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ASSESSMENT OF HEAVY METAL CONTAMINATION OF SOME DESIGNATED SCRAP-YARDS IN BENIN CITY, EDO STATE, NIGERIA

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ABSTRACT

This study was conducted to investigate the heavy metal (HM) contamination of some designated scrapyards located in Benin City, Edo State. The designated scrapyards are in Upper Iwehen and Idahosa streets Benin City. Navy Street and Lagos Street were chosen as Control sites. Soil samples were obtained at a depth of 30cm for laboratory analysis. Heavy metals were analysed using atomic absorption spectrometry (Polarized Zeeman Atomic Absorption Spectrophotometer ZA3000 Series). The value of Iron in the soil samples from Upper Iwehen scrapyard and Idahosa Street range from 1566 – 2902 mg/kg and 385-1267.50 mg/kg respectively. Upper Iwehen scrapyard was observed to have higher concentration of iron compared to Idahosa Street. Generally, it was observed that control soil samples for Upper Iwehen (Lagos Street) and Idahosa Street (Navy Street) had lower concentration of 216.50 mg/kg and 126mg/kg respectively. Concentration of manganese (Mn), zinc (Zn), copper (Cu) and chromium (Cr) for soil samples from Upper Iwehen ranged from 43.50 – 80.60mg/kg, 62.65- 116.10 mg/kg, 29.30 - 41.5 mg/kg and 28.90 - 40.7mg/kg respectively while those observed for Idahosa Street ranges from 15.7 - 35.20mg/kg, 26.95-50.7 mg/kg, 13.95-19.15 mg/kg and 13.10-20.70 mg/kg respectively. Percentage composition of clay, silt and sand in samples from Upper Iwehen ranged from 7.30-8.95%, 3.20-4.05%, 87.25-89.45% respectively while that of Idahosa Street ranged from 5.00-8.05%, 2.00-3.00%, 89.05-93.05% respectively. This study revealed the presence of various heavy metals in the soil samples due to uncontrolled activities of scrapyards at the various sites and showed that the samples were contaminated above permissible levels.

Keywords: *Clay silt, Contamination, Heavy metals, Scrap-yards, Soil*

INTRODUCTION

Soil is a critical medium in the environment, and is subject to different contaminants which come from a range of human activities (Orisadare *et al*., 2020). The current exponential growth in the world economy has increased the burdens on the soil. Among the constituents which make up the earth crust are heavy metal (HM) (Jones *et al*., 2021). The harm which HM can cause to environmental and human health is the reason HM contamination in soil has become a concern. Domestic and agricultural activities, traffic, chemical industries, smelting processes, the iron and steel industry and mining are some human activities and actions which contribute to soil contamination by HM (Kolawole *et al*., 2018; Olatunji *et al*., 2018). There have been drastic alterations in the equilibrium and bio-geochemical cycles of several HM, because of human activities (Mtunzi *et al*., 2015). Heavy metal are persistent in the soil over lengthy time periods, are characterized by their potential adverse impacts on health and can enter and move along food chains in considerably higher concentrations, hence, the need for routine assessment of the risks posed by the presence of these metals in soil in both areas where agriculture is practiced and where it is not (Abdulsalam and Bajoga, 2020).

As urbanization and industrialization have spread, the demands for metals have grown and are still growing with the increasing release of HM pollutants to soils, leading to widespread HM contamination in the soil. Organic contaminants biodegradation is often limited when the soil has high concentrations of HM (Olatunji and Kolawole, 2018). There are several mechanisms of exposure and toxicity through which the adverse effects of HM on human health and the ecosystem are experienced. These include human exposure by contact with or ingestion of contaminated soils, various interactions in the food chain (e.g. soil-plant-animal-human or soil-plant-human), consumption of groundwater which is contaminated, food quality reduction because of phytotoxicity, reduced ability of land in regards to agricultural productivity leading to issues in land tenure and adverse impacts on food security (Kolawole *et al*., 2023; Olajide-Kayode *et al*., 2022). Upon their deposition into soils, HM do not undergo degradation and exhibit persistence for lengthy periods during which they are responsible for serious pollution in the environment (Mtunzi *et al*., 2015). Accumulation of these metals in the soil and plants growing there occurs resulting to adverse influences on the plants' physiologic activities including absorption of nutrients, exchange of gases and photosynthesis, all of which add up to reduced growth and the accumulation of dry matter (Chukwu and Anoliefo, 2017).

At present, concerns are growing regarding the likelihood of plant uptake of HM from the soul and these being introduced into food chains and further impacting food safety (Pujar *et al*., 2012). These HM accumulate in the tissues and milk of animals which graze or eat such contaminated plants or drink contaminated waters, while marine organisms living and breeding in polluted water are also affected (Arinze *et al*., 2015; Ojekunle *et al*., 2016). When present in minute concentrations, most HM do not induce toxic responses in living organisms, with the exceptions to this being mercury, lead and cadmium which, even at very low concentrations, are toxic (Ademola *et al*., 2015). The bioavailability and mobility of HM in the environment is heavily dependent on the particulate or soluble forms in which they exist. HM speciation is now garnering interest as there is a relationship between the speciation of a metal and its toxicity (Mtunzi *et al*., 2015).

The aim of this study is to determine the concentrations of designated heavy metals present in soil samples obtained from scrap yards in Benin City, Nigeria.

MATERIALS AND METHODS

STUDY AREA

This study was carried out in some designated sampling locations. The locations are situated in Iyaro area located in Oredo Local Government Area, Benin City, Edo State. A total of four (4) sampling stations was considered and used in this study. The area is home to a wide range of local businesses and other economic activities including mechanic workshops and scrap yards.

SAMPLE COLLECTION AND PREPARATION

A total number of eighteen (18) soil samples were collected from Upper Iwehen and Idahosa streets in February, 2017. Two (2) control soil samples were also obtained from within the scrapyards. The six sampling points used in this study were basically scrap yard sites which was inhabited by local scavengers who sources for scrap metals and stored and sold them as a form of livelihood. The sampling locations are displayed in figure 1.

A handheld Geographic positioning system (GPS) device was used to obtain coordinates of the sampling stations. Using a spade, soil samples were obtained at a depth of 30cm below soil surface. Dug out soil was placed in black polymer bags, sealed and then transported to the laboratory for investigation of HM.

The samples were sorted out carefully into different trays and labelled in accordingly. Soil samples were freed from debris and unwanted materials. The samples were air-dried and subsequently sieved through a 2mm mesh sieve. After sieving the soil samples were placed in clean polymer bags at room temperature and stored until they were needed for analysis.

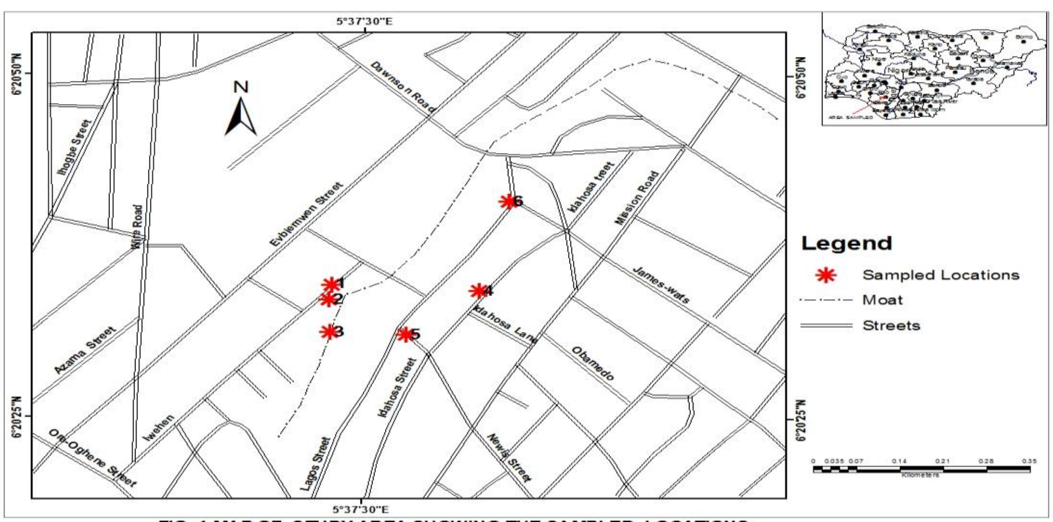

FIG. 1 MAP OF STUDY AREA SHOWING THE SAMPLED LOCATIONS

ANALYTICAL PROCEDURES

The particle size distribution of the various soil samples was evaluated by the hydrometer method. 20g of the soil was dispersed into 50ml of distilled water and a hydrometer submerged in the suspension. Readings were taken at intervals as the particles settled and the particle size distribution was determined by Stoke's Law. For the determination of HM concentrations, soil sample (5g) was weighed into a 250ml plastic bottle. Then 100ml of the extracting solution was added and then stoppered. The solution was then shake for 15min using a mechanical shaker. It was then filtered through Whatman filter paper No.42. Then HM (Fe, Cu, Mn, Zn, Cd, Cr, Pb, Ni and V) were analysed using atomic absorption spectrometry (AAS). The various HM analysed required hallow lamps with varying current ratings and were determined at different wavelengths. These are presented in Table 1.

Table 1: Wavelength and lamp current for AAS analysis

Lamp Name/Element	Wavelength (nm)	Lamp Current (mA)
Cadmium (Cd)	228.8	8
Iron (Fe)	248.3	15
Chromium (Cr)	357.8	10
Copper (Cu)	324.8	5
Iron (Fe)	248.3	15
Lead (Pb)	217.0	10
Manganese (Mn)	279.5	12
Nickel (Ni)	232.0	15
Zinc (Zn)	213.9	10

RESULTS

The soil samples collected from various scrapyards were analysed and results obtained were compared with soil samples from the two control locations. Table 1 shows the results of some HM from the soil samples collected in the various scrapyards locations in Benin City.

From the results, the concentration of Fe ranged from 126.00±9.89mg/kg (Navy Street Control 6) to 2902±926.31mg/kg (Upper Iwehen 2A 2nd Site (Moat)). The minimum concentration of Mn was 9.00±0.99mg/kg at Navy Street Control 6 and the maximum was 80.60±25.74mg/kg at Upper Iwehen 2A 2nd Site (Moat). Zn concentration was least at Navy Street Control 6 (13.55±2.47mg/kg) and highest at Upper Iwehen 2A 2nd Site (Moat) (116.10±37.05mg/kg). For Cu, recorded concentrations ranged from 1.58±0.06mg/kg (Navy Street Control 6) to 41.5±2.69mg/kg (Upper Iwehen 3A 2nd Site (Moat)). The concentrations of Cr were minimum at Navy Street Control 6 (1.17±0.08mg/kg) and maximum at Upper Iwehen 2A 2nd Site (Moat) (40.7±1.13mg/kg). Cd concentrations ranged from 0.78±0.05mg/kg at Navy Street Control 6 to 29.75±3.61mg/kg at Upper Iwehen 2A 2nd Site (Moat). Pb ranged from 3.56±0.80mg/kg (Navy Street Control 6) to 35.95±24.11mg/kg (Upper Iwehen 3A 2nd Site (Moat)). The recorded concentrations of Ni ranged from 0.18±0.01mg/kg at Navy Street Control 6 to 7.04±0.79mg/kg at Upper Iwehen 2A 2nd Site (Moat). Concentrations of V ranged from 0.13±0.01mg/kg (Navy Street Control 6) to 5.00±0.61 (Upper Iwehen 2A 2nd Site (Moat)).

The percentage concentration of soil particle size - clay, silt and sand of scrapyards in Benin City are also indicated in Table 2. The results show that for all samples, the percentage composition of sand was highest ranging from 87.25±4.45% at Upper Iwehen 3A 2nd Site (Moat) to 93.05±0.21% at Idahosa Street B Site 5. Also, in all samples, the silt concentration was the least ranging from 1.55±0.49% at Lagos Street Control A to 4.05±1.63% at Upper Iwehen 2A 2nd Site (Moat). The percentage composition of clay ranged from 5.00±0.14% at Idahosa Street B Site 5 to 8.95±2.19% at Upper Iwehen 3A 2nd Site (Moat).

Table 1: HM concentrations of soil samples collected from scrapyards in Benin City

Sample site	**Fe**	**Mn**	**Zn**	**Cu**	**Cr**	**Cd**	**Pb**	**Ni**	**V**
					mg/kg				
Upper Iwehen 1A 1st Site	1566±46.67	43.50±1.27	62.65±1.91	29.30±0.57	28.90±6.65	27.50±1.98	34.25±3.89	5.97±0.24	4.28±0.16
Upper Iwehen 2A 2nd Site (Moat)	2902±926.31	80.60±25.74	116.10±37.05	30.4±3.82	40.7±1.13	29.75±3.61	33.95±13.08	7.04±0.79	5.00±0.61
Upper Iwehen 3A 2nd Site (Moat)	2552.5±1365.42	71.1±37.62	102.1±54.59	41.5±2.69	37.55±5.02	25.05±6.58	35.95±24.11	5.84±1.46	3.67±0.34
Lagos Street Control	216.50±33.23	15.15±2.90	30.65±9.97	7.62±1.57	1.57±0.58	2.32±0.72	1.10±0.18	0.55±0.17	0.39±0.13
Idahosa Street A Site 5	1267.50±28.99	35.20±0.85	50.7±1.13	17.15±2.47	20.7±0.42	18.8±0.57	17.5±1.98	4.43±0.13	2.93±0.23
Idahosa Street B Site 5	385.00±80.61	15.7±4.81	30.45±3.75	13.95±0.07	15.20±6.65	10.73±3.92	10.82±2.38	2.53±0.93	1.81±0.66
Idahosa Street C Site 5	680.00±89.09	18.85±2.47	26.95±3.18	18.40±1.13	14.05±3.61	17.05±3.04	19.45±3.04	4.02±0.71	2.87±0.51
Idahosa Street D Site 5	1035±57.98	28.75±1.63	36.40±4.81	19.15±0.49	13.10±0.28	17.05±0.78	13.5±4.10	4.01±0.18	2.87±0.13
Navy Street Control 6	126.00±9.89	9.00±0.99	13.55±2.47	1.58±0.06	1.17±0.08	0.78±0.05	3.56±0.80	0.18±0.01	0.13±0.01

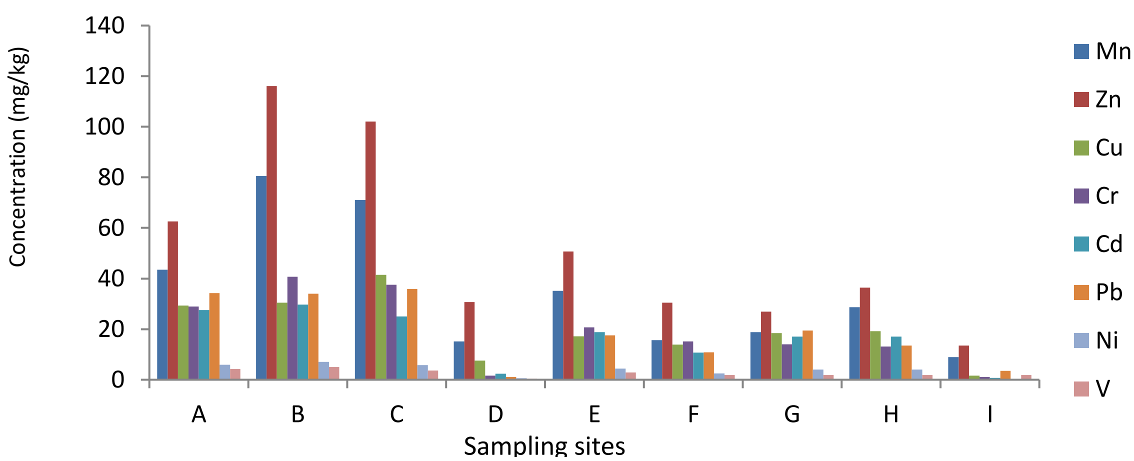

Figure 1: Bar chart of HM concentrations in soil samples

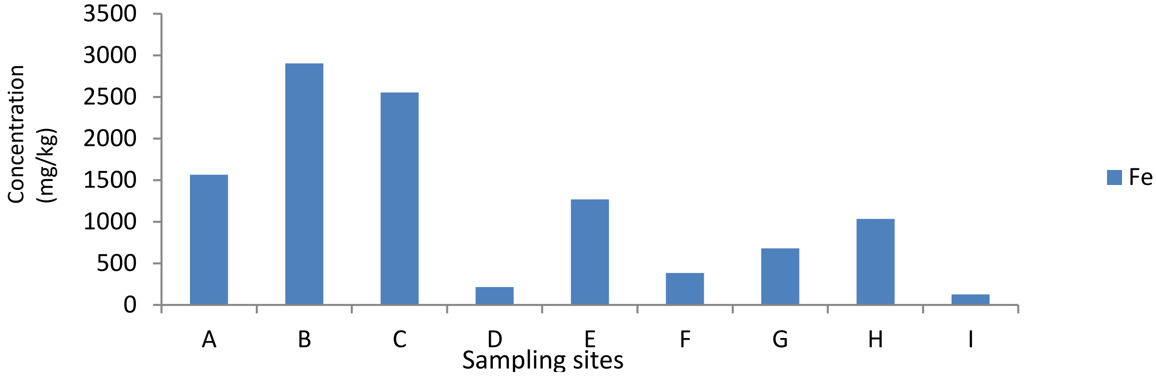

Figure 2: Concentrations of iron in soil samples

KEY: A= Upper Iwehen 1A 1st Site; B= Upper Iwehen 2A 2nd Site (Moat); C= Upper Iwehen 3A 2nd Site (Moat); D= Lagos Street Control A; E= Idahosa Street A Site 5; F= Idahosa Street B Site 5; G= Idahosa Street C Site 5; H= Idahosa Street D Site 5; I= Navy Street Control 6

Table 2: Percentage concentrations of soil particle size in soils of scrapyards in Benin City

	Concentration (%)		
Sample site	**Clay**	**Silt**	**Sand**
Upper Iwehen 1A 1st Site	7.35±0.92	3.2±0.42	89.45±1.34
Upper Iwehen 2A 2nd Site (Moat)	7.30±2.69	4.05±1.63	88.65±4.31
Upper Iwehen 3A 2nd Site (Moat)	8.95±2.19	3.80±2.26	87.25±4.45
Lagos Street Control A	5.60±1.56	1.55±0.49	92.85±1.06
Idahosa Street A Site 5	8.05±0.35	2.90±0.28	89.05±0.64
Idahosa Street B Site 5	5.00±0.14	2.00±0.28	93.05±0.21
Idahosa Street C Site 5	6.15±0.64	3.00±0.14	90.85±0.78
Idahosa Street D Site 5	7.50±0.99	2.95±0.21	89.55±0.78
Navy Street Control 6	6.55±1.20	1.60±0.14	91.85±1.06

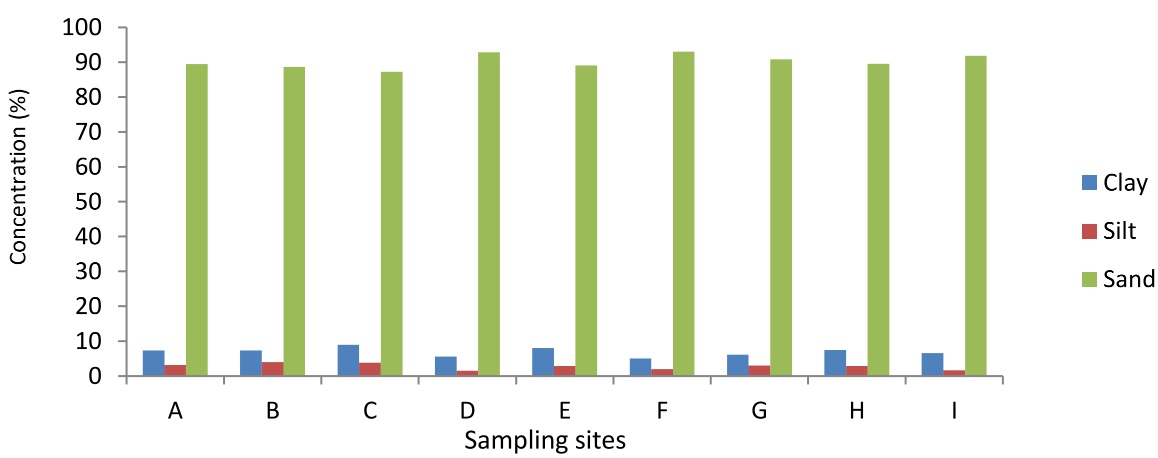

Figure 3: Bar chart representation of particle size distribution of the soil samples

KEY: A= Upper Iwehen 1A 1st Site; B= Upper Iwehen 2A 2nd Site (Moat); C= Upper Iwehen 3A 2nd Site (Moat); D= Lagos Street Control A; E= Idahosa Street A Site 5; F = Idahosa Street B Site 5; G = Idahosa Street C Site 5; H = Idahosa Street D Site 5; I = Navy Street Control 6

DISCUSSION

HM, usually collect on the surface of the soil, often with the few centimetres on top having the highest concentration which gradually decreases as the depth into the soil increases (Adedeji *et al*., 2014). The loss of organic matter is correlated with the decline of these components with depth. Sofilic *et al*. (2013) found that the more organic matter soil contains, the more HM it may adsorb. This demonstrates that organic matter may be important in the adsorption of these metals in soils from the various research region sites.

Different degrees of pollution caused by local activities are indicated by soil samples taken from the study's several scrapyards. Numerous soil contaminants do not result in obvious soil discoloration unless they are present in extremely high concentrations, despite the fact that the soils range in color from reddish brown to dark (Arinze *et al*., 2015). Iron concentration in soil samples from Upper Iwehen scrapyard were found to range from 1566-2902 mg/kg while the result of iron concentration at Idahosa street indicated a value ranging from 385-1267.50 mg/kg. Upper Iwehen scrapyard was observed to have higher concentration of iron compared to Idahosa street. Generally, it was observed that control soil samples for Upper Iwehen (Lagos street) and Idahosa street (Navy street) had lower concentration of 216.50 mg/kg and 126mg/kg respectively.

At Upper Iwehen, the concentration observed for manganese, zinc, copper and chromium were found to range from 43.50 – 80.60mg/kg, 62.65 - 116.10 mg/kg, 29.30 - 41.5 mg/kg and 28.90 – 40.7mg/kg respectively while those observed for Idahosa street was found to range from 15.7 – 35.20mg/kg, 26.95- 50.7 mg/kg, 13.95 - 19.15 mg/kg and 13.10 – 20.70 mg/kg respectively. The concentrations of HM in the soil samples were observed to be generally higher in Upper Iwehen scrapyard as compared to Idahosa street scrapyard.

In contrast to the Obalende scrapyard, Irokosun scrapyard exhibited larger amounts of metals leached into the soils, according to a research conducted by Adedeji *et al*. (2014). Some of these metals are easily leached because they are highly or moderately soluble in water. HM in their soluble and exchangeable forms are thought to be easily movable and accessible to plants (Ivezic *et al*., 2012).

These values obtained for copper in this study exceeded the maximum limit of/ 0.05 mg/kg for soils (WHO, 1996). Because copper is a necessary component of machinery and electrical equipment, areas near scrapyards have been found to have high concentrations of the metal. However, the amount of Cu pollution in the soils may pose a serious threat to both the environment and human health (Hogan, 2010). It poses a serious concern to kids who live at or around scrapyards. In a parallel research carried out in Jordan, the concentrations of all HM investigated were greater in the scrapyard region than in the control samples, and the concentrations of the HM fell with depth (Jones *et al*., 2021).

Cadmium concentrations in Upper Iwehen and Idahosa street scrapyards were found to range from 25.05-29.75 mg/kg and 10.73- 18.8 mg/kg respectively. These were however higher than the WHO permissible limit of 10 mg/kg dry soil for Cd in soil. In their study Adedeji *et al*. (2014) observed that concentration of cadmium was quite low in all the soil profile sampled in Obalende scrapyard ranging from < 0.01 to 0.04 - 0.02 mgkg-1 dry soil. The pollution level at Irokosun scrapyard were 0.03 - 1.00 mgkg-1 dry soil respectively in the topsoil.

Orisadare *et al*. (2020) discovered a scrapyard to have a cadmium content of between 5 and 10 mg/kg. Due to its extreme toxicity, the HM cadmium may quickly destroy a child's immune system (Atiemo *et al*., 2012). 3-5 mg/kg of cadmium is the critical amount in soil. Analysis of lead component present in scrapyard soils in this study revealed concentrations in Upper Iwehen and Idahosa street scrap yards ranged from 33.95 – 35.95 mg/kg and 10.82 – 19.45 mg/kg respectively. The results were below the lead standard limit set by the WHO at 70 mg/kg dry soil. According to a similar research conducted by Adie and Osibanjo (2009) on soil samples taken from a Nigerian auto battery production facility, lead concentrations were lower than levels between 243 and 126000 mg/kg dry soil. Additionally, it was determined that the mean lead concentration in the topsoil at the Obalende scrapyard was 0.60 mg/kg dry soil as opposed to 1.09 mg/kg dry soil at the Irokosun scrapyard, in comparison with findings in the study by Adedeji *et al*. (2014). In their investigation, the soils of the Irokosun scrapyard had a higher lead level than those at the Obalende scrapyard.

Ojekunle *et al*. (2016) found that the overall amounts of Pb, Cd, Cu, and Ni, which are primarily amorphous, significantly rise in the soils closest to the source and visibly decrease with distance. Metals like Cd and Pb pose risks because their content can rise as organisms migrate up the food chain (Metcheva *et al*., 2010). The effects of lead on people vary depending on the amount present, however they can cause harm to the kidney, liver, brain system, reproductive system, and blood system. Serious harm can result from high blood lead levels in humans. According to a study conducted in Croatia, Sofili *et al*. (2013) found that the concentrations of HM in all composite soil samples collected from a scrapyard area used for temporarily storing steel scrap exceeded the values of the same metals in the reference sample and the values set by some EU countries, indicating that the soil in this area could be considered contaminated.

According to Atiemo *et al*. (2012), lead (Pb), cadmium (Cd), arsenic (As), chromium (Cr), and nickel (Ni) are among the HM that are usually regarded as being hazardous to both plants and people. The buildup of these HM in the soil has the potential to limit its ability to perform its job, harm plants, and poison the food chain (Ivezic *et al*., 2012). Nickel concentration in scrapyard soils in this study revealed concentrations in Upper Iwehen and Idahosa street scrap yards ranged from 5.84 – 7.04 mg/kg and 2.53 – 4.43 mg/kg respectively while vanadium concentration in scrapyard soils in this study revealed concentrations in Upper Iwehen and Idahosa street scrap yards ranged from 3.67 – 5.00 mg/kg and 1.81 – 2.87 mg/kg respectively. Mean concentration of nickel in the topsoil analysed in the study of Adedeji *et al*. (2014) revealed that soil from Obalende scrapyard had nickel concentration ranging from 0.07-0.20 mg/kg of soil compared to 0.44-0.58 mg/kg in soil at Irokosun scrapyard. The results from the scrapyards fell within the tolerance of 0.50–6.5 mgkg-1 dry soil (WHO, 1996).

Although nickel is found naturally in alkaline magma rock and silty sedimentary rock, a significant amount of nickel enters the environment as a result of burning nickel-containing diesel oil (WHO, 1996). Nickel is a regulatory component for the many enzyme systems in living things and is connected to DNA and RNA molecules. Nickel not only disrupts the growth and development of flora and animals, but it also has an indirect or direct negative impact on human health (Adedeji *et al*., 2014). Nickel has been regarded as a trace element that is crucial for both human and animal health (Adedeji *et al*., 2014).

Percentage composition of clay, silt and sand in scrapyard soils from in Upper Iwehen in this study ranged from 7.30-8.95%, 3.20-4.05%, 87.25-89.45% respectively while that of soil from Idahosa street scrap yard ranged from 5.00-8.05%, 2.00-3.00%, 89.05-93.05% respectively.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates the possible release of several HM into soil samples as a result of scrapyards' unrestrained activity at diverse places. The study's findings suggested that soil from scrapyards, particularly that of Upper Iwehen scrapyard, was polluted since it had long been used as a location to disassemble and recycle metal debris. The low amounts of HM observed in the control locations close to the scrapyards show that the HM found there are not considerably sourced from the local geology. When there is a proposal to convert such a property into other uses such as housing and agricultural, the detrimental impacts of the pollution on human and environmental health should be taken into consideration. There are several ways to lower the amount of HM in the soil around scrapyards. One method to lessen the availability of HM to plants is by liming to a pH of neutral and maintaining adequate soil phosphorus levels. The usage of water from nearby streams and wells must be carefully monitored because there may be dangers involved for the consumers.

CONFLICT OF INTEREST

No conflict of interest was recorded during the course of this study.

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