The Tucker and Beatty method of determining CEC was employed [7].

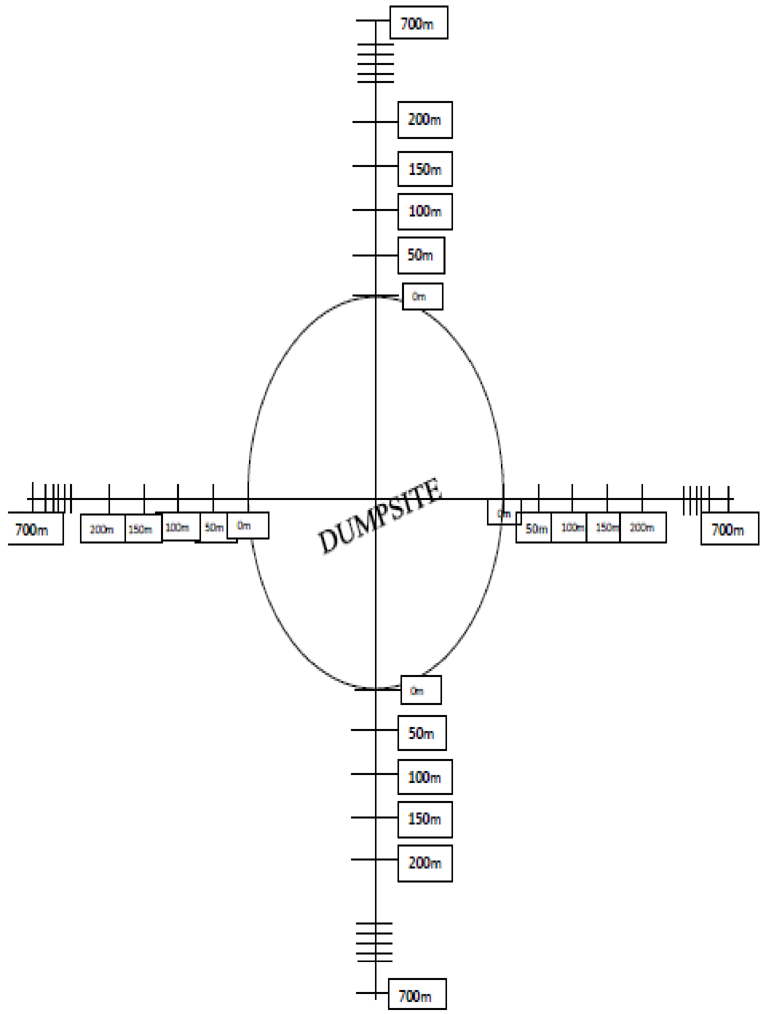

Figure 2: Soil sampling pattern

2.4 Determination of Heavy Metal Concentration in Soil Samples

The procedure recommended by AOAC (2002) as used by Ajai *et* al. [3] was employed for the soil digestion. In this method 10 cm^3 of HNO_3 was added to 1.0 g of soil sample in a 250 cm^3

beaker and the mixture boiled for 40 min. The mixture was then allowed to cool and 2.0 cm^3 of 70% $HClO_4$ added, followed by 1.0 cm^3 of concentrated H_2SO_4 and boiled gently until dense white fumes appeared. This was followed by cooling and addition of 20 cm^3 of distilled water. The mixture was then heated further to release any fumes. The solution was cooled and filtered into a 100 cm^3 volumetric flask and made up to volume with distilled water. The determination of heavy metal concentrations in sample digests was carried out using Atomic Absorption Spectrophotometer (Perkin-Elmer, Analyst 200). Appropriate working standards were prepared for each of the metal solution by serial dilution of the stock solutions. One way analysis of variance (ANOVA) was used to determine significant difference ($P<0.05$) between groups using SPSS 20. Data were presented as mean ± standard deviation.

3.0 Results and Discussions

3.1 Physico-chemical Parameters

The mean values for the physico-chemical parameters measured in the soil samples from the vicinities of both dumpsites are shown in Tables 1 and 2. The pH of the soils from Gurusu ranged from 5.28 to 7.45 while that of Kuyi ranged from 5.20 to 8.67. Neutral to high pH will not enhance metal mobility, as metals would be mainly in insoluble forms. Organic matter content of the soils from Gurusu site ranged from 1.0% to 12% (Table 1) while that of Kuyi ranged from 1.0% to 10.5% (Table 2). This result is comparable to that of 8.60±0.16% reported by Awokunmi *et al.* [8]. The low organic matter content will enhance metal mobility and bioavailability as less organic matter are available to bound metals. Table 1 shows that Gurusu dumpsite had low silt and clay content with the textural content decreasing in the order sand > silt >clay. Kuyi dumpsite has soil textures that varied between sandy loams, loamy sand, clay loams and silt loams (Table 2). The low clay and high sand contents, in the two sites, have potentials of leaching heavy metals [9]. This is because less clay is available to bind metals. Olayinka *et al* [10], obtained a similar result in which the soils were predominantly sandy with the top-layer (0–15cm) containing higher percentage of sand for both the dumpsite and control site. The Cation Exchange Capacity (CEC) of Gurusu dumpsite soil ranged between 12 meq/g and 120 meq/g (Table 1) while that of Kuyi dumpsite ranged between 16 meq/g to108 meq/g (Table 2). This fell within the range of mean values of 78.46±0.17 and 56.26±0.24 meq/g reported by Awokunmi *et al*. [8]. The high CEC is capable of enhancing the mobility of the metals for the contamination of underground water and agricultural soils through leaching and runoff [8].

3.2 Concentrations of Heavy Metals

Results of the heavy metal concentrations of soil samples collected from the vicinities of Gurusu and Kuyi dumpsites are shown in Tables 3 to 6.

Pb was only detected in three of the sampling points of Gurusu West; GW_0 (69.70±0.42mg/kg), GW_{50} (78.06±0.09 mg/kg) and GW_{100} (2.82±0.03 mg/kg) (Table 3). Table 4 shows a decline in the mean concentrations of Pb as one move away from the dumpsite indicating that contamination of the soil by Pb in the area is most probably as a result of the refuse dumping activity. Only GW_{100} had a concentration that was below the WHO permissible limit of 50 mg/kg [11] in agricultural soil. Pb was more widespread in Kuyi than Gurusu with a concentration range of 28.78±0.03 to 89.69±0.13 mg/kg. Pb concentrations in many sampling points were higher than the WHO limit. Table 6 shows mean concentrations of Pb decreasing from 0 m to 150 m from the dumpsite after which the trend was halted. The relatively high concentrations of Pb at Kuyi dumpsite could be attributed to the burning of e-waste (such as refrigerator, used computers, cables, printers, photocopy machines, automobile tires, batteries, air condition among others). The mean concentration of Pb recorded in this site was higher than mean concentrations of 16.14 mg/kg reported by Amos-Tautua *et al* [9] in municipal open waste dumpsite in Yenogua, 0.49 – 0.53 mg/kg reported by Olayiwola *et al* [1] in Ibadan and 37.12 mg/kg reported by Fosu-Mensah *et al* [12] for Korle Lagoon site in Accra, Ghana, where burning of e-wastes and cultivation of vegetables take place. It is however, lower than the mean concentration of 91.67 mg/kg reported by Olayinka *et* al [10] in Oke-ogi municipal dumpsite and 118 mg/kg reported by Bongoua-Devisme *et al* [13] for municipal open-air dumpsite in Bonoua, Ivory Coast.

Table 1: Physico-chemical Parameters of Soil Samples from Gurusu Dumpsite

SAMPLE	pH	EC (μS/cm)	% OM	CEC(meq/g)	% Silt	% Clay	% Sand	Textural Class
GN_0	6.58	5.79×10^2	2.50	88	10.25	11.00	78.75	Sandy Loam
GN_{50}	6.88	1.10×10^2	5.00	100	10.50	12.25	77.25	Sandy Loam
GN_{100}	6.83	1.10×10^2	4.02	108	16.75	5.25	78.00	Loamy Sand
GN_{150}	7.17	1.40×10^2	4.50	84	18.75	6.25	75.00	Loamy Sand
GN_{200}	5.49	5.90×10^2	8.00	120	25.75	13.50	74.00	Sandy Loam
GN_C	6.31	3.50×10^2	2.50	16	8.25	22.50	69.25	Sandy Clay Loam
GS_0	6.09	5.50×10^2	2.50	72	8.00	10.00	82.00	Loamy Sand
GS_{50}	5.45	3.90×10^2	2.50	64	7.25	9.25	83.50	Loamy Sand
GS_{100}	5.99	5.10×10^2	1.00	56	16.00	6.00	78.00	Loamy Sand
GS_{150}	5.99	2.90×10^2	1.50	72	14.50	5.50	80.00	Loamy Sand
GS_{200}	5.65	4.60×10^2	1.50	80	12.75	3.25	84.00	Loamy Sand
GS_C	4.36	5.09×10^2	3.00	20	2.00	1.50	96.50	Sand
GW_0	7.45	2.00×10^2	8.00	32	17.50	7.75	74.75	Loamy Sand
GW_{50}	6.64	2.00×10^2	12.00	24	17.75	8.00	74.25	Loamy Sand
GW_{100}	6.78	1.00×10^2	5.00	20	12.75	7.25	80.00	Loamy Sand
GW_{150}	7.12	1.20×10^2	4.50	24	16.50	5.50	78.00	Loamy Sand
GW_{200}	7.20	1.40×10^2	4.50	12	18.50	7.75	73.75	Loamy Sand
GW_C	6.29	0.60×10^2	5.50	29	50.25	14.25	35.50	Silt Loam
GE_0	6.35	0.40×10^2	2.50	56	11.50	6.25	82.25	Loamy Sand
GE_{50}	7.11	1.80×10^2	4.00	36	12.75	7.25	80.00	Loamy Sand
GE_{100}	5.28	3.50×10^2	7.50	52	7.25	11.75	81.00	Loamy Sand
GE_{150}	7.42	0.90×10^2	2.50	72	18.00	9.50	72.50	Sandy Loam
GE_{200}	6.38	5.80×10^2	2.00	84	21.00	7.00	72.00	Sandy Loam
GE_C	5.59	2.70×10^2	4.00	21	10.50	21.50	68.00	Sandy Clay Loam

GN=Gurusu North, GS=Gurusu South, GW=Gurusu West, GE=Gurusu East, C = control

Table 2: Physico-chemical Parameters of Soil Samples from Kuyi Dumpsite

SAMPLE	pH	EC (µS/cm)	% SOM	CEC(meq/g)	% Silt	% Clay	% Sand	Textural Class
KN_0	5.87	3.50×10^2	5.0	52	26.00	18.75	55.25	Sandy Loam
KN_{50}	5.82	0.80×10^2	5.5	56	20.00	17.00	63.00	Sandy Loam
KN_{100}	6.06	2.60×10^2	2.5	68	15.50	6.50	78.00	Loamy Sand
KN_{150}	6.64	0.90×10^2	2.0	48	14.25	7.75	78.00	Loamy Sand
KN_{200}	6.20	1.80×10^2	1.0	56	12.00	7.00	81.00	Loamy Sand
KN_C	6.38	3.00×10^2	3.0	32	12.00	12.25	75.75	Sandy Loam
KS_0	7.93	2.40×10^2	9.0	36	37.00	34.25	28.75	Silt
KS_{50}	8.67	1.30×10^2	8.5	40	29.25	31.25	39.50	Clay Loam
KS_{100}	7.78	0.80×10^2	6.5	44	29.75	31.00	39.25	Clay Loam
KS_{150}	7.43	0.90×10^2	7.0	56	30.00	9.50	60.50	Sandy Loam
KS_{200}	7.92	4.20×10^2	7.5	64	31.00	8.25	60.75	Sandy Loam
KS_C	6.97	3.90×10^2	7.0	38	20.50	20.25	50.25	Loam
KW_0	5.75	4.10×10^2	4.0	84	12.50	13.50	74.00	Sandy Loam
KW_{50}	5.66	1.40×10^2	2.0	96	15.25	12.75	72.00	Sandy Loam
KW_{100}	5.91	0.70×10^2	5.5	88	15.00	24.75	60.25	Sandy Clay Loam
KW_{150}	5.20	1.50×10^2	5.0	96	15.50	28.00	56.50	Sandy Clay Loam
KW_{200}	6.00	0.60×10^2	2.5	104	8.25	5.50	86.25	Loamy Sand
KW_C	6.23	1.70×10^2	3.0	25	5.50	17.50	74.00	Sandy Loam
KE_0	6.38	1.20×10^2	10.5	16	43.25	21.25	35.50	Silt Loam
KE_{50}	7.37	0.70×10^2	10.5	24	44.0	21.25	34.75	Silt Loam
KE_{100}	5.68	2.40×10^2	10.5	32	43.25	31.00	25.75	Silt Clay Loam
KE_{150}	8.51	1.00×10^2	1.5	44	44.00	35.00	21.00	Silt Clay Loam
KE_{200}	5.86	5.10×10^2	7.5	32	18.50	19.50	62.00	Sandy Loam
KE_C	6.41	3.90×10^2	6.0	22	17.00	12.25	70.75	Loamy Sand

KN=Kuyi North, KS= Kuyi South, KW=Kuyi West, KE=Kuyi East, C = control

Table 3: Concentrations of Heavy Metals (mg/kg) in Soil Samples from Gurusu Dumpsite

Sample	Pb	Cd	Ni	Cu	Zn
GN_0	BDL	1.63 ± 0.02^d	31.44 ± 0.05^j	10.42 ± 0.02^c	8.22±0.02
GN_{50}	BDL	2.30 ± 0.14^f	33.62 ± 0.03^l	32.44 ± 0.33^o	215.10±0.14
GN_{100}	BDL	1.23 ± 0.04^b	32.74 ± 0.01^k	22.23 ± 0.04^m	178.22±0.03
GN_{150}	BDL	1.42 ± 0.02^c	32.65 ± 0.06^k	19.15 ± 0.21^k	97.13±0.16
GN_{200}	BDL	2.06 ± 0.09^e	30.42 ± 0.02^c	18.86 ± 0.09^j	BDL
GN_C	BDL	1.62 ± 0.09^a	27.20 ± 0.04^c	14.95 ± 0.61^a	BDL
GS_0	BDL	1.62 ± 0.03^d	32.28 ± 0.40^k	13.50 ± 0.14^e	BDL
GS_{50}	BDL	2.22 ± 0.02^f	18.38 ± 0.04^b	16.12 ± 0.16^h	BDL
GS_{100}	BDL	2.63 ± 0.04^h	19.71 ± 0.16^c	15.62 ± 0.02^g	BDL
GS_{150}	BDL	2.43 ± 0.04^g	35.20 ± 0.01^n	11.41 ± 0.02^d	BDL
GS_{200}	BDL	2.61 ± 0.01^h	25.30 ± 0.08^f	18.13 ± 0.18^i	BDL
GS_C	BDL	2.88 ± 0.03^c	14.24 ± 0.06^a	19.60 ± 0.02^c	BDL
GW_0	69.70±0.42	4.25 ± 0.07^l	28.87 ± 0.09^h	73.53 ± 0.11^q	BDL
GW_{50}	78.06±0.09	5.63 ± 0.04^m	26.45 ± 0.07^g	138.66 ± 0.09^{qr}	BDL
GW_{100}	2.82±0.03	3.82 ± 0.03^k	25.50 ± 0.14^f	33.81 ± 0.01^p	BDL
GW_{150}	BDL	3.62 ± 0.01^j	22.82 ± 0.15^e	28.17 ± 0.24^n	94.81±0.01
GW_{200}	BDL	3.23 ± 0.04^i	91.71 ± 0.48^o	21.33 ± 0.14^l	38.10±0.14
GW_C	BDL	3.62 ± 0.02^d	22.63 ± 0.02^b	47.62 ± 0.01^d	BDL
GE_0	BDL	1.61 ± 0.14^d	22.06 ± 0.09^a	16.11 ± 0.15^h	38.06±0.09
GE_{50}	BDL	1.08 ± 0.11^a	20.63 ± 0.04^d	14.26 ± 0.08^f	7.82±0.02
GE_{100}	BDL	1.24 ± 0.06^b	16.26 ± 0.09^a	6.23 ± 0.04^a	BDL
GE_{150}	BDL	1.43 ± 0.04^c	31.12 ± 0.16^j	10.61 ± 0.01^c	30.76±0.23
GE_{200}	BDL	1.61 ± 0.01^d	34.12 ± 0.17^m	8.64 ± 0.05^b	BDL
GE_C	BDL	2.03 ± 0.04^b	33.23 ± 0.06^d	16.21 ± 0.03^b	BDL
WHO limit	50	3.0	50	100	300

BDL= below detection limit, GN= Gurusu North, GS= Gurusu South,GW= Gurusu West, GE = Gurusu East, C = control.Values in same column bearing same superscript are not significantly different at $p\geq0.05$.

Table 4: Mean Concentrations of Metals (mg/kg) at various Distances along the four Cardinal Points in the Vicinity of Gurusu Dumpsite

Distance from dumpsite	Pb	Cd	Ni	Cu	Zn
0m	17.43±34.85	2.27±1.31	28.66±4.63	28.39±30.18	11.57±18.08
50m	19.51±39.03	2.80±1.96	24.77±6.81	50.37±59.42	55.73±106.31
100m	0.71±1.41	2.23±1.24	23.55±7.21	19.47±11.59	44.56±89.11
150m	BDL	2.22±1.04	30.44±5.36	17.33±8.18	55.68±48.20
200m	BDL	2.38±0.70	45.39±31.09	16.74±5.51	9.52±19.05
*700m	BDL	2.52±0.89	24.31±8.01	24.35±15.60	BDL
WHO limit	50	3.0	50	100	300

* = Control, BDL= below detection limit

Table 5: Concentrations of Heavy Metals (mg/kg) in Soil Samples from Kuyi Dumpsite

Sample	Pb	Cd	Ni	Cu	Zn
KN_0	BDL	4.05 ± 0.07^{d}	BDL	18.50 ± 0.14^{d}	BDL
KN_{50}	37.89 ± 0.13^{c}	4.08 ± 0.11^{de}	0.44 ± 0.05	28.67 ± 0.09^{i}	BDL
KN_{100}	50.83 ± 0.04^{e}	5.21 ± 0.01^{jk}	BDL	15.82 ± 0.03^{b}	BDL
KN_{150}	47.70 ± 0.14^{d}	4.27 ± 0.10^{f}	7.22 ± 0.03	15.40 ± 0.01^{a}	BDL
KN_{200}	37.30 ± 0.14^{c}	5.81 ± 0.01^{l}	BDL	19.60 ± 0.05^{e}	BDL
KN_C	45.34 ± 0.12^{a}	4.42 ± 0.03^{b}	BDL	22.37 ± 0.29^{b}	BDL
KS_0	70.76 ± 0.23^{j}	4.22 ± 0.04^{ef}	BDL	33.85 ± 0.06^{l}	BDL
KS_{50}	61.24 ± 0.05^{i}	4.23 ± 0.04^{ef}	BDL	32.62 ± 0.03^{k}	4.22 ± 0.02
KS_{100}	63.13 ± 0.18^{f}	4.42 ± 0.02^{g}	BDL	36.68 ± 0.11^{m}	BDL
KS_{150}	77.86 ± 0.08^{k}	3.81 ± 0.01^{c}	BDL	44.22 ± 0.02^{n}	5.40 ± 0.04
KS_{200}	89.69 ± 0.13^{m}	4.12 ± 0.16^{de}	BDL	35.00 ± 0.57^{l}	BDL
KS_C	63.22 ± 0.03^{d}	5.21 ± 0.04^{d}	BDL	22.61 ± 0.01^{b}	BDL
KW_0	83.31 ± 0.16^{l}	5.22 ± 0.03^{jk}	BDL	22.84 ± 0.38^{f}	BDL
KW_{50}	60.12 ± 0.16^{i}	4.82 ± 0.02^{h}	BDL	29.12 ± 0.16^{j}	BDL
KW_{100}	57.45 ± 0.07^{h}	5.24 ± 0.05^{k}	BDL	28.27 ± 0.38^{i}	BDL
KW_{150}	60.38 ± 0.03^{e}	5.09 ± 0.13^{jk}	3.61 ± 0.01	23.64 ± 0.06^{g}	21.43 ± 0.14
KW_{200}	55.18 ± 0.25^{f}	5.08 ± 0.11^{i}	BDL	26.70 ± 0.14^{h}	BDL
KW_C	59.40 ± 0.53^{c}	5.03 ± 0.06^{c}	BDL	18.01 ± 0.01^{a}	BDL
KE_0	BDL	3.81 ± 0.01^{c}	34.11 ± 0.15	61.75 ± 0.21^{p}	BDL
KE_{50}	BDL	3.61 ± 0.01^{b}	41.65 ± 0.07	72.70 ± 0.14^{q}	BDL
KE_{100}	28.78 ± 0.03^{a}	3.81 ± 0.01^{c}	12.82 ± 0.02	52.12 ± 0.16^{o}	BDL
KE_{150}	31.23 ± 0.04^{b}	3.64 ± 0.05^{b}	0.42 ± 0.02	17.27 ± 0.10^{c}	BDL
KE_{200}	56.90 ± 0.14^{h}	2.82 ± 0.02^{a}	11.64 ± 0.05	35.12 ± 0.16^{m}	BDL
KE_C	47.83 ± 0.02^{b}	3.05 ± 0.03^{a}	18.23 ± 0.02^{b}	34.61 ± 0.02^{c}	BDL
WHO limit	50	3.0	50	100	300

KN= Kuyi North, KS= Kuyi South, KW= Kuyi West, KE= Kuyi East, C = control, BDL= below detection limit.Values in same column bearing same superscript are not significantly different at $p \geq 0.05$.

Table 6: Mean Concentrations (mg/kg) of Metals at Various Distances along the Four Cardinal Points in the Vicinity of Kuyi Dumpsite

Distance from dumpsite	Pb	Cd	Ni	Cu	Zn
0m	38.52±44.77	4.33±0.61	8.53±17.05	34.24±19.45	BDL
50m	39.81±28.64	4.19±0.49	10.52±20.75	40.78±21.35	1.05±2.11
100m	50.04±15.04	4.67±0.68	3.21±6.41	33.22±15.24	BDL
150m	54.29±19.73	4.20±0.65	2.83±3.34	25.13±13.20	6.71±10.14
200m	37.35±26.43	4.46±1.29	2.91±5.82	29.11±7.46	22.42±44.85
*700m	53.91±8.64	4.41±0.98	4.55±9.11	24.36±7.14	BDL
WHO Limit	50	3.0	50	100	300

* = Control, BDL= below detection limit

As shown in Table 3 the mean concentrations of Cd in soils from Gurusu dumpsite ranged from 1.08±0.11 to 5.63±0.04 mg/kg. Table 4 shows that mean concentrations of Cd was highest 50 m away from the dumpsite in Gurusu and the least concentration of 2.22±1.04 was recorded 150 m away from the dumpsite. Table 5 shows that the mean concentrations of Cd in soils from Kuyi dumpsite ranged from 2.82±0.02 to 5.81±0.01 mg/kg. The highest mean concentration of Cd was at a distance of 100 m away from the dumpsite (Table 6). The concentrations of cadmium in soils collected from the vicinity of Kuyi dumpsite was found to be higher than those found in soils around Gurusu dumpsite. The concentrations of Cd recorded in both dumpsites were above the WHO maximum permissible limit of 3.0 mg/kg for agricultural soil. These results were however lower than the mean values of 18.64 reported by Fosu-Mensah *et al* [12], 81 mg/kg reported by Bongoua-Devisme *et al* [13] and 28.56±17.95 - 40.17±18.21 mg/kg reported by Anietie and Labunmi [14].

The lowest concentration of Ni that was recorded in Gurusu dumpsite was 16.26±0.09 mg/kg at GE_{100} (Table 3). The highest concentration of 91.71±0.48 mg/kg was recorded at GW_{200}. Table 4 shows that the mean concentrations of Ni generally decreases with increasing proximity from the dumpsite. The deviation from this trend, noticed at 150 m and 200 m, could be as a result of the topography of the site, local contamination or other natural processes. In Kuyi dumpsite, Ni was only recorded in eight (8) of the twenty-four (24) samples collected (Table 5). Kuyi East indicated the presence of Ni in all five sampling points in concentrations ranging from 0.42±0.02 to 41.65±0.07 mg/kg. Other points where Ni was detected in Kuyi dumpsite were KN_{50} (0.44±0.05mg/kg), KN_{150} (7.22±0.03 mg/kg) and KW_{150} (3.61±0.01 mg/kg). Table 6 shows that mean concentrations of Ni decreased on moving from 0 m towards 150 m. The mean concentrations recorded in both dumpsites were however lower than the WHO permissible limit of 50 mg/kg for agricultural soil. It is also lower than mean concentration of 119 mg/kg obtained by Bongoua-Devisme *et al* [13]. The value in this study is however higher than that of 0.31 – 0.42 mg/kg reported by Olayiwola *et al* [1] and 2.91 mg/kg by Olayinka *et al* [10].

The mean concentrations (mg/kg) of Cu recorded in Gurusu dumpsite ranged from 6.23±0.04 at GE_{100} to 138.66±0.09 in GW_{50} (Table 3). However, mean concentrations of the metal decreases as the sampling distance increases (Table 4). From Table 5, the mean concentrations of Cu in soils collected from the vicinity of Kuyi dumpsite ranged from 15.40±0.01 mg/kg at KN_{150} to 72.70±0.14 mg/kg at KE_{50}. Table 6 shows a decrease in mean concentration of the metal as the distance of the sampling point increases. The sharp increase in the concentration recorded 200 m away from the dumpsite could be as a result of topography of the site or local contaminations. Mean concentrations of Cu in both dumpsites were below the 100 mg/kg WHO permissible limit for agricultural soil. These values were generally within the range of mean concentrations of 31.34±21.41 and 52.48±26.63 mg/kg reported by Anietie and Labunmi [14] for Cu in Akure dumpsite soil. Mean concentration of 38.8 mg/kg of Cu reported by Fosu-Mensah *et al* [12] for Korle Lagoon site in Accra, Ghana, was also within the range obtained in this study.

From Tables 3 and Table 4, the mean concentrations of Zn recorded in Gurusu ranged from 7.82±0.02 mg/kg in GE_{50} to 215±0.14 mg/kg in GN_{50}. Table 4 shows a considerable decrease (from 50 m to 150 m) in the mean concentrations of Zn as the distance of the sampling points increases. In Kuyi dumpsite, Zn was only found in three of the sampling points KS_{50}, KS_{150} and KW_{150} at concentrations of 4.22±0.02, 5.40±0.04 and 21.43±0.14 mg/kg respectively (Table 5). Table 6 shows an increase in the mean concentration of Zn as one moves away from the dumpsite, this shows that other natural processes rather than the dumpsite could be responsible for the accumulation of the metal in the soil. Mean concentrations of Zn in both dumpsites were below the 300 mg/kg WHO permissible limit for agricultural soil. They were also lower than mean concentration of 844 mg/kg reported by Bongoua-Devisme *et al* [13] for municipal open-air dumpsite in Bonoua, Ivory Coast. However, mean concentrations of Zn in this study were generally higher than that of 0.38 – 0.40 mg/kg reported by Olayiwola *et al* [1], 20.85 mg/kg reported by Olayinka *et al* [10] and 8.68 mg/kg reported by Fosu-Mensah *et al* [12].

Generally, there exist significant differences ($P<0.05$) in the concentrations of heavy metals in the soils collected from the dumpsite relative to the control site. This is an indication of some levels of contamination of the dumpsites by these metals. The order of accumulation of heavy metals in Gurusu dumpsite was Ni > Zn > Cu > Pb > Cd, while in Kuyi dumpsite, the order was Pb > Cu > Ni > Zn > Cd. This difference could be attributed to the source and composition of the wastes disposed in each of the sites [10]. The order in Kuyi is similar to that obtained by Olayinka *et al* [10], in which Pb was the most and Cd the least accumulated.

4.0 Conclusion

The result of this study revealed the presence of the selected heavy metals in varying concentrations in soil collected across several sampling points in the vicinities of Gurusu and Kuyi dumpsites in Minna. Generally, the concentrations of the heavy metals in soil decreases with distance from the dump heap. The few exceptions could be due to transfer of metals through runoff or the dumped waste might not be the only source of heavy metal accumulation in the soils. However, the dumpsite was a major contributor to the heavy metal build up. The concentrations of the heavy metals, Pb and Cd, in both dumpsites soil were found to be generally higher than the WHO permissive limit for agricultural soil. This calls for concern because agricultural activities take place in the vicinity of the dumpsites, hence, water, vegetation and food crops in these areas stand the risk of been contaminated with these metals due to leaching and runoff. Moreover, the low clay content, low organic matter and high Cation Exchange Capacity are potential factors for the enhancement of the solubility, mobility and bioavailability of the metals.

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