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The Evaluation of Some Heavy Metals on Soil in Dumpsite at Ifugbe Merogun, Warri South, Southern Nigeria

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Abstract
The evaluation of some heavy metals concentration of Chromium (Cr), Cadmium (Cd), Nickel (Ni), Lead (Pb), Zinc (Zn), Copper (Cu) and Iron (Fe) were undertaken on the soil in and around a dumpsite at Ifugbe Merogun, Warri South Local Government Area, Delta State. A total of twenty-two (22) composite soil samples were obtained. The soil samples were collected at depths of 0-10cm and 10 cm–20 cm interval from an active dumpsite. One (01) of the sample was collected at a distance of one hundred (100) meters away as control point to show the degree of dispersion from the source. The heavy metals evaluation was performed using Atomic Absorption Spectrometer (AAS) MODEL 210VGP. The results obtained were subjected to statistical test at $P < 0.05$ at 95% confidence level and the results presented in mean ± SD. All the studied heavy metals (Cr, Pb, Cd, Fe) except Ni (10-200 mg/kg), Cu (10-160 mg/kg) and Zn (40-2990 mg/kg) concentrations ranges in soil exceeded WHO standard. The sources of the heavy metals analyzed are considered to be mainly anthropogenic. However, there should be public awareness of the dangers and negative health implications of the dumpsite on humans and the environment.

Keywords
Heavy metals, concentration, contamination, dumpsite, anthropogenic, environment

1. Introduction

Heavy metals are naturally occurring elements that comprise essential (Cu, Fe, Ni, Zn etc.) and non-essential elements. Essential heavy metals have beneficial role in living things at certain concentration, high concentration of these metals in biological system could lead to toxicity on the exposed organisms while non-essential metals (Cd, Ag, As, Pb etc.) have no known role in living organisms and as such, they are highly lethal even at low concentration (Sylvester et al., 2017).

Although, human activities like industrial activities, mining and agricultural processes have led to a widespread distribution of heavy metals in the ecosystem, posing risks to ecological and human health. Owing to their bio accumulative potential along the food chain high toxicity, prevalence and persistence in the environment, heavy metals have become a major public health concern (Santo et al., 2018). These metals are released into the environment by both natural and anthropogenic sources. Heavy metals are defined as those metals and metalloids which have an atomic number greater than 20 and atomic density above 5g cm^{-3} and must exhibit the properties of metals (Raychaudhuri et al., 2021). Such as lead, cadmium, iron, chromium, nickel, mercury, arsenic, copper, zinc etc. All waste has the potential to cause environmental damage. One of the recent global challenges facing towns and cities is poor solid waste management. The pressure of population growth produces stresses that cause environmental degradation and in particular solid waste thereby polluting air, water and land on which all life so critically depends (Akaeze, 2001).

Soils are the major sink for heavy metals released into the environment by aforementioned anthropogenic activities and unlike organic contaminants which are oxidized to carbon (iv) oxide by microbial actions, most metals do not undergo microbial or chemical degradation and their total concentration in soils persists for a long time after their introduction (Adriano, 2003). Heavy metals toxicity is determined by route, pattern and duration of exposure. Route exposure of heavy metals includes (I) ingestion of soil, contaminated water, vegetables and fruits grown on contaminated soils and animals that graze contaminated areas. (ii) Inhalation of soils particles, dust and fumes and (iii) dermal contact. Drinking of contaminated water and consumption of agricultural products represent an important source of heavy metals ingestion (Kurt-Karakus, 2012). Immobilization, soil washing, and photo remediation techniques are frequently listed among the best demonstrated available technologies for pre-remediation of heavy metals contaminated soils, field application of these technologies have only be reported in developed countries. In most developing countries these are yet to become commercially available due to their inadequate awareness of their inherent advantages and principle of operation (Bolan et al., 2008). The indiscriminate dumping of refuse in and around our residential areas and the large portion of land occupied by refuse dumps is a great concern to the government and society at large as this imposes negative effect on our health and even greater disaster in the future if not curtailed.

The aim of this research is to conduct a qualitative analysis of the top and subsoil in a dumpsite, in order to determine the concentration and distribution of some heavy metal, their sources, health effects and possible recommendations. The primary objective of this analysis is to evaluate the concentration of some heavy metal on soil in the study area. Fig. 1 shows map of the study area with the sampled location.

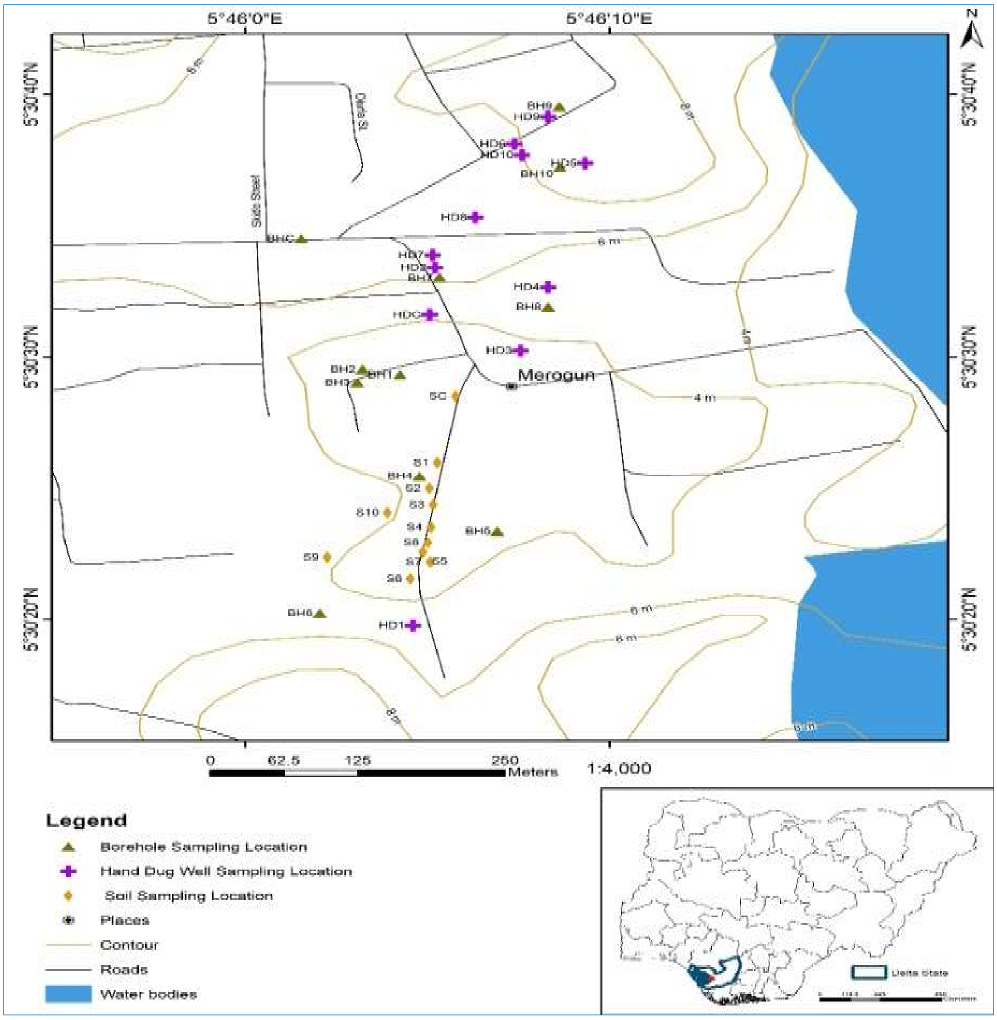

Fig. 1. Map of the study area with the sampled location

2. Geological Setting

The geological settings of the studied location belong to the Niger Delta Basin which is also referred to as the Niger Delta Province. It is an extensional rift basin located in the Niger Delta and the Gulf of Guinea on the passive continental margin near the Western coast of Nigeria Fig. 2. The Niger Delta Basin is one of the largest sub aerial basins in Africa, it has a sub aerial area of about 75,000 km^2, a total area of 300,000 km ^{2} (Tuttle et al., 2015). The sediment fill has a depth between 9-12 km, it is composed of several different geologic formations that indicate how this basin could have formed, as well as the regional and large-scale tectonics of the area. The Niger Delta Basin lies in the south westernmost part of a larger tectonic structure. Outcropping units of the Niger Delta include the Imo Formation and the Ameki Group consisting of the Ameki, Nanka, Nsugbe, and Ogwashi-Asaba Formations. The subsurface lithostratigraphic units are the major transgressive marine Akata Shales, the petroliferous paralic Agbada Formation, and the continental Benin Sands.

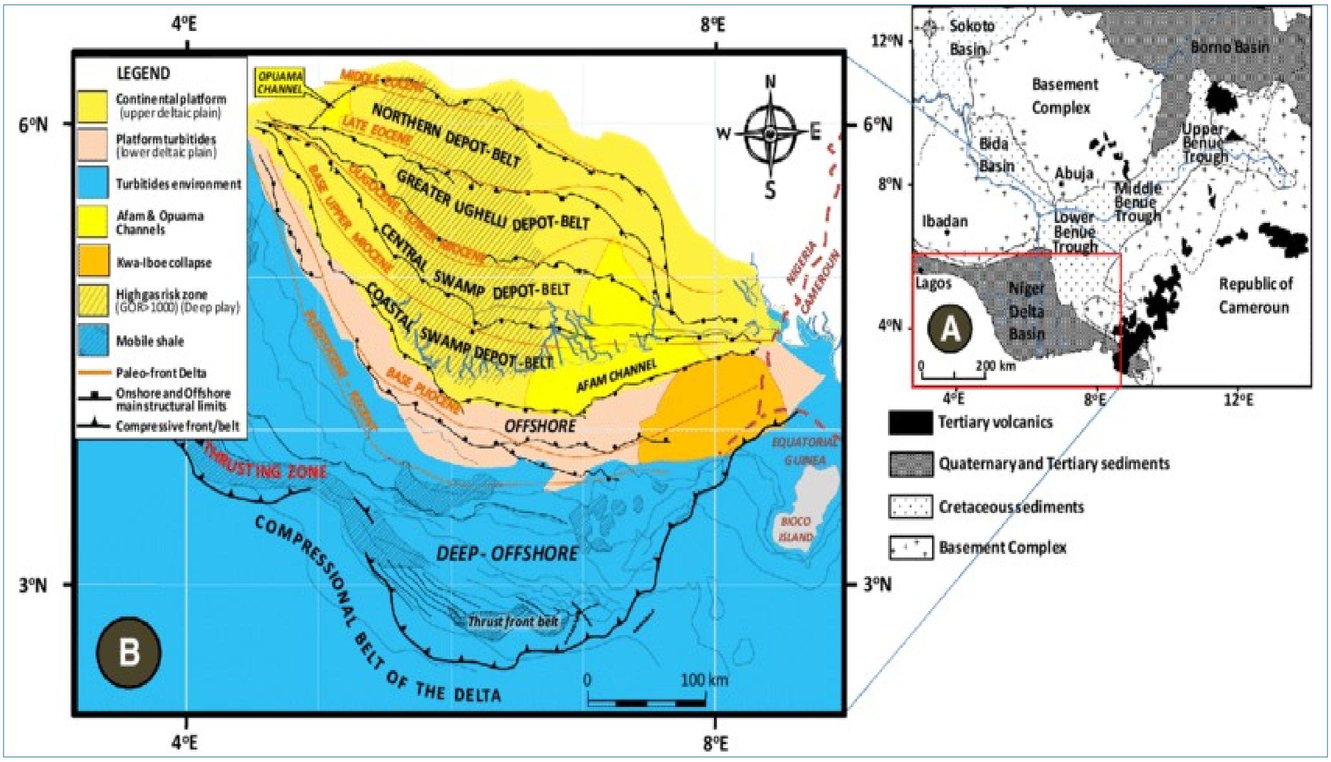

Fig. 2. Geologic map of Nigeria showing the location of the Niger Delta Basin (a) (redrawn from Ebong et al., 2017) and sectional map of the Niger Delta depobelts and structural limits (b) (Redrawn from Doust and Omatsola, 1990)

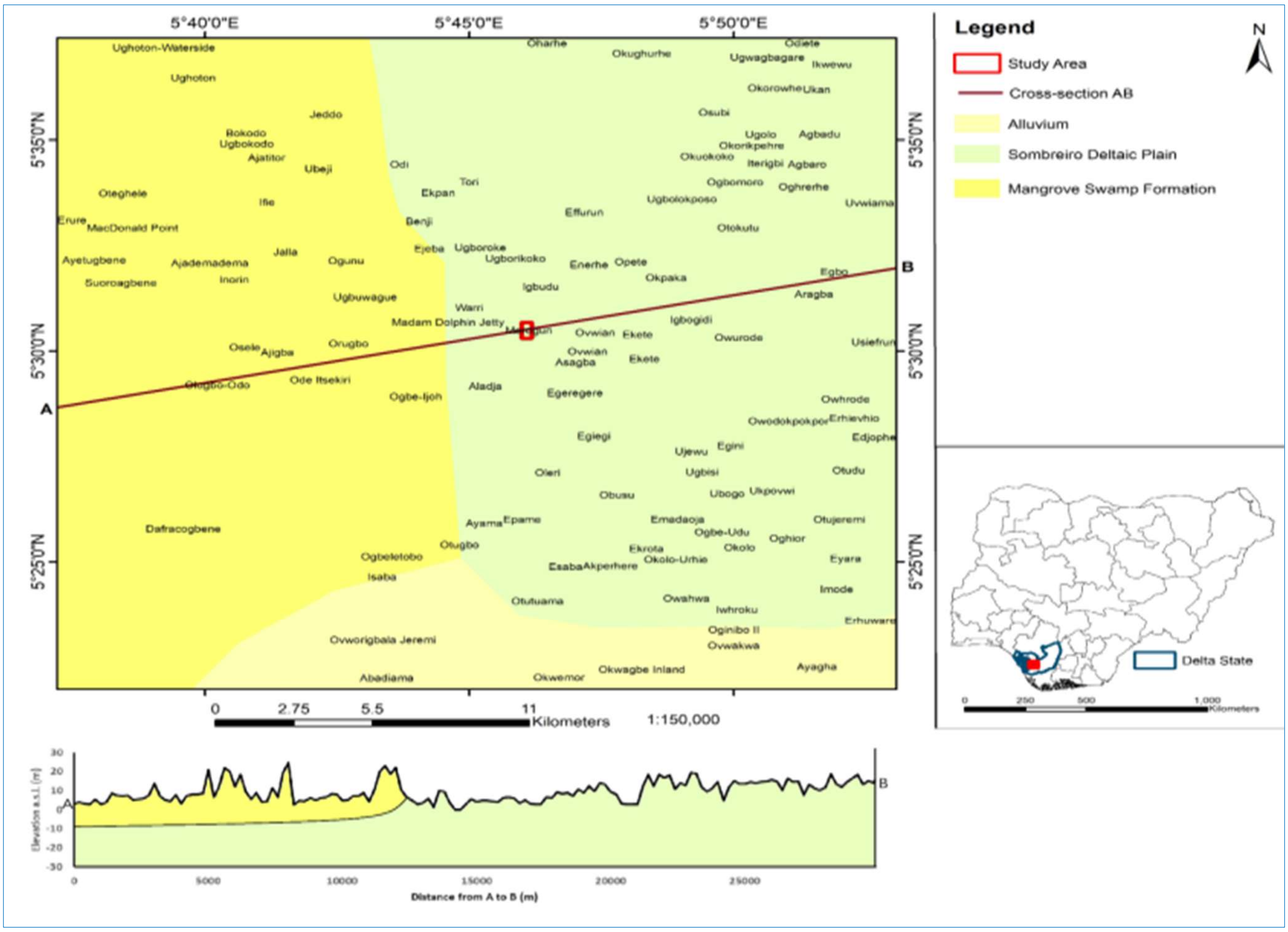

Fig. 3. Geological map of the study area

3. Local Geology of the Studied Area

The study area (Ifugbe Merogun) is located within the Warri metropolis which lies between Latitudes N5^{0}30'28.5" to N5^{0}30'37.9" and Longitudes E5^{0}46'5.7 to E5^{0}46'7.69" (Fig. 3). It is situated in Warri South Local Government Area of Delta State. It has a population of about 311,970 residents according to the 2006 Census (National Population Commission, 2006) and about 427,600 (population projection, 2022) surrounded by the following communities, Edukugho, Iyara, Ogedegbe, Igbudu, Enerhen, Ereku and Odion community. Their main occupation is fishing but they are also into various businesses. The area is characterized by sedimentary rocks of the Benin Formation (Miocene-Pliocene age) and the Agbada Formation (Eocene-Miocene age), unconsolidated sediments including sand, salt, and clay deposited by the Niger River and its distributaries, it is located on the coastal plain, characterized by sandy deposites often with interbedded clay and silt layers. Warri lies within the Niger Delta region underlain by Quaternary to recent sedimentary formations. The coastal sand and conglomeratic beds are of good to excellent aquifer characteristics but are predominantly unconfined thus making them vulnerable to surface and subsurface water contaminants especially from such sources as dumpsites. The vulnerability is bound to increase with the tropical heavy rainfall of the area (Akudo et al., 2010). Ifugbe Merogun community dumpsite is located at the southern region of the city.

4. Materials and Methods

4.1. Sample Collection

The following materials were used for sample collections; Hand Gloves, Polythene Bags, Hand Auger, GPS, Measuring Tape, Masking Tape, Trowel and Cutlass. Twenty-two (22) soil samples were collected at a depth of 0-10 cm and 10 cm–20 cm interval from an active dumpsite and its environs, one of the sample was collected at a distance of one hundred (100) meters away as control point to show the degree of dispersion from the source, samples was collected with hand auger instrument carefully stored in a polythene bag and properly labeled with a masking tape, before transported to the laboratory in the Federal University of Benin, Benin City, Edo State for further requisite analysis. A handheld GPS was used to obtain the geographical coordinates of each sampling location. The concentration of the heavy metal solution was determined by the uses of Atomic Absorption Spectrophotometer (AAS).

4.2. Heavy Metals Analyses

The apparatus used for the heavy metal's evaluation are Electronic Weighing Machine, 2 mm sieve, Agate Mortar and Pistol, Brush, Clinical Flask, Electric Heater, beaker, test tubes pipettes, Filter Paper (0.0 μm), AAS (Atomic Absorption Spectrophotometer) MODEL 210VGP. Reagents used are Nitric Acid, Hydrochloric Acid Perchloric Acid and Distilled Water

4.3. Samples Preparation

The collected twenty-two (22) soil samples were air dried for a period of three (3) days at room temperature, the dried samples were placed in an agate mortar and crushed for proper disaggregation and there after sieve through 2 mm sieve. 1g of each sample was weighed using an electronic weighing machine and then put in a clinical flask 10ml of nitric acid (HNO_3) and 5ml of perchloric acid ($HClO_4$) was added. The moisture was heated on an electric heater for about 15mins until colour change is observed and then allowed to cool down for about 10mins, then filtered into 100ml volumetric flask using Whatman no 42 filter paper, the sample was filled up to 100ml mark in the volumetric flask with a distilled water (Allen et al., 1974). Thereafter, analysis of the prepared (digested) samples were carried out in the University of Benin Chemistry Department Research Laboratory using the Atomic Absorption Spectrophotometer (AAS) MODEL 210VGP to determine the concentration of the studied elements in the soil samples. Figure 5 shows the digested soil samples.

Fig. 4. Merogun Dumpsite in Warri Metropolis of Delta State

Fig. 5. Digested Soil Samples Ready for Analysis

5. Presentation and Discussion Results

Concentration of heavy metals in soil sample: Table 1 shows the concentration of the heavy metals (Cd, Pb, Fe, Cu, Cr, Ni and Zn) in the soil samples collected from the studied area. The concentration and the degree of pollution of the heavy metals in the soils were assessed. The ranges of concentration (mg/kg) of heavy metals in the studied area are as follows.

Table 1. Results of heavy metals analysis on soil sample (mg/kg)

Samples	Control SC (0-10)	SC (10-20)	S1 (0-10)	S2 (10-20)	S3 (0-10)	S4 (10-20)	S5 (0-10)	S6 (10-20)	S7 (0-10)	S8 (10-20)	S9 (0-10)	S10 (10-20)	S11 (0-10)	S12 (10-20)	S13 (0-10)	S14 (10-20)	S15 (0-10)	S16 (10-20)	S17 (0-10)	S18 (10-20)	S19 (0-10)	S20 (10-20)	W.H.O. Guideline for heavy metals in soil (mg/kg) 2018
Pb	30	20	10	20	20	20	40	70	20	30	10	ND	70	40	30	10	ND	10	20	10	10	20	100
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	ND	ND	ND	10	ND	3
Ni	30	40	50	80	50	20	100	20	10	110	60	ND	200	100	20	30	40	80	ND	40	30	90	50
Cr	10	20	ND	30	20	ND	30	20	10	ND	20	10	ND	10	20	10	20	10	20	20	20	10	50
Fe	31,600	29,100	16,700	18,100	26,800	28,800	38,000	40,800	16,200	28,600	8,700	9,100	20,400	17,900	17,500	14,200	3,300	9,300	9,000	14,200	11,600	17,900	50,000
Zn	1870	1890	1090	1450	2430	2060	2170	2990	720	1600	310	160	2980	2760	1890	1740	270	410	970	1130	40	890	100
Cu	40	20	40	40	50	60	70	160	10	40	10	10	80	80	30	30	10	10	10	10	10	20	100

Note: Not Detected (ND)

5.1. Lead (Pb)

The concentration of lead in soil samples varied significantly across different sampling points, with values below WHO standards (100 mg/kg) for safe soil as observed by Nolan et al. (2003). It ranges from (10-70 mg/kg) except for 4 samples that exceeded the CS value (30 and 20 mg/kg) and from the graph plotted, it was shown that lead values were significant at $p<0.05$ compared to the WHO (2018). This implies that lead concentration of the soil samples is within permissible limit (Fig. 6). It is undesirable to humans because of its toxicity. Pb poisoning can lead to kidney dysfunctioning, Neurotoxicity, kidney damage, reproductive problems, cancer (Bellinger, 2008)

5.2. Cadmium (Cd)

The concentration of cadmium in the soil sample could only be found in S11 and S19 at depth 0-10 ranging from ND- 10 mg/kg, while cadmium was not detected in majority of the samples (Fig. 7). Comparing the results with W.H.O maximum permissible limit for cadmium, sample S11 and S19 exceeded the WHO limit as also reported by Tatah et al. (2020) of 1-3mg/kg and falls within the CS (30/20 mg/kg) and was not significant at $p<0.05$ compared to the WHO (2018) from the plotted graph. Cd effect on the human system includes Degenerative bone disease, kidney dysfunction, liver damage, lungs damage, cancer, neurotoxicity and gastrointestinal disorder ATSDR (2012).

5.3. Nickel (Ni)

The concentration of nickel in soil sample has the highest in the sample S11 (200 mg/kg) at depth 0-10 and the lowest concentration in the sample S7 (10 mg/kg) at depth 0-10, with a mean value of 62.7 mg/kg (Fig. 8). CS has nickel value as 30 and 40 mg/kg at depth 0-10 and 10-20 respectively. While no nickel was found in sample S10 and S17 at depth 10-20 and 0-10, or it's ND (Not detected). Comparing the result with W.H.O maximum permissible limit for nickel (20-50 mg/kg) and CS value, 12 samples collected were above WHO limit as also observed by Saheed et al. (2020) except for S4, 6, 10, 13, 14, and 19 which fall within the permissible limit, and from the graph plotted, Nickel values was significant at $p<0.05$ compared to the WHO (2018). The high concentration of Nickel could be as a result of dumping of metal manufacturing waste, sludge, wind-blown dust, derived from weathering of rocks and soils, incineration of waste and sewage and from the combustion of coal, diesel oil and fuel. The notable effect of Ni toxicity includes Cancer, dermatitis, Respiratory problems, Neurotoxicity (Denkhaus and Salnikow, 2002).

5.4. Chromium (Cr)

The concentration of chromium in the soil was found in the range of 10 to 30 mg/kg with a mean value of 17.5 mg/kg but was not detected in sample S1, S4, S8 and S11 at various depths (Fig. 9). WHO maximum permissible limit for Chromium is 50-100 mg/kg. All the soil samples were below WHO permissible limit as also obtained by Musa et al. (2020) and within sample CS values (10 and 20 mg/kg), except for sample S2 and S5 which exceeded CS this could be as a result of dumping of high chromium industrial waste which could lead to dermatitis and respiratory problems ATSDR (2012) . From the graph plotted, it was shown that Chromium value was significant at $p<0.05$ compared to the WHO (2018) standard.

5.5. Copper (Cu)

The concentration of copper in the soil sample ranges from 10-160 mg/kg with a mean value of 39 mg/kg and has the highest value in S6 depth 10-20 (160 mg/kg) and the lowest concentration in S7, S9, S15, S17, S19 at depth 0-10 and S10, S16, S18 at depth10-20 (10 mg/kg, respectively). (Fig. 10). Comparing the results with WHO Maximum Permissible Limits (WHO, 2018) for copper in the soil, 9 samples collected at depth 0-10 and 10-20 have valued above the recommended level of 50-100 mg/kg which could be as a result of deposit of metal scraps, organic residues and sewage sludge in the dumpsite. And from the plotted graph, it was shown that Copper values were not significant at $p<0.05$ compared to the WHO standard. Neurological problems, impaired immune function and liver damage are some of the negative effects of Cu on human health (Linder and Hazegh-Azam, 1996).

5.6. Zinc (ZN)

The concentration of zinc in the soil sample has the highest in the sample S6 at depth 10-20 and the lowest concentration in the sample S19 at depth 0-10, the concentration of Zinc (Zn) ranges from (40-2990 mg/kg), with a mean value of 1403 mg/kg. (Fig. 11). While CS is 1870 mg/kg and 1890 mg/kg at depth 0-10 and 10-20 respectively. Comparing the results with WHO maximum permissible limit for zinc which is 100-200 mg/kg, all the soil samples are above the limit as also observed by Olorundare et al. (2011), except for S19 (40 mg/kg) which is below the limit. From the graph plotted, zinc values were significant at $p<0.05$ compared to the WHO standard. The high concentration of Zinc in the soil could be as a result of deposits of industrial and municipal waste and surface run-off of soil particles containing zinc. Impaired growth weakened immune function gastrointestinal problems and neurological damage are associated with Zn poisoning in the human system (NIEHS, 2020; ATSDR, 2005).

5.7. Iron (Fe)

The concentration of iron in the soil sample has the highest in S6 at depth 10-20 and the lowest concentration in the sample S15 at depth 0-10, while it is 31600 and 29100 mg/kg (depth 0-10, 10-20) respectively at the control sample (Fig. 12). The concentration of iron ranges from (3300-40800 mg/kg. All samples comply when comparing the results for iron with WHO maximum permissible limit (50,000 mg/kg). However, some of the samples were above the sample SC value which could be as a result of Fe bioavailability increases environmental risk which can lead to abdominal cramps, diarrhea, nausea, vomiting (ATSDR, 2005; ATSDR, 2012). The soil samples are all below the WHO permissible limit as also reported by Ojo et al. (2013) while from the plotted graph it was shown that iron values were significant at $p<0.05$ compared to the WHO (2018).

6. Summary

It could be observed from the study that the concentration of most heavy metals increases from the top soil to the subsoil which is inverse to the decrease of heavy metals from the top soil to the subsoil as observed by Imasuen and Omorogeiva (2013). S6 (10-20 m depth) has the highest concentration of Fe (40,800 mg/kg), Zn (2990 mg/kg), Cu (160 mg/kg) and Pb (70 mg/kg), respectively. Which makes it highly contaminated while Pb, Cd, and Ni were not detected in S10 with a low concentration of Cr (10 mg/kg), Cu (10 mg/kg), Zn (160 mg/kg), and Fe (9,100 mg/kg), respectively and could be said to be the lowest contaminated soil sample. Cd was not detected in all the soil samples except S11 (10 mg/kg) and S19 (10 mg/kg). The analysis of variance (ANOVA) shows that the metals in soil was significant at $p<0.05$ as also observed by Awokunmi et al (2010), when compared to WHO standard. However, Ni (10-200 mg/kg) and Zn (40-2990 mg/kg) concentrations ranges in soil exceeded WHO permissible limits (WHO, 2018) which means they can potentially impose health risks and environmental concerns

7. Conclusion

The assessment of heavy metals contamination (Cu, Zn, Ni, Fe, Pb, Cr and Cd) in soils from Ifugbe Merogun Dumpsite was made in comparison with World Health Organization (2018) and control sample. The analysis of variance (ANOVA) shows that the metals were significant at $p<0.05$ when compared to WHO standard. The concentration of these metals in the soil is profiled according to W.H.O maximum permissible limit for heavy metals in soil and the results show that most of the soils are contaminated (S1, S2, S3, S5, S7, S8, S9, S11, S12, S15, S16, S17, S18, and S20) due to their high concentration in Ni, Cu and Zn which demand immediate remediation. The concentrations of some of these heavy metals at the dumpsite are higher than the values in the control site, especially Ni and Zn but few of them do not exceed WHO guideline for heavy metal in soil. Contamination of soil is due to improper waste disposal, and leaching activities. The sources of these metals are mainly from anthropogenic activities. The high concentration of heavy metals are potential health risks to the environment and nearby community

8. Recommendation

- Sanitary disposal site or landfill should be sited in the outskirts of the main town that is hydrological and geologically appropriate (high adsorption capacity, low permeability, a sufficiently safe distance away from acquired)
- Government should provide funds for proper waste management
- There should be proper sensitization of the people about the hazardous effect of open dumps in residential area and the need for proper municipal waste disposal to be set up.
- Treatment of industrial effluents before disposal

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