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Assessment of Heavy Metal Pollution of Surface Soils from Scrapyards in Benin City, Nigeria

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Abstract

Scrap metals found in scrapyards accounts for a large proportion of municipal solid waste in Nigeria. They are a menace to the environment and pose potential health risk to nearby residents. This study assessed the physicochemical quality and heavy metal contamination of surface soils from selected scrapyards in Benin City, Nigeria. Surface soils were collected from 12 randomly selected scrapyards between February and April 2018. Physicochemical analyses were carried out using standard analytical methods, while heavy metal (Fe, Cd, Zn, Cr, and Pb) concentrations were determined using atomic absorption spectrophotometry. The physicochemical indicators showed values which ranged from 6.17 ± 1.17 to 7.81 ± 0.88, 335.00 ± 60.62 to 2467.33 ± 1708.95µS/cm and 2.18 ± 0.39 to 44.27 ± 17.72 mg/kg for pH, electrical conductivity (EC) and nitrate (NO^-_3) respectively. The texture of the scrapyard soils was predominantly sand. The concentrations of the heavy metals in the scrapyard sites were significantly ($p < 0.05$) higher than the control site. A strong positive correlation existed among the studied metals. The concentrations of heavy metals were above the WHO/FAO critical level of 100 mg/kg except for Cr and Cd. Contamination indexes of the scrapyard soils showed that the soils samples from all the locations were highly contaminated with heavy metals. There is urgent need for evacuation of the scrap metal wastes from the scrapyards and enactment of appropriate legislations which prohibits the use of land in residential areas as scrapyards in the city to prevent likely health hazards.

Keywords: Scrap Yard; Soil pollution; Heavy metals; Benin City

Introduction

One of the major challenges confronting Nigeria as a country is solid waste management [1]. Municipal solid wastes are routinely deposited on the roads, drains, water bodies and uninhibited lands. Scrap metals are important parts of the municipal solid wastes (MSW), which have monetary value in Nigeria [2]. According to ICRCL [3] scrapyards are haphazardly sited in urban centres in Nigeria where all kinds of scraps from abandoned automobiles, machineries, and electrical appliances are disassembled and recycled for further uses. Many of these scrap materials are made up of contaminants that are toxic including heavy metals and adversely affect the environment when not properly managed [4]. Heavy metals present in solid municipal wastes via interaction with soil components, bioaccumulate and persist in soil and consequently go into the food chain through plants or animals [5]. The increased level of metals that accumulate in the soil and affect nearby ecosystems primarily originates from anthropogenic activities [6]. Some of the human activities known to influence the level of heavy metals in soil are discharge of industrial and domestic wastes, mining, smelting operations, and vehicular emission [6]. Weathering of the natural rocks is also a known source of heavy metal pollution in soils however; Nriagu and Pacyna reported that the input of metals from human sources in soils is higher than the input from natural sources [7].

Several authors have reported that the concentration of heavy metal pollution in the surface soils is more compare with that of deep soil due to the degree of recent pollution from different anthropogenic sources [8]. Identification of metal concentrations of soil is done by using different indices such as the contamination factor (CF), Pollution load index (PLI), the metal enrichment factor (EF) and geoaccumulation indexes (Igeo) [9]. These indexes are used in identifying pollution level in soils by calculating the soil exchangeable fraction as it represents the real bio-available fraction. The determination of the metals in soil, dust, plant and sediments are very important in monitoring the quality and extent of environmental pollution [10]. Osazee, et al. also noted that the microbiological imbalance of soils as well as decline in soil fertility could results from high concentration of metals in the soil [11]. Metal scrap yard is made up of different types of materials including, harmful pollutants such as Cadmium (Cd), Cobalt (Co), Copper (Cu), Nickel (Ni), Lead (Pb), and Zinc (Zn) hence there is the tendency of leaching of the primary materials which can end up in nearby water bodies as a result of runoff action, depending on the topography of the area.

Residents in neighborhood nearby scrapyards are directly vulnerable to health hazards due to inhalation and ingestion of the poisonous metals which include lead and cadmium This study was aimed at assessing the physicochemical quality and the risk assessment of heavy metals in top soils obtained from selected scrapyards in Benin City, Edo State, Nigeria [12,13].

Materials and Methods

Study Area

Benin City is a humid tropical urban metropolis which comprises four Local Government Areas namely Egor, Ikpoba Okha, Oredo and Ovia North East. It is located within latitudes 6°20'N and 6°58'N and longitudes 5°35'E and 5°41'E [14]. It broadly occupies an area of approximately 112.552 km with an estimated population of 1,086,882 people [15] (Figure 1).

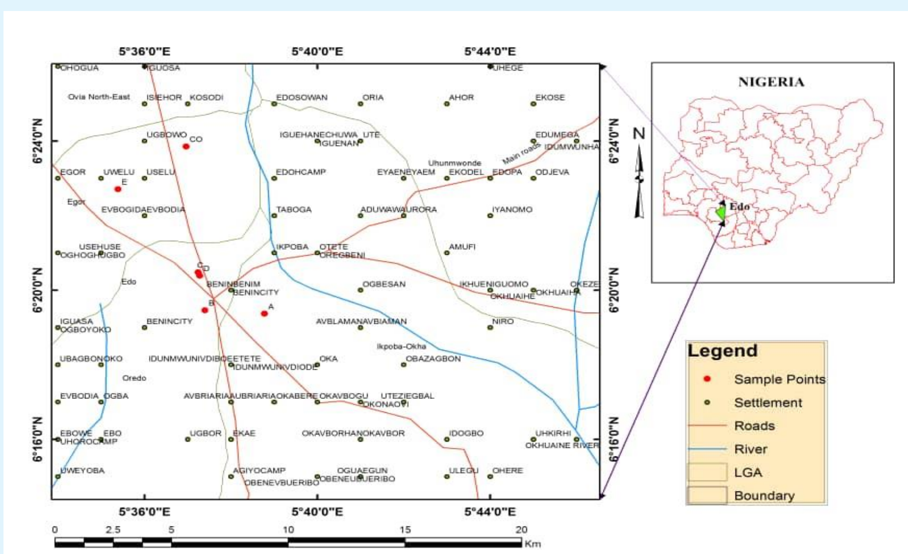

Figure 1: Map of study areas.

Sample Location

A total number of twelve scrapyards, (four each) were selected across Oredo, Egor and Ikpoba Okha Local Government areas in Benin City, Nigeria. The choice of these locations stems from the proximity of the scrapyards to residential neighborhoods. The scrapyards are located in Aduwawa, St. Saviour, Ibiwe, Iyaro and Uwelu areas of the city and were made up of various abandoned automobiles, machineries and electrical appliances which are brought by scavengers for sale.

Sample Collection

Surface soil samples were collected from 12 scrapyards across Benin City, Edo State. The samples were collected between February and April 2018. About 100g of the surface soil samples were collected in triplicates at a depth of 2-20cm with the aid of a soil auger. The surface debris on the soils was removed before sampling. The samples were dispensed into sterile containers and appropriately labeled. A control soil sample was obtained from the University of Benin botanical site Ugbowo, Benin City.

Physicochemical Analyses of the Soil Samples

Physiochemical properties which included pH, electrical conductivity (EC) and particle size distribution were ascertained using procedures described by Kalra and Maynard [16]. Soil samples were also analyzed for Nitrate (NO^-_3) content using methods described by Onyeonwu.

Heavy Metal Analyses

Soil samples were analysed for heavy metal contents such as: Iron (Fe), Cadmium (Cd), Zinc (Zn), Chromium (Cr), and Lead (Pb). The samples were digested using nitric acid and the metal concentrations were determined using atomic absorption spectrophotometry (Perkin Elmer Analyst 800 series Graphite Furnace AA) according to the analytical procedures outlined in Standard Methods for the Examination of Water and Wastewater [17].

Determination of Pollution Indexes of the Scrapyard Soils

Contamination Factor (Cf)

Contamination factor is a quantification of the extent of contamination corresponding to either average crustal composition of respective metal or to the measured background values from geologically similar and uncontaminated area [18].

It is expressed as: $Cf = Cm/Bm$

Where Cm is the mean concentration, while Bm is the background concentration of metal directly determined from a geologically similar area (control sample).

There are four classes of Cf [19]. They are presented in Table 1.

Contamination Factor	Description
Cf<1	Low degree of contamination
$1 \leq Cf < 3$	Moderate degree of contamination
$3 \leq Cf < 6$	Considerable degree of contamination
$Cf \geq 6$	Very high degree of contamination

Table 1: Classes of contamination factor (Cf).

Pollution Load Index (PLI)

PLI was used to evaluate the degree of pollution in scrapyard sites. PLI was calculated based on the contamination factor (Cf).

PLI provides a simple comparative mean for assessing the level of metal contamination according to the equation [19].

$$PLI = \sqrt[n]{Cf1 \times Cf2 \times Cf3 \ldots Cfn}$$

Where Cf is the contamination factor and n is the number of heavy metals considered, n is the number of metals. Two classes of PLI were proposed by Tomlinson, et al. [20].

Pollution Load Index	Description
PLI > 1	pollution exists
PLI < 1	no metal pollution

Table 2: The categories of Pollution load index (PLI).

Statistical Analysis

All parameters tested in this study were reported as means ± standard deviations. The statistics package for social sciences (SPSS version 20) was used to generate analysis of variance (ANOVA). Duncan's multiple range tests were used to test for significance and mean separation respectively at 5% level of confidence. Pearson correlation was employed to examine and establish the association between the physicochemical characteristics and the heavy meal indexes of soil obtained from various scrapyards.

Results and Discussion

Physicochemical Parameters

The results of the physicochemical parameters and heavy metal concentrations of soil samples from selected scrapyards collected in Benin City are presented in Table 3. The pH values from soil samples investigated in this study ranged between 6.17 ± 1.17 and 7.81 ± 0.88 indicating that majority of the samples were slightly alkaline. pH is a significant property of the soil that affects solute concentration and absorption in soil. Lee and Saunders opined that alkalinity of soil obtained from dumpsites could be as a result of the sorption of metals in the soil [21]. The least pH was recorded from scrapyard 12 (SY12) while the highest pH was obtained from scrapyard 5 (SY5). These values are similar with the values reported by Osakwe and Otuya and Akpoveta, et al. but higher than the values reported by Tukura, et al. Iwegbue, et al. Ano, et al. and Ovasogie and Ofomaja [22-26]. There was no significant difference in the pH of the most of the soils obtained across the scrapyard locations. But it varied significantly ($p < 0.05$) from the pH of the soil at the control site except at SY11 and SY12. The electrical conductivity (EC) of the scrapyard soil samples analysed ranged from 335.00 ± 60.62 to 2467.33 ± 1708.95µS/cm. The least conductivity level was recorded at SY3 while the highest was recorded in the SY5. These values were similar to that of Adedeji, et al. who reported 1231.25µScm at the Irokosun scrapyard in Mushin Lagos but higher than the findings of Shemang and Akpoveta, et al. who reported 1.75-2.05 µScm/cm and 165-201µS/cm respectively [4,23,27].

Location	pH	EC	NO^-_3	Fe	Zn	Pb	Cr	Cd	Clay	Silt	Sand
		µS/cm	mg/kg						%		
SY1	7.39 ± 0.06^{def}	870.00 ± 225.17^{ab}	14.10 ± 2.60^{b}	1568.33 ± 565.80^{def}	170.83 ± 71.48^{bc}	36.90 ± 5.89^{d}	27.77 ± 1.85^{d}	24.83 ± 2.31^{g}	6.43 ± 0.40^{cde}	3.33 ± 0.75^{defg}	90.23 ± 1.15^{cde}
SY2	7.46 ± 0.04^{def}	830.00 ± 277.13^{ab}	6.89 ± 6.25^{ab}	1436.33 ± 545.02^{cdef}	162.77 ± 57.56^{bc}	34.80 ± 5.54^{cd}	28.97 ± 8.08^{d}	20.53 ± 2.02^{fg}	5.97 ± 0.12^{abcd}	2.83 ± 0.75^{bcde}	91.20 ± 0.87^{defg}
SY3	6.82 ± 0.01b^{cde}	335.00 ± 60.62^{a}	2.18 ± 0.39^{a}	1589.33 ± 380.47^{def}	171.97 ± 52.71^{bc}	27.80 ± 1.91^{c}	23.43 ± 3.75^{d}	20.50 ± 3.29^{fg}	8.27 ± 0.81^{g}	4.00 ± 0.17^{ghi}	87.73 ± 0.64^{a}
SY4	6.76 ± 0.13^{bcd}	364.33 ± 115.47^{a}	1.97 ± 0.38^{a}	1611.00 ± 446.87^{def}	174.90 ± 59.24^{bc}	30.17 ± 1.50^{cd}	24.27 ± 3.87^{d}	19.57 ± 6.12^{cdefg}	6.83 ± 0.29^{ef}	3.63 ± 0.29^{efgh}	89.53 ± 0.58^{bc}
SY5	7.81 ± 0.88^{ef}	2467.33± 1708.96c	44.27 ± 17.72^{d}	739.67 ± 118.36^{b}	82.70 ± 13.34^{ab}	18.30 ± 9.70^{b}	13.77 ± 4.10^{b}	11.40 ± 2.42^{b}	5.77 ± 0.23^{abcd}	2.30 ± 0.35^{ab}	91.80 ± 0.00^{fg}
SY6	6.84 ± 0.42^{bcde}	1656.67 ± 993.04^{bc}	22.27 ± 1.10^{c}	896.33 ± 143.18^{b}	100.33 ± 16.05^{abc}	18.60 ± 5.20^{b}	13.40 ± 0.87^{b}	15.67 ± 2.48^{bcdef}	6.50 ± 0.52^{de}	2.97 ± 0.12^{bcde}	90.53 ± 0.64^{cdef}
SY7	7.31 ± 0.17^{def}	720.00 ± 225.17^{ab}	9.01 ± 0.42^{ab}	1644.33 ± 389.13^{def}	191.53 ± 30.60^{c}	26.90 ± 4.33^{c}	24.27 ± 3.87^{d}	21.23 ± 3.41^{fg}	6.43 ± 0.46^{cde}	3.10 ± 0.17^{bcdef}	90.47 ± 0.64^{cdef}
SY8	7.85 ± 1.08^{f}	1011.33 ± 275.97^{ab}	5.23 ± 1.99^{ab}	1129.67 ± 180.71^{bcdef}	126.43 ± 20.21^{bc}	18.03 ± 2.89^{b}	15.67 ± 2.48^{bc}	14.00 ± 2.25^{bcd}	7.30 ± 0.35^{f}	4.20 ± 0.17^{hi}	88.50 ± 0.52^{ab}
SY9	7.22 ± 0.35^{cdef}	888.00 ± 128.17^{ab}	10.73 ± 1.96^{ab}	1735.33 ± 472.27^{f}	172.37 ± 90.64^{bc}	29.40 ± 4.68^{cd}	26.00 ± 4.16^{d}	22.80 ± 3.64^{g}	6.37 ± 0.40^{cde}	3.40 ± 0.52^{defg}	90.23 ± 0.92^{cde}
SY10	7.16 ± 0.16^{cdef}	850.00 ± 86.60^{ab}	9.23 ± 1.70^{ab}	1679.00 ± 268.47^{ef}	154.63 ± 87.76^{bc}	26.83 ± 4.27^{c}	23.80 ± 3.81^{d}	20.77 ± 3.35^{fg}	6.90 ± 0.17^{ef}	3.20 ± 0.52^{cdef}	89.90 ± 0.69^{cd}
SY11	6.29 ± 0.74^{abc}	1574.33 ± 1118.33^{bc}	5.71 ± 3.65^{ab}	1057.33 ± 169.16^{bcde}	108.37 ± 36.26^{bc}	47.73 ± 1.33^{e}	28.00 ± 8.14^{d}	20.10 ± 3.12^{defg}	5.70 ± 0.35^{abc}	1.83 ± 0.06^{a}	92.47 ± 0.29^{g}
SY12	6.17 ± 1.17^{ab}	1110.33 ± 744.20^{ab}	5.77 ± 4.96^{ab}	1069.67 ± 166.85^{bcde}	119.47 ± 19.11^{bc}	46.27 ± 5.48^{e}	21.20 ± 2.94^{cd}	13.77 ± 4.10^{bc}	6.03 ± 0.12^{bcd}	2.40 ± 0.17^{abc}	91.57 ± 0.29^{efg}
Control	5.71 ± 0.17^{a}	148.00 ± 83.14^{a}	4.14 ± 1.76^{a}	136.67 ± 40.99^{a}	15.43 ± 3.87^{a}	0.27 ± 0.01^{a}	0.14 ± 0.05^{a}	0.41 ± 0.03^{a}	5.28 ± 0.25^{a}	2.43 ± 0.40^{abc}	91.87 ± 0.23^{fg}

Table 3: Mean concentration of the physicochemical parameters and heavy metals of top soil in scrap yards in Benin City. Values are Mean ± SD of triplicates. Different superscripts in the same column indicate significant differences at $p < 0.05$ according to Duncan Multiple Range Test (DMRT). EC Electrical conductivity, NO3- nitrates, Fe Iron, Zn Zinc, Pb, Lead, Cr Chromium and Cd Cadmium.
SY Scrap yard locations.

The observed high electrical conductivity values in the sampled scrapyard soils can be explained by the reactions that could have occurred between acid containing deposits in the yard such as car batteries and some metals from vehicular scraps, resulting in the availability of some soluble inorganic salts in the soils. The EC values of the control soil only varied significantly from soils at SY 5, 6 and 11 at ($p < 0.05$). The nitrate level of the soil ranged from 2.18 ± 0.39 to 44.27 ± 17.72 mg/kg. There were no significant difference between the nitrate content of most of the soil samples from the different scrapyard locations compared to the control sites at $P < 0.05$ except at SY 5 and 6 sites. The nitrate content of soil in this study is higher than those reported by Uba, et al. and Osazee, et al. who reported 4.17 to 11.33 mg/kg and 3.476 to 4.522 mg/kg respectively [11,28].

High nitrate in the soil could be due to the mineralization of nitrogen as a result of organic matter in the soil. The results of the particle size distribution (Table 3) show that the textures of the sampled soils were predominantly sand. The mean sand content of the scrapyard soil ranged from 87.73 ± 0.64 to 92.47 ± 0.29%.

The sand fraction was generally higher compared to the clay and silt fractions. This finding was similar to the study of Osazee, et al. who reported a range of 56.4-70.4%. High percentage of sand on the topsoil could encourage seepage and leaching of major cations and anions to the deeper layers.This findings was however different from that of Ogbonna, et al. (who reported low sand fractions (< 40) from waste dumpsites soils obtained from Port Harcourt, Nigeria [11,28,29].

Heavy Metal Assessment of Scrapyard Soils

The iron content detected from the scrapyard soil samples ranged between 739.67 ± 118.36 to 1679.00 ± 268.47mg/kg. The least mean concentration of iron was detected in SY5 while the highest was detected in SY10. The iron content of the control soils was significantly lower than those of the scrapyard sites ($p < 0.05$) which were directly affected by anthropogenic pressure. The high content of Fe in this study was similar to the findings of Akpoveta et al. 2010 who reported mean concentration of 1411mg/kg for Fe in soils around metal scrap dumps in some parts of delta state, Nigeria. Adefemi, et al. also found that Nigeria soil has is high concentration of Fe content [30].

The Zn content ranged from 82.70 ± 13.34 to 172.37 ± 90.64 mg/kg. There was significant difference ($p < 0.05$) between the Zn concentrations across the sampling site. These values were significantly higher ($p < 0.05$) than that of the control soil and the critical levels of 100 mg/kg for WHO/FAO [31]. The findings of this study is in tandem with the study by Akpoveta, et al. who reported 97.21 mg/kg and Olatunji, et al. with 56.0-4188.0 mg/kg in soils around metal recycling factories in south western Nigeria [23,32]. The Lead content of the analysed scrapyard soils had values ranging from 18.03 ± 2.89 to 46.27 ± 5.48mg/kg. These values were significantly higher than that of the control site (0.27 ± 0.01mg/kg) at $p < 0.05$ and the critical level of 100 mg/kg WHO/FAO.

The high levels of lead in the soils could be attributed to the waste in the scrapyards that originated from point source emitters such as smelters, batteries and leaded gasoline emissions from automobiles. Pb is released into the air during the burning of oil or waste. It combines with rain and particles and enters into the soil where it binds strongly to soil particles and attaches to the upper layer of soil [33].

The Pb content recorded in this study were lower than those of Adie and Osibanjo who reported Pb values varying between 243 and 126000 mg/kg in dry soil obtained from car battery manufacturing plant in Nigeria [34]. The Cr content ranged from 15.67 ± 2.48 to 28.97 ± 8.08mg/kg and showed a highly significantly difference ($p < 0.05$) when compared with the control sites. This could be as a result of anthropogenic activity on the scrapyards. Possible sources of chromium in soils are electronic waste, automobiles, chromium byproducts, ferrochromium slag, or chromium plating baths and leather tanning [35]. However, the values were below the critical level of 100 mg/kg [31]. This finding was similar to that of Adelekan and Alawode who reported in the range of the concentration range reported in this study for the Cr was within the range of values reported 13.15 – 75.55 mg/kg but was different from those of Awokunmi, et al. and Ukpong, et al. who reported higher concentrations of chromium (212.00 – 2020.00 mg/kg, 107.50 - 181.25 mg/kg and 1.00 – 4.50 mg/kg respectively [36-37].

Cadmium values in this study ranged from 11.40 ± 2.42 to 24.83 ± 2.31 mg/kg. The Cd content did not significantly vary across sampling site but were significantly higher ($p < 0.05$) when compared with the mean concentrations of the control site. Increased Cadmium levels in the scrapyards could be due to anthropogenic input such as the dumping of wear of the thread on motor vehicle tyres and incineration of wastes in the scrapyard sites. The Cd content of the sampled soil was lower than the threshold value of 100 mg/kg [31]. The findings in this study were higher than that of Akpoveta, et al. who reported 1.21 to 1.65mg/kg in soil around scrapyards located in different parts of Delta state [23].

Heavy metals are one of the factors which influence organisms in soils [8]. They permeate into the soil environment from a various sources and substantially modify soil properties. As a result they cause a great problem to the ecosystem and people in the environment [39,40].

Contamination Indexes in Scrapyard Soil

The Contamination Factor (CF) of the soil in the study area is presented in Figure 2. The contamination factor was used to determine the contamination status of the scrapyard soils. Generally the results revealed that CF of the heavy metals (Fe, Zn, Pb, Cr and Cd) of soil samples in the studied areas based on the local soil background was indicating very high degree of contamination (CF ≥ 6) except for location SY5 where there was considerable degree of contamination (3≤ *Cf* < 6) for Fe (CF = 5.42) and Zn (CF = 5.40).

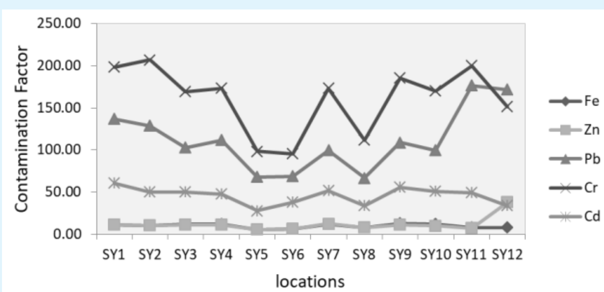

Figure 2: Contamination factor (Cf) of heavy metals in scrapyard soils.

This finding was similar to that of Adedeji, et al. who reported high pollution levels in soil and water around urban scrapyards [4]. Nwaogu, et al. stated that contamination level in soils can be attributed to the influence of human activities and other anthropogenic inputs to the soil [42]. The nature of the waste materials in the scrapyard as well as the optimum physicochemical conditions of the soil controlling the dissolution and precipitation of metals strongly results in the accumulation of metals in the soil [43].

Pollution Load Index (PLI)

The calculated PLI values of the soils ranges from 5.58 to 12.08 (Figure 3) across the sampling sites. Pollution load index (PLI) for soils in this study showed that metal concentration were greater than 1 on the basis of the local soil backgrounds in all the studied sites indicating high contamination by the five metals (Fe, Zn, Pb, Cr and Cd).The soil was contaminated by anthropogenic input from scrapyard activities.

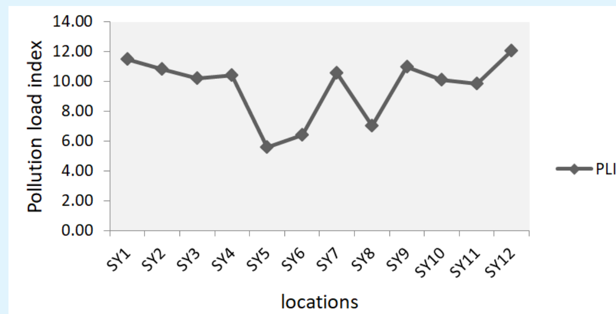

Figure 3: Pollution load index (PLI) of heavy metals in scrapyard soils.

Correlation Analysis for the Physicochemical and Heavy Metal Variables

Pearson correlation analysis for the heavy metal variables is shown in Table 4. The result shows that the association among pH and heavy metals (Fe, Zn, Pb, Cr and Cd) in this study was weakly positive. This shows that increase in soil pH leads to a slight increase in the levels of these metals in the scrapyard soils. Zhao, et al. stated that the dissolution of heavy metals is influenced by soil pH [43]. Decrease in soil pH may be cause increased solubility and high availability of heavy metals for plant roots, while increase in pH result in accumulation of heavy metals in soil.

	pH	Fe	Zn	Pb	Cr	Cd
pH	1.000					
Fe	0.455**	1.000				
Zn	0.283*	0.946**	1.000			
Pb	0.528**	0.613**	0.584**	1.000		
Cr	0.463**	0.762**	0.715**	0.799**	1.000	
Cd	0.185	0.876**	0.818**	0.708**	0.909**	1.000

Table 4: Correlation between pH and heavy metal variables in top soil of scrap yards.
**. Correlation is significant at the 0.01 level (2-tailed).*.

Fe positively correlated with Zn, Pb, Cr and Cd (r = 0.946, 0.613, 0.762 and 0.876) at $p < 0.01$ significant level. Zn showed a positively strong correlation with Cr and Cd (r = 0.715 and 0.818) but weak positive correlation with Pb (r = 0.584) at $p < 0.01$. Pb correlated positively with Cr and Cd (r = 0.799 and 0.708) while Cr strongly and significantly correlated with Cd (r = 0.909) at $p < 0.01$ significant level. Generally, the correlation matrix (Table 4) showed strong positive association among the analysed metals. This finding is the same as the report of Khudhur, et al. and Stanley, et al. who reported positively strong correlation between metals in soil around steel and cement company [44,45]. Rahman, et al. stated that a strong positive association between metals in soil is an indication that they may have originated from the same anthropogenic sources [46].

Conclusion

The current study revealed that soil samples from scrapyards across Benin City showed higher concentration of metals (Fe, Cd, Zn, Cr, and Pb) when compared with the content of metals in soils obtained from the control site. The concentration of heavy metals was above the critical level of 100 mg/kg (WHO/FAO) except for Cr and Cd. This suggested that the scrapyards could pose environmental and health threat to the nearby residents. Calculated contamination indexes (contamination factor and pollution load index) of the scrapyard soils showed that the soils samples from all the locations were highly contaminated with the assessed heavy metals. Generally, there were strong positive associations among the studied metals which may indicate that the metals are from identical source, and may have originated from anthropogenic sources. Further pollution of these sites could be averted by the evacuation of existing scrap wastes for recycling and enactment of appropriate laws which prevents the utilization of land in residential areas as scrapyards in the city.

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Conflicts of interest: The authors declare that they have no conflict of interest.

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