

Contributions of Municipal Solid Waste to Heavy Metal Concentration in Soil Near Oke Ese Dumpsite, Ilesha, Osun State, Nigeria

E. E. Awokunmi^{*1}, S. S. Asaolu², S. O. Adefemi³, A. Y. Gbolagade⁴

¹⁻⁴Chemistry Department, Faculty of Science, Ekiti State University, Ado Ekiti, Nigeria

^{*1}getemmano2010@yahoo.co.uk

Abstract-The levels of heavy metals in water and soil have increased due to the indiscriminate dumping of domestic and industrial wastes. This research was conducted to examine the contributions of municipal solid waste disposal to the concentrations of heavy metals in water sources near Oke-Ese Dumpsite in Ilesha, Osun State. Soil samples were collected from Oke -Ese Dumpsite at intervals of 10 m, at depths of 0-15 cm using calibrated soil auger. A control soil sample was also collected at a distance of 200 m from the last sampling point at the dumpsites. Water samples were randomly collected from five water sources (river and wells). Physicochemical parameters, sequential extraction and heavy metals analyses were conducted on collected samples. Results indicate that pH (6.20 ± 0.11), organic matter content (8.60 ± 0.16) and Cation Exchange Capacity (78.4 ± 0.17) of the control sample were greater than 5.70 ± 0.12 , 7.62 ± 0.14 and 56.26 ± 0.24 respectively. Heavy metals were observed at elevated concentrations at dumpsites locations with average values in the following order: Pb (22.7), Fe (134.9), Cd (42.7), Cu (9.0), Zn (116.0), Mn (15.5), Ni (27.7) and Cr (11.0). However, the results of sequential extraction revealed that these heavy metals were distributed in considerable proportions in the exchangeable fraction of soil ($11.2 - 89.3$ mg/kg). Both Sequential Extraction Procedures (SEPs) employed, indicated the possibility of these metals leaching into the surrounding water sources. In addition, these heavy metals were found in greater concentrations than the limit set by World Health Organisation (WHO) in all water sources near the Oke-Ese Dumpsite. In conclusion, there is need to cite dumpsite away from residential area and contaminated water sources should be treated before domestic applications.

Keywords- Contributions; Municipal; Heavy Metals; Dumpsites; Concentrations

I. INTRODUCTION

The levels of heavy metals have increased in recent years as a result the indiscriminate disposal of industrial, municipal and domestic wastes [1-4]. These metals accumulate in the soil over time and are also retained within the soil matrix through interaction with soil components and may later find their way into the food chain through plants and animals. Awokunmi et al. [1] reported that the continuous disposal of waste may result in lateral leaching of heavy metals within the soil profile which may end up in nearby water bodies. Mpofu et al. [5] also reported that the concentration of heavy metals in soil close to dumpsite depends on type of waste, topography, run-off and the level of scavenging. These metals are often finally introduced into the ecosystem through the infiltration or disposal of leachates.

Waste is generated worldwide and originates as a result of human activities. Odewumi [6] observed that the generation of waste is an unavoidable aspect of human life, which can only be managed, rather than eliminated. Population is a major challenge to the provision of efficient methods of waste management while achieving a healthy, waste-free environment. An increase in the population of an area (or environment) will invariably result in an increase in the level of waste generated within it. Many urban centres are confronted with the task of removing large amounts of solid waste, as well as the possible effects of these wastes on health, as well as the quality of environment and the urban landscape [7].

Common sources of heavy metals pollution include; discharge from electroplating and plastic manufacturing, ceramics, inks, motor oils, fertilizer production plants and metallurgical processes [8]. Due to the non-biodegradability of heavy metals, they are protected from rapid detoxification and removal by metabolic activities; thus increasing their resident time within the soil environment. Solubility of these heavy metals can be increased with complexing agents; such as organic acids, chlorides, sulphates and carbonates. Awokunmi et al. [1] reported the influence of variations in pH on the heavy metals availability in the soil of dumpsites. The available heavy metals may be leached into the nearby water bodies, which may eventually enter food chain. However, this research seeks to examine the contributions of municipal solid waste disposal to the heavy metal concentrations in water sources near the Oke- Ese dumpsite, Ilesha, Osun State.

II. METHODOLOGY

A. Study Area

Ilesha is a town located in the south west of Nigeria, between latitude $7^{\circ} 37' 0''$ N longitude $4^{\circ} 43' 0''$ E, and with a population of 310,000 as of the 2010 National Population Census. Ilesha has witnessed tremendous growth in population and infrastructure with several small-scale and cottage industries with associated electronic, agricultural, domestic and industrial

waste which dominated the study area. These commercial activities have contributed to increases in the volume and composition of wastes. Oke-Ese Dumpsite has an area of 100 m², is located within a residential area, the River-Ora is 50 m downslope from the final dumpsite sampling point near other sources of water (Fig. 1).

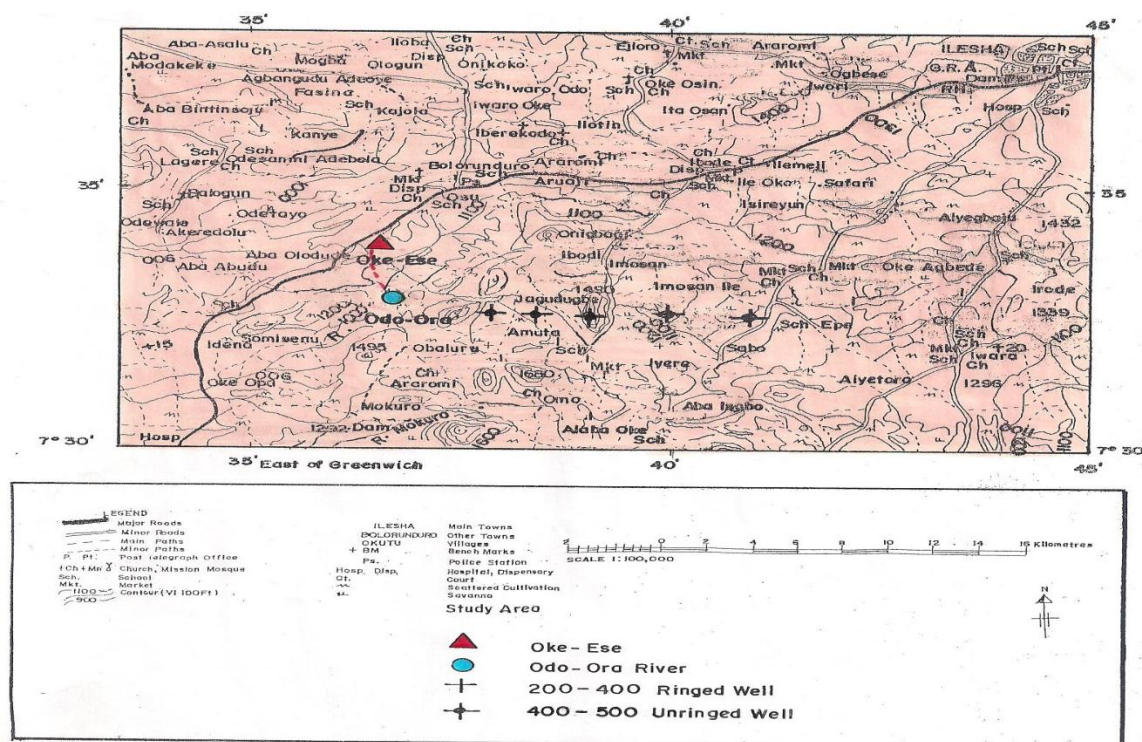


Fig. 1 Relief Map of Ilesha Showing the Topography of the Studied Area

Source: Extraction form Topographical Map of Ilesha Sheet 243, edition 1, compiled and drawn by Mr. R.O. Ilesanmi, dept. of Geography and Planning Science, Cartographic Unit, Ekiti State University, EKSU, Ado-Ekiti.

B. Sample Collection

1) Collection of Soil Samples

Soil samples were collected from ten locations downslope of the dumpsite at 10 m intervals from using calibrated soil auger at a depth of 0-15 cm to determine the effects of leaching on the concentration of heavy metals within the selected distance. A control sample was collected in similar manner 200 m away from the final dumpsite sampling point. These samples were stored in already-leached polythene bags and transported to the laboratory for further analysis.

2) Collection of Water Samples

Grab water samples of 500 mL were collected from three ringed wells at distances of 200 m, 300 m and 400 m from Oke-Ese Dumpsite, one un-ringed well at a distance of 500 m from the Dumpsite and from the River Ora at a distance 50 m away from the Dumpsite. Sample depths ranged from; 30m – 50m, and all locations were downslope from the dumpsite and located within the residential area of Ilesha town. The samples were collected in clean sample bottles during the wet season in May, 2013. The pH values of these water samples were determined on-site with a standardised electrode pH meter according to APHA [9]. The water samples were later transported to the laboratory for further analyses.

C. Analyses of Soil Samples

Soil samples were first classified as loamy before they were analyzed for pH, organic matter content, cation exchange capacity and heavy metals concentration by acid digestion and two Sequential Extraction Procedures in order to assure reproducibility of results. The soil samples were classified as sandy-loam by the Department of Geology, Ekiti State University and scanty vegetation was observed growing at the dumpsite at the time of sample collection.

1) Acid Digestion

Air-dried soil samples of 0.1 g of were treated with 4 mL of an oxidising mixture (HNO₃: HCl in 3:1 ratio), next a Teflon beaker containing 6 mL of HF was placed in microwave oven for four minutes. The recovered sample was then treated with 5.6 g of HBO₃ to avoid silica evaporation. The sample was then filtered into a volumetric flask and diluted to 100 mL with distilled /de-ionized water. Heavy metal concentrations were determined by Atomic Absorption Spectrophotometer (model PG 990).

2) Tessier's Method of Sequential Extraction

A five-step modified Tessier's sequential extraction procedure was employed (SEP) [10]. The metal in aqueous phase of soil was extracted with 45 mL of 1M ammonium acetate at pH 5 with acetic acid under stirring for 24 hours. The exchangeable fraction was determined by extraction with 22.5mL hydroxylammonium chloride (1M) and 22.5 mL acetic acid (25%), with stirring at room temperature. Metal adsorbed on inorganic soil constituent was extracted by 12.5 mL of 0.1M HCl and stirring for 24 hours. Metals adsorbed on organic matter was treated with 12.5 mL of 0.5 M NaOH and stirred for 24 hours, later dried under an IR lamp at 60°C and then digested with 4 mL of 65% HNO₃ and 2 mL of 40% HF in a microwave oven. The metals precipitated as pure or mixed solids were extracted using 12.5 mL of 8M HNO₃ and digested for three hours at 80°C. Finally, the residual solid was digested with 4 mL of oxidising mixture (HNO₃: HCl) and 6 mL HF in Teflon recipient placed in a microwave oven. The sample was shaken with 5.6g HBO₃ to avoid silica evaporation and diluted to 100 ml by deionized water. Concentrations of heavy metals were determined by Atomic Absorption Spectrophotometer (model PG 99).

3) BCR Method of Sequential Extraction

The method employed here was described by Community Bureau of Reference [11]. The exchangeable metals were determined by adding 40 mL of 0.11 mol/L to 1.0 g of soil, in a 50 mL Polypropylene tube. The mixture was shaken at 400 rpm for 16 hrs overnight at 22.0°C. Separation achieved by centrifugation at 3800 rpm for 20 minutes. The supernatant was then decanted into a volumetric flask, where it diluted to 100 mL with distilled / deionized water. The metals bound to iron and manganese oxides were extracted by the addition 40 mL hydroxylammonium chloride (adjusted to pH 2 by the addition of 2 mol/L acetic acid) onto the residue obtained after shaking the mixture for 16 hours at 22.0 °C, the extract was separated as previously described. Next, 10 mL of 8.8 mol/L hydrogen peroxide was carefully added to aliquots of the residue in the centrifuge tube, in order to determine the identity of metals bound to organic materials and sulphides. The mixture was digested at room temperature for one hour, and then at 85°C for one hour, after which it was heated in a water bath. The solution was heated to near dryness before addition of 50 mL of 1.0 mol/L acetic acid solution. The pH adjusted to 2 with the addition of nitric acid. The solution was then centrifuged and separation conducted as previously described. Lastly, the residual solid was digested with 4 mL of oxidising mixture (HNO₃: HCl) and 6 mL HF in Teflon recipient put in microwave oven. The sample was also shaken with 5.6g HBO₃ to avoid silica evaporation and diluted to 100 ml by de-ionized water. Concentrations of heavy metals were determined by Atomic Absorption Spectrophotometer (model PG 990).

D. Statistical and Data Analyses

The data were collected in triplicate, and statistical analyses included the mean, standard deviation and percentages of soil samples.

III. RESULTS AND DISCUSSION

A. Physicochemical Properties of Soil

Table 1 depicts the physicochemical parameters of soil samples collected from locations at the Oke-Ese dumpsite and control site. The mean pH value of 6.22±0.11 was greater than the value obtained on the control site (5.70±0.12). The higher pH of the dumpsite compared to the control site may be as a result of mineral build-up at the dumpsite. Awokunmi et al., [1] reported higher pH values on selected dumpsites in Ekiti state, when compared to control sites. The low pH enhances bioavailability, solubility and the possible leaching of heavy metals [12].

TABLE 1 MEAN PHYSICOCHEMICAL PARAMETERS OF SOIL COLLECTED FROM LOCATIONS ON OKE ESE DUMPSITE

Parameters	pH	Organic Matter Content	Cation Exchange Capacity
Dumpsite N = 10	6.22±0.11	8.60 ±0.16	78.46 ±0.17
Control N = 10	5.70 ±0.12	7.62 ±0.14	56.26 ±0.24

The mean organic matter content of soil collected from the Oke-Ese dumpsite was determined be 8.60±0.16, while that of the control site was 7.62±0.14. The higher organic matter content at the dumpsite may be as a result of the dumping of wastes containing organic matter at the dumpsite, which has been subjected to years of biodegradation. Baker et al. [13] reported that the organic matter content of soil contributes to the increase in the availability of mineral elements.

Another factor that contributes to mobility and availability of mineral elements in soil is cation exchange capacity, which also provides information regarding soil texture, degree of compression, level of porosity and permeability [14]. Moderate mean values of cation exchange capacity were obtained at the dumpsite (78.46±0.17) and the control site (56.26±0.24) with the dumpsite value higher than that of the control site. The moderate cation exchange capacity values indicated the possible redistribution of heavy metals within the soil horizon, thereby increasing the mobility of heavy metals and possible leaching to the nearby water bodies.

B. Heavy Metal Concentration of Selected Location on Dumpsite

Table 2 presents heavy metals concentrations from bulk soil collected from ten locations at the Oke-Ese Dumpsite, Ilesha. The concentrations of heavy metals vary randomly among locations, from one end of the dumpsite to the other.

The concentration of Pb ranged from 5.0 – 41.0 mg/Kg (Table 2), with an average value of 22.7 mg/Kg, were greater than that of the control (9.0 mg/Kg). However, the levels of Pb presented herein are relatively low compared to the levels reported by Adelekan and Alawode [15] in soil from dumpsites located within Ibadan, in southwestern Nigeria. Human exposure to heavy metals occurs through three primary routes; inhalation, ingestion and skin absorption [15]. Pb is a particularly dangerous metal which has no biological role [16] and negatively affect children in significant ways. The values of Pb reported in this study were less than intervention value set by the Department for Petroleum Resources [17].

TABLE 2 CONCENTRATIONS OF HEAVY METALS FROM BULK SOIL COLLECTED FROM TEN POINTS ON OKE-ESE DUMPSITE (MG/KG)

Sampling point	Pb	Fe	Cd	Cu	Zn	Mn	Ni	Cr
1	22.0	134.0	41.0	3.5	82.0	21.0	19.0	28.0
2	23.0	139.0	47.0	4.8	89.0	13.0	30.0	41.0
3	30.0	143.0	59.0	2.1	96.0	5.00	41.0	48.0
4	18.0	122.0	22.0	7.6	84.0	20.0	22.0	24.0
5	19.0	128.0	26.0	10.9	109.0	15.0	26.0	30.0
6	21.0	124.0	31.0	10.0	116.0	18.0	27.0	40.0
7	19.0	128.0	63.0	12.1	136.0	12.0	31.0	44.0
8	29.0	132.0	24.0	12.6	151.0	8.00	19.0	33.0
9	41.0	123.0	39.0	13.3	134.0	36.0	19.0	19.0
10	5.00	176.0	75.0	13.3	163.0	7.0	43.0	52.0
Mean	22.7	134.9	42.7	9.0	116.0	15.5	27.7	35.9
Control	9.00	18.00	10.0	1.6	24.0	7.00	8.00	11.0

The concentration of Fe ranged from 122.0 to 176.0 mg/Kg at all sampling sites (Table 2), with an average value of 134.9 mg/kg. The concentration of Fe in all sampled locations were greater than that of the control sample (18.0 mg/kg); this may be a result of dumping of Fe-containing waste at the dumpsite, though Fe has been reported at elevated levels in Nigerian soils [18-20].

Concentration of cadmium in selected locations ranged from 22.0 – 75.0 mg/kg, with an average of 42.7 mg/kg, considerably higher than that of the control (10.0 mg/kg). The results obtained in this study were lower than the ones reported by Awokunmi et al. [1] from the study on selected dumpsite in Ekiti State. However, higher values of Cd have been reported in Nigeria soil [21-23]. Cd concentrations in all locations were above the intervention levels prescribed by the DPR [17].

Concentration of Cu ranged from 2.1 – 13.3mg/kg, with an average of 9.0 mg/kg. The levels of Cu in all sites in this study were comparatively high compared to the control site. Dara [24] reported that bio-degradable waste introduced metallic Cu into soil at levels greater than natural loads.

Of all the metals considered in this study, the concentration of Zn is higher than all other metals falling in the range of 82.0 – 163.0 mg/kg with an average of 116.0 mg/kg which was significantly higher than control (24.0 mg/kg). The major sources of Zn at sampled locations is indiscriminate dumping of Zn-containing refuse, motor oil, lubricating oil, rubber and tires, which contain Zn as a portion of many additives such as Zinc dithiophosphates [25].

Concentration of Mn ranged from 5.0 - 36.0 mg/kg with an average of 15.5 mg/kg. However, concentration of Mn (7.0 mg/kg) was lower in the control site. Manganese is found naturally in the most soil as it is one of the most essential mineral for life [24].

The levels of Ni observed in the present study were higher than the levels observed in other industrial sites in Nigeria [26-28]. Higher values of Ni have been reported for soil around industrial area in India [29]. Global input of Ni to the human environment is approximately 150,000 and 180,000 metric tonnes per year from natural and anthropogenic sources respectively; including emissions from fossil fuel consumption and the industrial production, as well as the use and disposal of Ni compounds and alloys [30]. A study by Nwuche and Ugoji [31] determined that the rate of respiration of microbial soil populations is inhibited by heavy metals Cu, Zn and Ni. Nickel is known to accumulate in plants and the excessive intake of Ni from plants grown on nickel-rich soils (such as tea, beans, vegetables), demonstrate higher chances of the development of

cancers of the lungs, nose, larynx and prostate as well as greater risks respiratory failures, birth defects and heart disorders [32].

All the sampled sites display Cr concentration higher than that of control site; this implies that the high concentrations at the dumpsite are the result of the dumping of Cr-containing waste. The values of Cr obtained in this study were lower than the 900 – 2000 mg/kg reported by Adefemi and Awokunmi [20] at selected dumpsites in Ado – Ekiti the south west of Nigeria. Although Cr toxicity in the environment is relatively rare, it still present some risks to human health, because it can be accumulated on the skin, lungs, muscles, fat in liver, dorsal spine, hair, nails and placenta, where it is related to bleeding of the gastrointestinal tract, cancer of the respiratory tract, as well as ulcers of the skin and mucus membrane [33, 34].

C. Sequential Extraction of Heavy Metals

The distribution of selected heavy metals in various soil fraction explored by the techniques prescribed by Tessier et al., [37] and BCR [11] is depicted in Tables 3 and 4. It was observed that all metals considered in this study were abundant in non-residual phase of the soil (anthropogenic) as follows in percentages: Pb (98.4), Fe (60.3), Cd (99.4), Cu (96.9), Zn (98.6), Mn (97.2), Ni (91.9) and Cr (93.7), while similar results were obtained in BCR [12] with slight variations in concentrations of anthropogenic phase metals as follows: Pb (89.6), Fe (59.7), Cd (91.3), Cu (93.6), Zn (93.0), Mn (82.2), Ni (75.5) and Cr (92.7). It has been reported that metals in the non-residual phases of soil are the most mobile and bio-available and, may be used to gather information about their possible source, either anthropogenic or lithogenic [19, 35, 36].

According to Tessier et al. [37] procedure Cd, Cu, Zn and Cr dominate exchangeable fraction at values of 62.8, 86.6, 70.6, 22.8 respectively. The BCR [11] procedure obtained similar results with Cd, Cu, Zn and Cr found in dominance in the exchangeable, water and acid soluble fraction as 33.4, 89.3, 86.2 and 36.2, mg/kg respectively. Metals in the exchangeable, water and acid soluble phases of soil have been shown to possess the highest degree of solubility and bio-availability [11, 37]. As a result of this solubility, lateral and horizontal leaching of these metals into the soil profile- tends to occur. Awokunmi *et al.* [1] reported the lateral leaching of heavy metal on selected dumpsites in Ekiti State, southwestern Nigeria. Considerable concentrations of such metals may be found in the surrounding water bodies.

TABLE 3 SEQUENTIAL EXTRATION OF HEAVY METALS FROM SOIL COLLECTED FROM OKE ESE DUMPSITE BY TESSIER'S TECHNIQUE

Heavy Metals	Step I mg/kg	Step II mg/kg	Step III mg/kg	Step IV mg/kg	Residual mg/kg	Anthropogenic mg/kg	Lithogenic mg/kg	% Anthro	% Lith
Pb	38.6	14.8	13.6	5.6	1.2	72.6	1.2	98.4	1.62
Fe	8.4	23.2	10.6	9.2	33.8	51.4	33.8	60.3	39.7
Cd	62.8	13.4	10.8	8.6	0.6	95.6	0.6	99.4	0.60
Cu	86.6	13.6	11.8	7.2	3.8	119.2	3.8	96.9	3.09
Zn	70.6	38.2	10.2	6.2	1.8	125.2	1.8	98.6	1.42
Mn	14.8	11.2	9.2	6.8	1.2	42.0	1.2	97.2	2.77
Ni	11.2	15.6	13.2	14.8	4.8	54.8	4.8	91.9	8.05
Cr	22.8	12.6	11.2	10.2	3.8	56.8	3.8	93.7	6.27

TABLE 4 SEQUENTIAL EXTRATION OF HEAVY METALS IN SOIL FROM OKE ESE DUMPSITE BY BCR TECHNIQUE

Heavy Metals	Step I mg/kg	Step II mg/kg	Step III mg/kg	Residual mg/kg	Anthropogenic mg/kg	Lithogenic mg/kg	% Anthro	% Litho
Pb	15.2	12.8	7.3	4.1	35.3	4.1	89.6	10.4
Fe	11.6	26.4	10.6	32.8	48.6	32.8	59.7	40.3
Cd	33.4	26.2	11.4	6.8	71.0	6.8	91.3	8.74
Cu	89.3	12.3	10.2	7.6	111.8	7.6	93.6	6.37
Zn	86.2	42.4	12.8	10.6	141.4	10.6	93.0	6.97
Mn	12.4	13.2	7.6	7.2	33.2	7.2	82.2	17.8
Ni	10.2	16.2	11.8	12.4	38.2	12.4	75.5	24.5
Cr	36.2	18.6	6.2	4.8	61.0	4.8	92.7	7.29

In both procedures, selected heavy metals were found in considerable concentrations in all extractive steps (Table 3 and 4). A comparison of the metals in non-residual (probable anthropogenic) phases of soil to the metals in residual (probable lithogenic) phase of soil revealed that the concentration of all metals considered were lower in the non – residual phase as Tessier methodology obtained [38]:- Pb (1.62), Fe (39.7), Cd (0.60), Cu (3.90), Zn (1.42), Mn (2.77), Ni (8.05) and Cr (6.27) while in BCR [12]; Pb (10.4), Fe (40.3), Cd (8.74), Cu (6.37), Zn (6.97), Mn (17.8), Ni (24.5) and Cr (7.29) all in- lithogenic

percentages. Awokunmi et al. [19] observed similar results using sequential extraction procedure to evaluate the phase distribution of heavy metals at selected dumpsite in Ekiti State, southwestern Nigeria.

D. Concentration of Heavy Metals in Water Sources

The results presented in Table 5 were obtained from the River-Ora located 50 m from dumpsite; ringed wells located 200 m, 300 m and 400 m from the dumpsite and one unringed well 500 m from the dumpsite.

TABLE 5 HEAVY METALS CONCENTRATIONS (MG/L) OF WATER SAMPLES COLLECTED FROM SELECTED WATER SOURCES NEAR OKE ESE DUMPSITE

Heavy Metals	River Ora (50m)	Ringed well (200m)	Ringed well (300m)	Ringed well (400m)	Unringed well (500m)
Pb	11.0	9.00	8.00	5.00	BDL
Fe	14.0	12.0	10.0	9.00	1.00
Cd	15.0	13.0	10.0	8.00	BDL
Cu	39.0	31.0	31.0	17.0	1.00
Zn	39.0	29.0	21.0	18.0	1.00
Mn	13.0	12.0	9.00	1.00	BDL
Ni	13.0	10.0	8.00	1.00	BDL
Cr	17.0	12.0	12.0	9.00	BDL

BDL = Beyond Detection Limit

The concentration of Pb in all water sources was found to range from BDL to 11.0 mg/kg, with the highest value at the Rive-Ora, 50 m from the dumpsite. These values were found to vary with distance. Pb concentrations were above the harmful limits sited by WHO [34], except in the unringed well 500 m away from the dumpsite, where Pb concentration could not be detected. However, Pb may be present in these water sources as a result of refuse dumping (Table 6).

TABLE 6 HARMFUL EFFECTS OF EXCESSIVE LEVELS OF HEAVY METALS IN DRINKING WATER

Heavy metal	Harmful health effects	WHO recommendation (mg/l)
Cadmium	Neurotoxin, hypertension, carcinogenic, teratogenic, mutagenic, liver and kidney dysfunction	0.003
Chromium	Chronic toxicity (above 5mg/l), bleeding of the gastrointestinal tract, cancer of the respiratory tract, ulcers of the skin and mucus membrane	0.05
Cobalt	Possibly carcinogenic. High concentrations cause vomiting, nausea, vision problems, thyroid damage	None yet
Lead	High blood levels can inhibit haem synthesis, cause irritation, mental retardation, brain damage; produce tumor	0.01
Nickel	Carcinogenic, negatively affects reproductive health.	0.02

[35]

Iron is abundant in Nigerian soil [1, 20], which may be the reason why Fe is found in all water sources in appreciable concentrations ranging from 1.0 – 14.0 mg/L with the highest value obtained at the River – Ora 50 m from dumpsite. These values vary with distance from the dumpsite from the closest to the farthest water source.

The concentrations of Cd ranged between BDL to 15.0 with the highest at the River- Ora 50 m from the dumpsite. High concentration of Cd can lead to neurotoxin and hypertension, as well as mutagenic, liver or kidney dysfunction in the human system [34].

The highest concentration of Cu 39.0 mg/L) was obtained in the River-Ora. The ringed wells located 200 m and 300 m from the dumpsite demonstrated identical concentrations of Cu (31.0 mg/L) but the concentrations were lower at the ringed and un-ringed wells located 400 m and 500 m from the dumpsite respectively.

Zn and Mn are essential metals occurring naturally in substantial ore deposits [38]. Concentration of Zn varied from 1.0 to 39.0 mg/L and Mn varied from BDL to 13.0 mg/L; the highest values of both were obtained at the River-Ora.

Cr and Co concentrations varied from BDL to 13.0 mg/L and from BDL to 17.0 mg/L, respectively. The highest values of Cr and Co were both obtained at the River- Ora. Concentrations of Cr were higher compared to limit set by WHO [34]. This is an indication that any direct or indirect ingestion of water from these sources may pose possible health risks.

IV. CONCLUSION AND RECOMMENDATION

Elevated values of heavy metals considered in this study (Pb, Fe, Cd, Cu, Zn, Mn, Ni, Cr) were found to be distributed randomly at sample locations through the selected dumpsites. Sequential extraction procedures revealed that (Cd, Cu, Zn, and Cr) were dominantly, because they were found at the exchangeable phase of the soil. These metals may be laterally leached

into the surrounding water bodies. Some of the heavy metals concentrations were found to be beyond the limits set by WHO, and as a result could pose health risk to humans, necessitating the proper treatment of these water sources before domestic and industrial applications.

REFERENCES

- [1] E. E. Awokunmi, S. S. Asaolu, and K. O. Ipinmoroti, "Effect of Leaching on Heavy Metals Concentration of Soil in some dumpsites," *African Journal of Environmental Science and Technology*, vol. 4(8), pp. 495-499, 2010.
- [2] P. Vandana, N. Murthya, and R. Praveen, "Assessment of heavy metal contamination in soil around hazardous waste disposal sites in Hyderabad city (India): Natural and anthropogenic implications," *Journal of Environmental Research and Management*, vol. 2(2), pp. 027-034, 2011.
- [3] O. O. Ogundiran and T. A. Afolabi, "Assessment of the physicochemical parameters and heavy metals toxicity of leachates from municipal solid waste," *Open dumpsite. Int. J. Environ. Sci. Tech.*, vol. 5(2), pp. 243-250, 2008.
- [4] S. Uba, A. Uzairu, G. F. S. Harrison, M. L. Balarabe, and O. J. Okunola, "Assessment of heavy metals bioavailability in dumpsites of Zaria metropolis, Nigeria," *African Journal of Biotechnology*, vol. 7 (2), pp. 122-130, 2007.
- [5] K. Mpoju, P. Nyamugafata, I. Maposa, and K. Nyoni, "Impacts of waste dumping on Pomona medium sand, clay, loam soils and surface water quality in Harare, Zimbabwe ARPN," *Journal of Science and Technology*, vol. 3(12), pp. 1215-1216, 2013.
- [6] S. G. Odewunmi, "Solid Waste Transportation in Lagos State: Developing a Sustainable Model," PhD. Seminar, University of Lagos, Lagos, Nigeria, 2001.
- [7] A. S. Momodu, W. O. Siyanbola, D. A. Pelemo, I. B. Obioh, and F. A. Adesina, "Carbon flow pattern in the forest zones of Nigeria as influenced by landuse change," *African Journal of Environmental Science and Technology*, vol. 5(9), pp. 700-709, 2011.
- [8] J. K. Nduka, E. Constance, and E. Obiakor, "Selective bioaccumulation of metals by different parts of some fish species from crude oil polluted water," *Bull Environ Contam Toxicol.*, vol. 77(6), pp. 846-853, 2006.
- [9] APHA, AWWA, WPCF, *Standard Methods for the Examination of Water and Wastewater*, 20th ed., Washington D. C., 1998.
- [10] L. Campanella, D. Dorazio, B. M. Pentronio, and E. Pietratonio, "Proposal for a metal speciation study in sediments," *Anal. Chimica Acta*, vol. 309, pp. 387-393, 1995.
- [11] A. M. Ure, P. H. Quevauviller, H. Muntau, and B. Griepink, "Speciation of heavy metals in soils and sediments: An account of the improvement and harmonization of extraction techniques undertaken under the auspices of the BCR of the Commission of European Communities," *Int. J. Environ. Anal. Chem.*, vol. 51, pp. 135-151, 1993.
- [12] E. E. Awokunmi, S. S. Asaolu, O. O. Ajayi, and O. A. Adebayo, "The role of EDTA on heavy metals phytoextraction by *Jatropha gossypifolia* grown on soil collected from dumpsites in Ekiti State, Nigeria," *British J of Envi. and Climate Change*, vol. 2(2), pp. 153-162, 2012.
- [13] A. J. M. Baker, R. O. McGrath, and J. A. C. Smith, "Metal hyperaccumulator plants: A review of the ecology and physiology of a biological resource for phytoremediation of metal-polluted soils," N. Terry and G. Banuelos, Eds., *Phytoremediation of contaminated soil and waters*, Lewis publishers, Boca Raton, 2000 FL., pp. 85-107, 2000.
- [14] A. Fabio and L. Reinaldo, "Evaluation of Cation Exchange Capacity (CEC) in Tropical Soils Using Four Different Analytical Methods," *J. of Agric. Sci.*, vol. 4(6), pp. 278-289, 2012.
- [15] B. A. Adelekan and K. D. Abegunde, "Heavy Metals Contamination of Soil and Groundwater at Automobile Mechanic Villages in Ibadan, Nigeria," *International Journal of the Physical Sciences*, vol. 6(5), pp. 1045-1058, 2011.
- [16] D. Sobolev and M. F. T. Begonia, "Effect of Heavy Metal Contamination Upon Soil Microbes; Lead – Induced Changes in General and Denitrifying Microbial Communities as Evidenced by Molecular Markers," *Int. J. Environ. Res. Public Health*, vol. 5(5), pp. 450-456, 2008.
- [17] DPR (Department of Petroleum Resources), *Environmental Guidelines and Standards for the Petroleum Industry in Nigeria* (Revised Edition). Department of Petroleum Resources, Ministry of Petroleum and Natural Resources, Abuja, Nigeria, 2012.
- [18] S. O. Adefemi, O. A. Ibigbami, and E. E. Awokunmi, "Level of heavy metals in some edible plants collected from selected dumpsites in Ekiti State, Nigeria," *Global Advance Research Journal of Environmental Sci. and Toxicology*, vol. 1(5), pp. 132-136, 2012.
- [19] E. E. Awokunmi, S. S. Asaolu, O. O. Ajayi, and O. A. Adebayo, "Source Identification and Sequential Leaching of Heavy Metals in Soil Samples Collected from Selected Dumpsites in Ekiti State, Nigeria," *J. Int. Environ. Appl. Sci.*, vol. 6(3), pp. 371-379, 2011.
- [20] S. O. Adefemi and E. E. Awokunmi, "Determination of Physicochemical Parameters and Heavy Metals in Water Samples from Itaogbolu Area of Ondo State, Nigeria," *Afri. J. Env. Sci. and Tech.*, vol. 4, pp. 145-148, 2009.
- [21] O. Bamgbose, O. Odukoya, and T. O. A. Arowolo, "Earthworm as Bioindicator of Heavy Metal Pollution in Dumpsite of Abeokuta City, Nigeria," *Revista de Biologia Tropical*, vol. 48(1), pp. 229-234, 2000.
- [22] C. M. A. Iwegbue, F. E. Egbueze, and K. Opuene, "Preliminary Assessment of Heavy Metals in Soils of an Oil Field in the Niger Delta, Nigeria," *International Journal of Environmental Science and Technology*, vol. 3(2), pp. 167-172, 2006a.
- [23] P. O. Oviasogie and E. Omoruyi, "Levels of Heavy Metals and Physicochemical Properties of Soil in a Form Manufacturing Industry," *Journal of Chemical Society of Nigeria*, vol. 32 (1), pp. 102-106, 2007.
- [24] S. S. Dara, *A textbook of Environmental Chemistry and Pollution Control*, S. Chand and Company Ltd., Ram Nagar, New Delhi 110055, 1993.
- [25] Q. M. Jaradat and K. A. Momami, "Contamination of Roadside Soils, Plants and Air with Heavy Metals in Jordan: a comparative study," *Turkish Journal of Chemistry*, vol. 23, pp. 209-220, 1999.
- [26] G. R. E. Aina and M. K. C. Sridhar, "Soil Quality near a fertilizer industry at Port Harcourt, Nigeria," *AJEAM – RAGEE*, vol. 8, pp. 19-

- 26, 2004.
- [27] J. R. Gungshik and J. D. Mohammed, "Impact of Mining on Trace Metal Contents of Soil," *African Journal of Natural Sciences*, vol. 10, pp. 21-24, 2007.
- [28] G. Machender, R. Dhakate, L. Prasanna, and P. K. Govil, "Assessment of Heavy Metals Contamination in Soils around Balanagor industrial area, Hyderabad, India," *Environmental Earth Science*, vol. 63(5), pp. 945-953, 2010.
- [29] K. S. Kasprzak, F. W. Sunderman Jr., and K. Salnikow, "Nickel Carcinogenesis," *Mutat. Res.*, vol. 533, pp. 67-97, 2003.
- [30] C. O. Nwuche and A. O. Ugoji, "Effects of Heavy Metal Pollution on the Soil Microbial Activity," *Int. J. Environ. Sci. Tech.*, vol. 5(2), pp. 409-414, 2008.
- [31] A. Duda-Chodak and U. Blaszczyk, "The impact of Nickel on Human Health," *J. Elementology*, vol. 13(4), pp. 685-696, 2008.
- [32] Lenntech Water Treatment (2009), Chemical Properties, Health and Environmental Effects of Cobalt. Lenntech Water Treatment and Purification Holding. Available: www.lenntech.com/periodic/elements/co.htm.
- [33] L. R. Reyes-Gutierrez, E. T. Romero – Guzman, A. Cabral – Prieto, and R. Rodriguez – Castillo, "Characterization of Chromium in Contaminated Soil Studied by SEM, EDS, XRD and Mossbauer Spectroscopy," *Journal of Minerals and Materials Characterization and Engineering*, vol. 7(1), pp. 59-70, 2007.
- [34] World Health Organisation (2004): Report on Water, Sanitation and Hygiene links to health. Geneva: WHO.
- [35] A. Hass and P. Fine, "Sequential selective extraction procedures for the study of heavy metals in soils, sediments and waste materials – A critical review," *Environmental Science and Technology*, vol. 40, pp. 365-399, 2010.
- [36] A. M. Ure and C. M. Davidson, "Chemical Speciation in the Environment," Blackie Academic and Professional, Chapman and Hall, London, pp. 441, 2012.
- [37] A. Tessier, P. Campbell, and M. Bisson, "Sequential extraction procedures for the speciation of particulate trace metals," *Analytical Chemistry*, vol. 51, pp. 844-851, 1979.
- [38] Z. Budimir and B. Marko, "Distribution of Cd, Pb Cu and Zn in carbonate sediments from the Krka river estuary obtained by sequential extraction," *Science of Total Environment*, vol. 170, pp. 100-181, 2003.