IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 8, Issue 5 Ver. I (May. 2014), PP 60-68
www.iosrjournals.org

Soil and Water Pollution Levels in and around Urban Scrapyards

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Abstract: *This study examines pollution levels of soils and water around two sites used as scrapyards in Abeokuta and Lagos Metropolis, Nigeria. Twenty-four soil samples and water samples from a stream and hand-dug well were collected from the scrapyards. Soil samples were obtained at two depths, 0-15 cm and 15-30 cm. Physicochemical parameters (pH, colour, temperature, conductivity and total dissolved solids) that affect the mobility of metals were also determined on both soil and water according to standard methods. Concentrations of heavy metals, namely Cd, Co, Cr, Cu, Ni, and Pb in both soil and water of the scrapyards were determined by atomic absorption spectrophotometery (AAS). Generally, the levels of all heavy metals studied in the scrapyard area were found to be higher than those of the control samples. The levels of heavy metals also decreased at distances farther away from the scrapyard area. Heavy metal contaminations in the soils of the scrapyards were compared with International Standard Limits. The study revealed that concentrations of heavy metals in all samples collected from the Irokosun scrapyard in Lagos showed higher values of heavy metals compared to the concentrations in the control sites and the standard.*
Keywords: *Contamination, Heavy metal, Soil, Metal scrap, Pollution Load Index*

I. Introduction

Recent pace of urbanization and industrialization in many parts of developing countries of the world have led to increased generation of scrap materials often dumped in parts of urban centres where heavy metals and other components are leached into the ecosystem causing damage. Heavy metals are serious pollutants because of their toxicity, persistence and non-degradability in the environment [1-3]. They significantly affect ecological quality including soil and water [4] . Soils are usually regarded as the ultimate sink for heavy metals discharged into the environment [5-6], however, at certain level of contamination; heavy metal becomes dangerous to the health of the soil and plants in the environment. Heavy metal contamination of urban topsoil and water usually derives from anthropogenic sources such as the activities of scrapyards that endanger the health of people who may ingest the toxic metals such as lead and cadmium [7-8]. Although heavy metals concentration and distribution in environmental media such as the soil and water bodies are well documented for a number of places of developed countries, there is a paucity of information for most developing countries [9]. For instance, in Nigeria, little attention had being paid to activities in scrapyards, which are liable to pollution arising from leaching of heavy metals and other toxic substances. Scrapyards are indiscriminately sited in urban centres in Nigeria where all sort of scraps from disused automobiles, machineries, and electrical appliances are dismantled and recycled for further uses [10]. Many of these scrap materials are full contaminants that are toxic and have negative environmental effects when not properly managed [11-12]. Scrapyards are also associated with emission of flammable, asphyxiant or corrosive gases and possible presence of radioactive materials. Surface runoff from scrapyards may present a risk of pollution of water especially the surface watercourses and groundwater sources.

Activities on scrapyards such as the dismantling of motor vehicles, machinery, metal cleaning, sorting and recovery especially for non-ferrous metal values, poses potential risk such as the presence of toxic substances, which may affect human health, plant growth and animal life [4]. Soil, being a complex porous material retains and transports harmful pollutants such as Cd, Co, Cu, Ni, Pb, and Zn into both nearby surface and groundwater making residents in such neighbourhood directly vulnerable health hazards [11, 13-14]. Studies have shown that groundwater in the neighbourhood of scrapyards contained one or more of these heavy metals [15]. Concern for heavy metals in soils is directly related to their interactions within all the systems through the food chain as soil heavy metals composition may influence uptake by plants, which consequently determines that of animals and humans [16]. Not much is known about the scale of scrapyard soil contamination in Nigeria due to inadequate investigation and definitional issues, hence assessment of the soils and water around scrapyards would help determine the extent of effect of exposure to these heavy metals and how the risks posed by these heavy metals can be minimized and guarantee public health safety. The aim of this study is to assess the heavy metal concentration in the soils and water around scrapyards in urban environment. the specific objectives of the study include: i) to examine the concentrations of Co, Ni, Cd, Cu, and Pb for soils and water in neighbourhood of scrapyards in the study area, ii) to establish the spatial variability in the concentration of heavy metals in soil and water in the scrapyards.

II. Materials and Methods

Study Area

Two scrapyards were selected in Abeokuta and Lagos Metropolis in Nigeria because of the location within residential neighbourhoods. The scrapyard in Abeokuta is located in Obalende, Idi-Aba area on Latitude 7º 15′ N and Longitude 3º 22′ E (Figure 1).

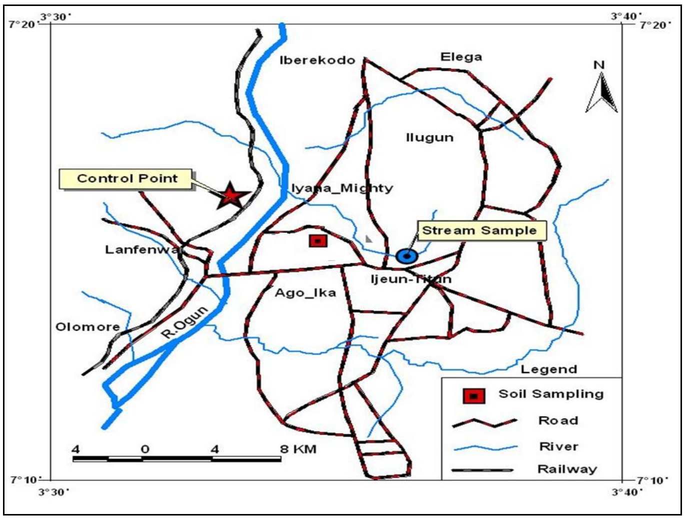

Figure 1: Location of Obalende Scrapyard in Abeokuta Metropolis

It started operation around 1976 where various disused automobiles, machineries and electrical appliances are dismantled and scavengers bring in scraps for sale. The other scrapyard is situated on Irokosun Street, Mushin, Lagos. It is located between Latitude 6˚31´N and Longitude 3˚20´E (Figure 2). It was established on a reclaimed waterlogged area around November 1989 and was later converted into depot for collection, recycling and sale of different types of scraps.

Sampling

Twenty-four soil samples were collected in a grid system around the scrapyards at two depths, 0-15 cm and 15-30 cm using stainless steel soil auger. The samples were transferred into polyethylene bags and labelled for easy identification. In order to assess pollution level of soil in the scrapyards, comparison was done between levels of heavy metal concentrations in analyzed samples and reference sample taken outside the area, which was used as control.

These areas chosen as control were not under the direct influence of the scrapyard activities or any other anthropogenic influences. In addition, water samples were collected in hand dug wells sited within the Irokosun scrapyard in Mushin, Lagos, while water samples were collected in a nearby stream around the Obalende scrapyard in Abeokuta Metropolis.

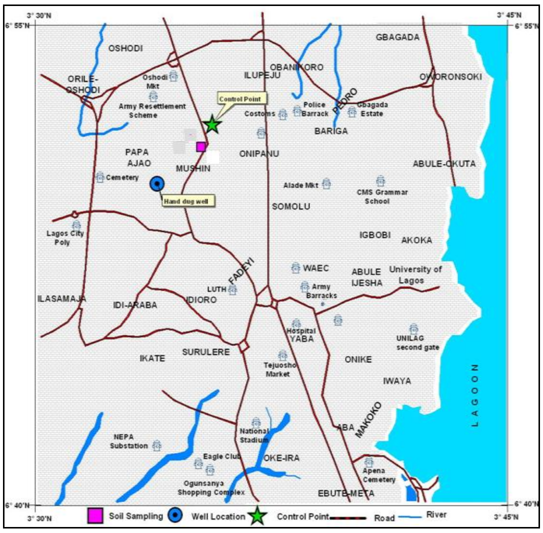

Figure 2: Location of sampling point at Irokosun Scrapyard in Mushin, Lagos

Laboratory Analysis

The soil samples were air-dried for three days after which they were pulverized to increase the volume of the samples and then ground into powdered form with the use of mortar and pestle. The samples were sieved with a 2.0 mm sieve to remove the large particles that cannot pass through the sieve. Two grams of the sieved sample were weighed and transferred to a Pyrex tube. Then, 10 ml of aqua regia (1M HNO_3 and 1M HCl) were added. The sample was transferred to a heating block for 8 h to complete digestion, then centrifuged, transferred to a volumetric flask and made up to 25 ml with 1 M HNO_3 [17] . The digests were analyzed for heavy metals (Co, Cd, Cu, Ni, and Pb) using an Atomic Absorption spectrophotometer (model AA-6200). Water samples were also digested and analysed for heavy metals using atomic absorption spectrophotometer (AAS). Physico-chemical parameters (pH, Total Dissolved Solid and Electrical Conductivity) were analyzed with HANNA Hl 83200 multiparameter ion specific meter. All the standard solution was prepared from analytical grade. All procedures of sampling and handling were carried out without contact with the metals, to avoid potential contamination of the samples.

Assessment of pollution level in scrapyard soils

For the assessment of pollution level of the scrapyard soils by the heavy metals, the Pollution Load Index (PLI) was calculated using Equation 1.as proposed by Tomilson et al. [18].

PLI is expressed as: PLI = (CF1 x CF2 x CF3 x …… x CFn) 1/n --------------- (1)
where, n is the number of metals (five in this study) and CF is the contamination factor which can be calculated as described in Equation 2.

$$CF = \frac{C_m \text{ Sample}}{(C_m \text{ Background })} \quad \text{------------------------- (2)}$$

Contamination factor CF < 1 refers to low contamination; 1 ≤ CF < 3 means moderate contamination; 3 ≤ CF ≤ 6 indicates considerable contamination and CF > 6 indicates very high contamination. The PLI provides simple but comparative means for assessing a site quality, where a value of PLI < 1 denote perfection; PLI = 1 present that only baseline levels of pollutants are present and PLI > 1 would indicate deterioration of site quality[18].

Statistical Analysis

Data collected from the laboratory analyses were subjected to both descriptive statistics and Pearson Moment Correlation analysis using the Statistical Package for Social Sciences (SPSS 17.0). Concentrations of metal were compared using One-Way analysis of variance (ANOVA) to compute the statistical significance of the mean.

III. Results

Table 1 shows the physico-chemical parameters and heavy metal pollution levels in the soil in Obalende scrapyard. The soils have reddish brown in most of the profile studied except for sample points OB1 and OB3, which was dark brown and dark grey respectively in the top soil. Soil pH of the topsoil ranges from 7.02 to 7.54 with an average of 7.42. The pH for the subsoil range from 7.50 to 7.55, with average of 7.47. Temperature remained constant at about 28.3ºC for all the studied soil profiles. Electrical conductivity varies from 80 µScm in the subsoil at OB2 to 98 µScm in the subsoil at OB3. Average EC was to 92.5 µScm and 92.25 µScm in the topsoil and subsoil respectively at Obalende scrapyard. Total dissolved solid (TDS) ranged between 40 to 49 $mgkg^{-1}$ in the topsoil. Mean concentration of Ni, Cu, and Pb in the topsoil and subsoil ranged from 0.02 to 0.88 $mgkg^{-1}$, 0.16 to 20.91 $mgkg^{-1}$ and 0.02 to 1.00 $mgkg^{-1}$ dry soil respectively in the soil at Obalende scrapyard. Cadmium and Cobalt were relatively low (0.01 to 0.04 $mgkg^{-1}$ dry soil) in the soil profile sampled in the area these were however, higher in the subsoil than the topsoil (Table 1).

The soils in Irokosun scrapyard in Mushin, Lagos, were predominantly dark or black in colour except for the subsoils IRK 2 and IRK 5 that were brown and reddish brown respectively. Soil pH in the Irokosun scrapyard ranged from 6.00 to 6.99, while temperature was constant at about 28.4ºC (Table 2). Electrical conductivity (EC) ranged from 1210 µScm in the subsoil at IRK4 to 1265 µScm in the in the topsoil at IRK4. Mean EC was 1231.25 µScm and 1223.5 µScm for the topsoil and subsoil respectively. TDS correspondingly ranged between 605 $mgkg^{-1}$ in the subsoil at IRK4 to 633 $mgkg^{-1}$ in the topsoil also at IRK4.

Table 1: Descriptive characteristics of physical parameters and heavy metal concentrations (mg/Kg), characteristics of Top (T) and Sub soil samples (S) from scrapyard at Obalende area of Ogun State.

0-15 cm	pH	Temp oC	EC (µScm)	TDS	Ni	Cu	Cd	Co	Pb
					mg/kg dry soil				
Mean	7.42	28.35	92.50	46.50	0.07	2.92	0.01	0.02	0.60
Median	7.52	28.30	92.50	46.50	0.05	0.43	0.01	0.01	0.65
Standard Deviation	0.21	0.10	6.35	2.89	0.09	5.05	0.01	0.02	0.25
Range	0.43	0.20	11.00	5.00	0.20	10.17	0.01	0.05	0.59
Minimum	7.11	28.30	87.00	44.00	0.00	0.33	0.00	0.00	0.25
Maximum	7.54	28.50	98.00	49.00	0.20	10.50	0.01	0.05	0.84

15-30 cm	pH	Temp oC	EC (µScm)	TDS	Ni	Cu	Cd	Co	Pb
					mg/kg dry soil				
Mean	7.47	28.35	92.25	46.00	0.25	5.56	0.02	0.03	0.52
Median	7.53	28.35	96.00	48.00	0.05	0.53	0.01	0.01	0.53
Standard Deviation	0.33	0.06	8.22	4.00	0.42	10.23	0.02	0.05	0.41
Range	0.78	0.10	17.00	8.00	0.87	20.62	0.04	0.11	0.98
Minimum	7.02	28.30	80.00	40.00	0.01	0.29	0.00	0.00	0.02
Maximum	7.80	28.40	97.00	48.00	0.88	20.91	0.04	0.11	1.00
Control	7.58	28.30	92.50	46.50	0.03	0.19	0.00	0.02	0.35

Mean concentration of Cd and Co in the topsoil and subsoil at Irokosun scrapyard were 0.03 and 1.00 $mgkg^{-1}$ dry soil and 0.02 and 0.94 $mgkg^{-1}$ dry soil respectively (Table 2). For Cu, Ni, and Pb concentration in the soil ranged from 0.01 to 28.34 $mgkg^{-1}$, 0.01 to 0.60 $mgkg^{-1}$, and 0.31 to 1.82 $mgkg^{-1}$ dry soil respectively. While mean concentration of Cu in the topsoil was 13.55 $mgkg^{-1}$ dry soil compared to 12.34 $mgkg^{-1}$ dry soil in the subsoil; the maximum concentration of the metal (28.34 $mgkg^{-1}$ dry soil) was observed in the subsoil. Maximum concentration of Pb (1.82 $mgkg^{-1}$ dry soil) was found in the topsoil compared to 1.71 $mgkg^{-1}$ dry soil found in the subsoil.

Table 2: Descriptive characteristics of physical parameters and heavy metal concentrations (mg/Kg), characteristics of Top (T) and Sub soil samples (S) from scrapyard at Irokosun Scrapyard, Lagos

0-15 cm	pH	Temp oC	EC (µScm)	TDS	Ni	Cu	Cd	Co	Pb
					mg/kg dry soil				
Mean	6.73	28.48	1231.25	616.00	0.44	13.55	0.03	1.00	1.09
Median	6.75	28.50	1222.50	611.50	0.43	12.10	0.01	0.92	0.95
Standard Deviation	0.03	0.05	23.21	11.63	0.10	8.36	0.03	0.97	0.52
Range	0.06	0.10	50.00	25.00	0.24	19.07	0.06	1.87	1.18
Minimum	6.69	28.40	1215.00	608.00	0.34	5.47	0.01	0.14	0.64
Maximum	6.75	28.50	1265.00	633.00	0.58	24.54	0.07	2.01	1.82

15-30 cm	pH	Temp oC	EC (µScm)	TDS	Ni	Cu	Cd	Co	Pb
					mg/kg dry soil				
Mean	6.57	28.48	1223.50	612.25	0.40	12.34	0.02	0.94	1.43
Median	6.75	28.50	1217.00	609.50	0.40	9.54	0.02	0.61	1.49
Standard Deviation	0.38	0.05	18.05	8.77	0.18	11.78	0.01	1.13	0.30
Range	0.77	0.10	40.00	20.00	0.41	26.40	0.03	2.45	0.70
Minimum	6.00	28.40	1210.00	605.00	0.19	1.94	0.01	0.05	1.01
Maximum	6.77	28.50	1250.00	625.00	0.60	28.34	0.04	2.50	1.71
Control	6.94	28.30	120.50	60.00	0.02	0.17	0.01	0.11	0.38

Physico-chemical parameters and heavy metal concentration in water

Table 3 shows the average physico-chemical parameters and heavy metal concentration of water obtained from a stream near the Obalende scrapyard and a hand-dug well at Irokosun scrapyard. Average pH in water obtained from the stream near the Obalende scrapyard was 7.10, while the one for the well water from Irokosun was 7.28. Temperature was constant for the two areas at 31ºC.

Table 2: Heavy metal concentrations (mg/L) in water samples close to scrapyard at Obalende area of Ogun State and Irokosun area of Lagos State.

Sampling site code	**Water colour**	**pH**	**Temp (ºC)**	**EC (µScm)**	**TDS (ppm)**	**Ni**	**Cu**	**Cd**	**Co**	**Pb**
IRK	Clear	7.28	31.02	54	27	N.D	0.01	<0.01	N.D	0.18
	Clear	7.28	31.02	54	27	N.D	0.01	<0.01	N.D	0.18
***IRK**		**7.28**	**31.02**	**54**	**27**	**N.D**	**0.01±.01**	**<0.01**	**N.D**	**0.18±.18**
OB	Brown	7.09	31.10	29	15	N.D	0.01	<0.01	N.D	0.22
	Brown	7.10	31.10	31	16	N.D	0.02	<0.01	N.D	0.26
***OB**		**7.10**	**31.10**	**30**	**16**	**N.D**	**0.02±.02**	**<0.01**	**N.D**	**0.24±.24**
BLANK	Clear	7.00	28.3	60	30	N.D	N.D	N.D	N.D	N.D

Average value (*), Temperature (Temp), Electrical conductivity (E.C), Total Dissolved Solid (TDS), Not Detected (N.D) and BLANK (Blank Sample)

Electrical conductivity (EC) for the water from the Obalende scrapyard has a mean of 30 µScm, while that of the stream water from Irokosun scrapyard was 54µScm. On the other hand, TDS for water from the two scrapyards were 16 mgL^{-1} and 27 mgL^{-1} respectively. Heavy metals, such as Co and Ni were not detected in the water samples from the two scrapyards, while Cd was below 0.01 mgL^{-1} for all the sampled water. Pb had the highest concentration among all the heavy metals studied with an average of 0.24 mgL^{-1} and 0.18 mgL^{-1} for the Obalende and Irokosun scrapyard respectively. Mean Cu concentrations were 0.02 mgL^{-1} and 0.01 mgL^{-1} at Obalende and Irokosun scrapyard respectively.

IV. Discussion

Soils in the two scrapyards have shown different levels of pollution due to the activities in the area. Although the soils have colours varying from reddish brown to dark, many soil contaminants do not cause obvious soil discoloration unless they are in very high concentrations [19]. The Irokosun scrapyard soil with pH ranging from 6.00 to 6.77 is slightly acidic in nature than the soils from Obalende scrapyard whose pH ranged from 7.02 to 7.80 in the subsoil. The dark colour of most soils in the Irokosun scrapyard showed much more metal might have leached onto the soil than the soils of the Obalende scrapyard. Mean EC and TDS for the topsoil at the Obalende scrapyard were 92.5 µScm and 46.5 $mgkg^{-1}$ dry soil respectively compared to 1231.25 µScm and 616 $mgkg^{-1}$ dry soil at the Irokosun scrapyard. These values were slightly lower in the subsoil for the two scrapyard (Tables 1 and 2). All the heavy metal examined had higher pollution levels in the soil at Irokosun scrapyard compared to the Obalende scrapyard showing the Irokosun scrapyard probably has higher amount of metals leached into the soils. Some of these metals are highly or moderately soluble in water and therefore easily leached. Water soluble and exchangeable forms of heavy metals are considered readily mobile and available to plants [20].

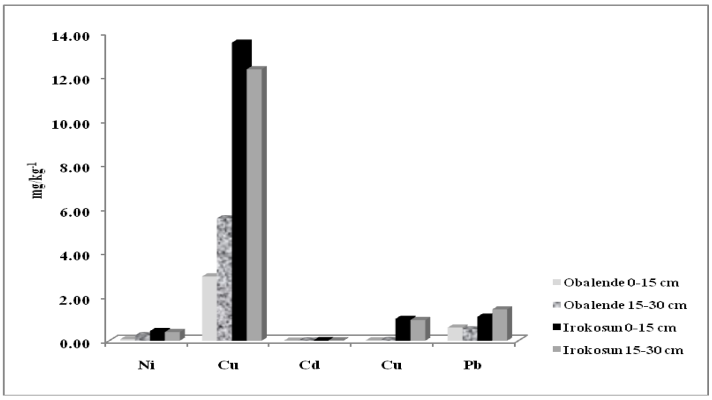

Figure 3: Comparison of average Heavy metal concentrations (mg/Kg) of Top (T) soil samples from scrapyards at the different locations

For instance, topsoils from the Irokosun scrapyard had mean concentration of 13.55 mgkg^{-1} dry soil for Cu compared to 2.92 mgkg^{-1} dry soil found in the Obalende scrapyard ((Figure 3). Concentration of Cd was quite low in all the soil profile sampled in Obalende scrapyard ranging from < 0.01 to 0.04 mgkg^{-1} dry soil, with a mean of 0.02 mgkg^{-1} dry soil. The pollution level at Irokosun scrapyard were 0.03 mgkg^{-1} dry soil and 1.00 mgkg^{-1} dry soil respectively in the topsoil. These were however lower than the WHO permissible limit of 10 mgkg^{-1} dry soil for Cd in soil [21]. Mean concentration of cobalt in Obalende scrapyard were 0.02 mgkg^{-1} dry soils, with a maximum of 0.05 mgkg^{-1} dry soil for the topsoil, while the subsoil has a mean 0.03 mgkg^{-1} dry soil and maximum of 0.11 mgkg^{-1} dry soil. The control site at Obalende has lower concentration of cobalt (0.02 mgkg^{-1} dry soil) compared to the soils in the scrapyard. Similar patterns were observed at the Irokosun scrapyard which however has higher concentration of cobalt in the soils. Mean concentration of cobalt in the topsoil at Irokosun was 1.00 mgkg^{-1} dry soil, with a maximum of 2.01 mgkg^{-1} dry soil, while mean concentration in the subsoil was 0.94 mgkg^{-1} dry soil and a maximum of 2.50 mgkg^{-1} dry soil. Cobalt is a natural earth element present in trace amounts in soil, plants and in our diets. It usually occurs in association with other metals such as copper, nickel, manganese and arsenic [22]. The average concentration of cobalt in soils throughout the world is 8 parts per million (ppm). Majority of cobalt in the soil is not bioavailable and cobalt forms stable carbonate and hydroxide minerals, which cannot be absorbed by animals or plant lifes [23]. Therefore, it requires large volume of the element before local wildlife could be adversely affected. Cobalt in the form of vitamin B_{12} (hydroxocyanocobalamin) is in the physiologically active form and the body needs only in trace amount. It is very essential to provide 2.0 μg per day in the form of vitamin B_{12} for a diabetic individual. The toxicity of cobalt is quite low compared to many other metals in soil; however, exposure to very high levels of cobalt can cause health effects. Effects on the lungs, including asthma, pneumonia, and wheezing [22]. In addition, children tend to be more affected by exposure to high concentration of cobalt because they have smaller body weights. Soils with high cobalt concentration usually have also high nickel, which is more toxic to plants and humans [24].

Mean concentration of Ni in the topsoil at Obalende was 0.07, with a maximum of 0.20 mgkg^{-1} dry soil compared to a mean of 0.44 mgkg^{-1} and maximum of 0.58 mgkg^{-1} dry soil at Irokosun scrapyard. The values obtained in the scrapyards were within limit of 0.50-6.5 mgkg^{-1} dry soil [25]. Nickel occur naturally in connection with alkaline magma rock as well as silty sedimentary rock, however considerable part of nickel finds its way into the environment as a result of the burning of diesel oil containing nickel [26]. Nickel is associated with DNA and RNA molecules and a regulatory element for the various enzyme systems of living things [27]. Nickel and cobalt causes not only disturbances in the growth and development of flora and fauna, but indirectly or directly affect human health [28]. Cadmium pollution level is very low in both scrapyards compared to similar study by Leung *et al.* [14], who found cadmium concentration in the range of 5 to 10 mgkg^{-1} dry soil in a school compound situated around a scrapyard. Cadmium is a very toxic heavy metal, which can devastate children's immune system within a short period of exposure [29]. Critical level of cadmium in soil is 3-5 mg/kg [30]. Mean concentration of Pb in the topsoil at Obalende scrapyard was 0.60 mgkg^{-1} dry soil compared to 1.09 mgkg^{-1} dry soil at the Irokosun scrapyard. These values were lower than the values obtained by Adie and Osibanjo [31] in the study of soil from an automobile battery manufacturing plant in Nigeria that have values varying between 243 and 126000 mgkg^{-1} dry soil for Pb. The Pb content soils at Irokosun scrapyard was more than that of the Obalende scrapyard, however, the values obtained were lower than the WHO standard limit of 70 mgkg^{-1} dry soil for Pb [21].

Copper had the highest concentration in the two locations especially in the top soil (Tables 1 and 2). These values exceeded the maximum limit of 0.05 mgkg^{-1} for soils [25]. Copper forms an integral part of machines and electrical appliances and therefore high concentrations has been found in neighbourhood of scrapyards [29]. The level of Cu pollution present in the soils may however pose substantial health risk to human beings as well as the environment [32]. It is a major threat to children living in and around scrapyards [29]. In a related study conducted in Jordan, the levels of all heavy metals studied in the scrapyard area were higher than those of the control samples and the levels of heavy metals decreased with depth [33]. Martin *et al*. [34] observed that a significative increase in the total contents of Pb, Cd, Cu, and Ni, mainly amorphous in the soils closer to the source, which clearly decrease with distance. Risks from metals such as Cd and Pb are amplified by their ability to increase in concentration as they move up the food chain [35]. The effect of Pb in humans vary with the quantity present but include damage to the kidney, liver, nervous system, reproductive system, impaired growth and interference with blood system. High levels of lead in human blood can cause serious damages. In a study in Croatia, Sofilić *et al*. [3] reported that the concentrations of heavy metals in all composite soil samples taken from scrapyard area used for temporarily storing steel scrap, exceed values of same metals in the reference sample and values as regulated by some EU countries, implying this soil can be defined as contaminated. Cheng et al. [36] stated that among heavy metals, cadmium (Cd), arsenic (As), chromium (Cr), nickel (Ni), and lead (Pb) are commonly considered as toxic to both plants and humans. Accumulation of these heavy metals in the soil has potential to restrict the soil's function, causing toxicity to plants and contaminates the food chain [37].

Contamination of water sources such as hand-dug well and streams prevents its use for human consumption and worsen the problem of scarcity [38]. In this study, heavy metals, such as Co and Ni were not detected or below detection limit in the water samples from the two scrapyards. However, Pb had an average concentration of 0.24 mgL^{-1} and 0.18 mgL^{-1} for the Obalende and Irokosun scrapyard respectively. Concentration of Pb found the water sample taken from the two scrapyards were above the WHO permissible limit of 0.05 mgL^{-1} for drinking water [39] , which poses a great risk to the health of the people who consume such water. In naturally occurring waters, cobalt occurs in small amounts; its average natural content in river waters is approximately 0.2 μgL^{-1}. Nickel on the other hand is often leached from metals in contact or because of dissolution from nickel ore-bearing rocks in some groundwaters [40]. Nickel has been considered as an essential trace element for human and animal health. However, studies have shown the carcinogenicity of nickel compounds in experimental animals [41] causing tumours induced at the site of administration of the nickel compound. The maximum permissible limit for Ni in water is 0.2 mgL^{-1} [39]. Mean Cu concentrations were 0.02 mgL^{-1} and 0.01 mgL^{-1} at Obalende and Irokosun scrapyard respectively, which were lower than the 1.0 mgL^{-1} permissible limit [39].

Correlation matrices for the metals in the topsoil in the two scrapyards showed some metals were interrelated with each other (Tables 4 and 5).)

Table 4: Pearson Correlation Analysis of Heavy Metals of Top soil samples in Obalende Area of Ogun State

Ni	Cu	Cd	Co	Pb	
Ni	1				
Cu	0.961**	1			
Cd	0.961**	1.000**	1		
Co	0.188	-0.058	-0.049	1	
Pb	-0.521	-0.577	-0.590	-0.037	1

**. Correlation is significant at the 0.01 level (2-tailed).

There is however a strong correlation 0.961 between Cu and Ni ($p<0.05$) in the top soil in the two sample sites indicating significant influence of one metal on the other. It also suggests that, there is possibility of the metals having the same source, because the correlation coefficient between Cu and Ni.

Table 5: Pearson Correlation Analysis of Heavy Metals of Topsoil samples in Irokosun Area of Lagos State

	Ni	Cu	Cd	Co	Pb
Ni	1				
Cu	0.852*	1			
Cd	0.260	-0.237	1		
Co	0.681*	0.519	0.572	1	
Pb	0.440	-0.080	0.922*	0.501	1

*. Correlation is significant at the 0.05 level (2-tailed).

Pollution load index (PLI)

Pollution load index (PLI) for soils in this study showed that metal concentration in the scrapyard soils exceeds the average natural background concentration. The soils were contaminated by anthropogenic inputs from the scrapyard activities. The calculated PLI values of the soils ranges from less than 1.25 at Obalende scrapyard to 3.25 at the Irokosun scrapyard. This indicated that soils in the scrapyards were both above the limiting value of 1.0, indicating considerable metal contamination by the five metals especially Pb and Cu. Excessive content of metals beyond Maximum Permissible level (MPL) leads to number of nervous, cardiovascular, renal, neurological impairment as well as bone diseases and several other health disorders [42].

V. Conclusion

This study showed the potential discharge of various heavy metals in the soil and water samples due to uncontrolled activities of scrapyards. The results obtained from the study qualify analysed soil from the scrapyards especially that of Irokosun in Lagos as contaminated soil, because by its use over a long time as a site to dismantle and recycle metal scraps. The Pb and Cu contents soils at Irokosun scrapyard was more than that of the Obalende scrapyard, however, the values obtained for Pb were lower than the WHO standard limit of 70 mgkg^{-1} dry soil. In addition, values obtained for Cu did not exceed the maximum limit of 200 mgkg^{-1} for soils set by environmental bodies such as Tanzania Local Standards. Heavy metals found in the soils of the scrapyards are not significantly derived from the natural geology of the area as evident from the low concentrations obtained from the control sites near the scrapyards. Concentration of Pb found the water sample taken from the two scrapyards were above the WHO permissible limit for drinking water, which poses a great risk to the health of the people who consume such water. The deleterious effects of the pollution on human and environmental health should be taken into consideration when there is a plan to redevelop such site into other uses such as housing and agriculture. A number of measures can be used to reduce the heavy metal contents in the soil of the scrapyards. One way is by liming to a neutral pH and maintaining optimal soil phosphorus levels can reduce heavy metal availability to plants. Much precaution have to be taken especially on the use of water from the streams and hand-dug wells around the scrapyards as this may pose risks to the users.

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