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ASSESSMENT OF HEAVY METALS IN SOILS FROM METAL RECYCLING COMPANIES IN ILE-IFE AND IKIRUN, OSUN STATE, NIGERIA.

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Abstract

This study was conducted to assay the levels of six heavy metals (Cd, Cr, Cu, Fe, Mn & Zn) in soil samples from two metal recycling companies in Osun state using Flame Absorption Spectrophotometer 400 (FAAS). The results obtained showed the levels of these elements within the range of 0.32-1343.00 mg/kg in the order of magnitude Fe>Zn>Cu>Mn>Cr>Cd recycling sites and 0.00-456.65 mg/kg in the control. Using SPSS 17 ($t<0.05$), the elemental levels (except Zn) of soils from the sites were significantly higher than the control. Cd, Cu and Zn were also found higher while Cr and Fe were within the maximum permissible limits recommended by WHO/FEPA for soil meant for cultivation of crops and agriculture.

1.0 Introduction

Soil is defined as a reactor, transformer and integrator of material and energy from other natural resources (solar radiation, atmosphere, surface and subsurface waters, biological resources), storage of water, nutrients and heat, natural filter and a medium for biomass production, past and present human activities [1,2,3]. It a basic component of ecosystem and also one of the most vulnerable to contamination and degradation through accidental or deliberate mismanagement. Anthropogenic activities such as essentially inadequate agricultural and forestry practices, tourism, urban and industrial sprawl are named as the main impacting factors that prevent the soil from performing to its full capacity leading to soil degradation. Soil degradation can cause decline in soil fertility, carbon and biodiversity; lower water retention capacity, disrupt gas and nutrient cycles and reduce degradation of contaminants particularly metals [2]. Other sources include the use of metal containing agricultural sprays or soil amendments, disposal of wastes from mines or mills, emissions from large industrial sources such as metal smelters and refineries, municipal incinerators, emissions from moving sources principally automobiles and other relatively minor sources of terrestrial contamination like small-scale industries that process metals. Recycling scrap metals amongst all involves processes like collection, sorting, shredding, bailing and melting as well as fabrication. It requires significantly less energy than manufacturing new metals from virgin ore, reduces greenhouse gas emissions substantially and helps in conserving natural resources. Despite all these merits or environmental benefits, pollutants or toxic materials could be released from the plant into the environment thereby contaminates surface soil or in-fill material, surface and ground water, air, vegetation and could also be devastative to the existing buildings in the site [4]. It is important to have qualitative and quantitative data on heavy metals in soil used by a population for agricultural proposes. This is because heavy metals may pose health risk when they accumulate in the human body. The present study has produced a statistical data of heavy metal content of soil samples from the two metal recycling companies in Osun state, Nigeria. The data from this study might be used by the authorities to monitor and control the metal contamination in the soil within these locations.

2.0 Materials and methods

2.1.0 Study area

The two metal recycling companies studied in this work lie within the tropical zone with latitude 07°55′ N and longitude 04°41 ′E as well as longitude 4°

69′E and latitude 70° 50′ N respectively. The indigenes are predominantly farmers cultivating crops within and outside the town.

2.1.1 Sample collection

Sampling was carried out at the only two metal recycling companies (Ile- Ife and Ikirun) in Osun state. Twenty four (24) soil samples were collected in all. Sixteen (16)-Four (4) clay and 4 loamy soils from each site and 8 identical samples were also collected as control behind Obafemi Awolowo University (OAU), Ile-Ife conference centre (where no anthropogenic activity that could cause contamination takes place). The samples were collected using clean stainless steel material. The soil samples were collected (0.3 m deep), thoroughly mixed and transferred into clean and labelled polythene bags for onward analysis at OAU Central Science Laboratory,

2.1.2 Sample preparation and digestion procedure

A mass of 0.5 g of each soil sample was put on a glossy paper and transferred into new pre-treated graduated plastic tube. The tube was put inside the fume cupboard where 3 ml of nitric acid (HNO_3) and 1 ml of hydrofluoric acid (HF) were added and sealed (respectively). The test tube was heated for 2-3 hrs at 68 ^oC until complete digestion was achieved. After digestion, the tube was allowed to cool to room temperature for a few hours and the sample was diluted to 50 ml with 4 % boric acid to dissolve CaF_2 precipitate and to remove HF acid. A colourless solution was obtained after complete dissolution of CaF_2 by [9]. Blank was also prepared and analyzed using the sameprocedure. The concentrations of the metals were determined by Flame Atomic Absorption Spectrometry (FAAS) using “Buck Scientific 200A” by flame atomization.

2.1.3 Quality assurance

Quality assurance was guaranteed through double measurements and the use of blanks for correction of background and other sources of error. Standards were prepared for the six elements determined and analyzed by the equipment used before running the samples. The high correlation coefficients (0.999172-0.999895) obtained in the calibration curves for the elements indicated proper calibration and the reliability of the results presented in this work.

3.0 Statistical Analysis

The data obtained were subjected to descriptive statistical analysis such as mean, standard deviation, t-test and analysis of variance using SPSS 17.

4.0 Results and discussion

Eight heavy metals (Ca, Cd, Cr, Cu, Fe, Mg, Mn, Zn) were detected and quantified in soil samples from the sites. Table 1 gives the descriptive statistics of the levels of these heavy metals in the samples while Table 2 depicts the comparison of the levels of these heavy metals (mg/kg) with WHO/FEPA limits as reported by Offiong et al [6]. The summary of the t-test results and enrichment factors are presented in Tables 3 and 4 respectively.

The data showed the presence of these elements within the range (0.32 -1343.00 mg/kg) in recycling sites and (0.00 - 456.00 mg/kg) in the control. In most cases, the concentrations of Cd and Cr in control were below the detection limits. The comparative analysis indicated that samples from the sites were slightly enriched in Cu except loamy soil in site 1 (Table 4) among other elements.

Table 1: Descriptive statistics of the concentration of elements in soils from the sites and control (mg/kg)

Location	Sample Descript.	No		Cd	Cu	Fe	Mn	Cr	Zn
			Range	0.33-0.53	286.00-290.00	841.00-951.00	139.00-161.00	0.32-16.55	544.00-744.00
	Clay	4zx	Mean + SD	0.40±0.10	288.00±1.34.00	870.00±53.70	147.00±9.81	4.14±0.81	636.00 ±82.00
			Range	2.53-5.50	190.00-281.00	1121.00-1343.00	539.00-594.00	16.56-18.85	647.00-892.00
Site 1	Loamy	4	Mean + SD	3.57±1.32	230.00±43.00	1212.00±105.00	560.00±25.00	13.18±1.34	737.00 ±114.00
		4	Range	1.59-1.93	314.00-335.00	883.00-953.00	138.00-142.00	0.52-16.42	643.00-683.00
	Clay	4	Mean + SD	1.76±0.16	322.00±9.43	913.00±30.00	140.00±1.60	4.12±0.65	662.00 ±16.80
			Range	2.00-4.25	279.00-283.00	1018.00-1036.00	474.00-492.00	ND	621.00-633.00
Site 2	Loamy	4	Mean + SD	2.91±1.05	281.00±1.79	1027.00±7.69	482.00±7.29	ND	363.00 ±61.40
			Range	ND	32.10-37.20	159.00-163.00	149.00-154.00	ND	292.00-400.00
	Clay	4	Mean + SD	ND	35.00±2.60	161.00±2.10	150.00±3.11	ND	362.00 ±61.40
Control			Range	ND	32.10-36.20	163.00-167.00	149.00-153.00	ND	451.00-456.65
	Loamy	4	Mean + SD	ND	33.80±2.13	165.00±1.96	151.00±2.40	ND	454.00 ±2.25

Table 2: Comparison of WHO (1984) / FEPA (1991) limits with the results obtained

	Site A (mean conc. mg/kg)		Site B (mean conc. mg/kg)		Control (mean conc. mg/kg)		
Elements	Clay	Loamy	Clay	Loamy	Clay Control	Loamy Control	WHO(1984)/FEPA(1991) maximum permissible limits (mg/kg) [6].
Cd	0.40	3.57	1.76	2.91	ND	ND	0.006
Cr	4.14	13.18	ND	ND	ND	ND	5-1000
Cu	286.00	230.00	322.00	281.00	35.00	33.80	2-100
Fe	870.00	1212.00	913.00	1027.00	161.00	165.00	10,000-100,000
Mn	147.00	560.00	140.00	482.00	150.00	151.00	NG
Zn	636.00	737.00	662.00	363.00	363.00	454.00	10-300

NG=Not given

Table 3: T-test result

Sample location	Sample description	Ca	Cd	Cu	Fe	Mg	Mn	Cr	Zn
Site 1 (Ile-Ife)	Clay	0.0001 (S)	0.0009 (S)	0.0001 (S)	0.0001 (S)	0.0001 (S)	0.60 (NS)	0.45 (NS)	0.0048 (S)
	Loamy	0.0001 (S)	0.006 (S)	0.0006 (S)	0.0001 (S)	0.0001 (S)	0.0001 (S)	0.053 (NS)	0.0084 (S)
Site 2 (Ikirun)	Clay	0.0001 (S)	0.0001 (S)	0.0001 (S)	0.0001 (S)	0.0001 (S)	0.25 (S)	0.44 (NS)	0.0002 (S)
	Loamy	0.0001 (S)	0.0053 (S)	0.0001 (S)	0.0001 (S)	0.0001 (S)	0.0001 (S)	NS	0.0001 (S)

NOTE: S= Significant (t < 0.05) NS = Non-significant (t >0.05)

The enrichment factor of each element was also determined using crustal values and Fe as reference. The enrichment factor (E.F) is given as

$$EF = \frac{x\ /[concofFe]_{sample}}{y\ /[concofFe]_{control}} \qquad (2)$$

Where X= Concentration of each element in the sample, Y= Concentration of the same element in reference/control [5].

Table 4: Enrichment factors

Sample	Element	Enrichment factors	Comment
SOIL	Cu (except loamy soil in site 1)	1.25-1.71	Slightly enriched
	Cd, Cr, Mn and Zn	0.17-0.53	Not enriched

Note: E.F < 1 = Not enriched, E.F (Between 1 and 10) = slightly enriched, E.F> 10 = Enriched.

Fe was used as normalizing element and therefore not necessary to calculate its enrichment factor. However, from t-test results, significant differences were observed (t < 0.05 i.e between 0.0001 and 0.0084) between the levels of these heavy metals and control except Cr. This indicated that the concentrations of heavy metals in sites considered were significantly higher than the control (Table 3). However, no significant difference exists in the levels of chromium in soil samples from the sites and control. The concentrations of Ca and Cu were significantly higher in clay soil than loamy while Cd, Fe, Mg and Mn were significantly higher in loamy soil than clay (t < 0.005). This suggested that the absorption of heavy metals do not depend only on soil type or nature but also vary according to the metals and other factors. The higher values obtained in mean concentrations of these heavy metals in soil samples from the sites than control could also be an indication of contamination of soil by this anthropogenic activity since no other activities that could result into increase in concentration takes place in the locations. Figures 2 and 3 show the frequency distribution of the observed concentrations of these heavy metals in the sites 1 and 2 relative to control respectively.

Heavy metals Cd, Cu and Zn in the soil samples from the metal recycling sites were above the WHO/FEPA recommended limits for soil meant for agriculture while Cr and Fe were within the recommended limits-Table 2) [6].

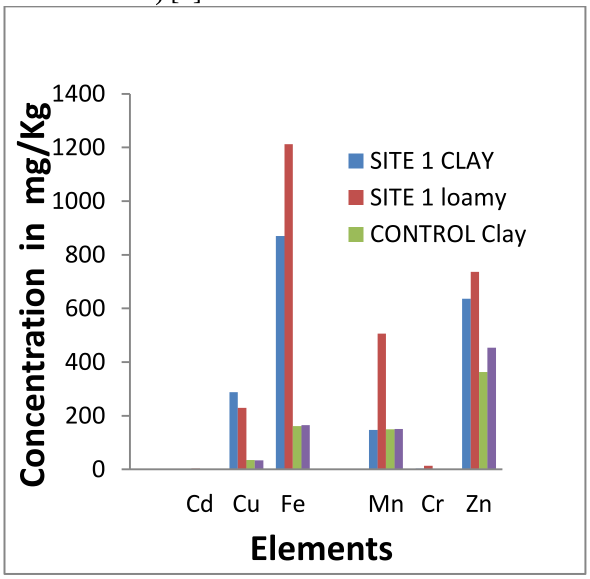

Figure 2: Frequency distribution of heavy metals in soil samples from metal recycling site 1 and control site.

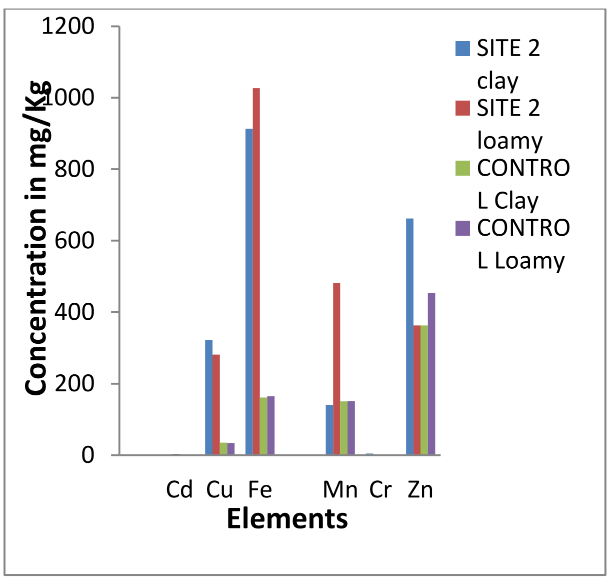

Figure 3: Frequency distribution of heavy metals in soil samples from metal recycling site 2 and control site.

5.0 Conclusion

From this work, it has been established that metal recycling operation has given rise to a significant increase in concentration of some of these heavy metals examined using Flame Atomic Absorption Spectrometry (FAAS). The heavy metals determined were in the order of magnitude Fe>Zn>Cu>Mn>Cr>Cd. Soil samples from the sites were significantly higher in Cd, Cu, Cr, Fe, Mg and Mn relative to the control ($t<0.05$-table 3). Cd, Cu and Zn were also found higher than the maximum permissible limits recommended by FEPA(1991)/WHO(1984) as reported by [6] for soil meant for cultivation of crops and agriculture while the levels of Cr and Fe were within.

It should however be noted that even if the concentrations of these heavy metals are below the recommended limits, they could still pose risks to soil, plants and human life. Heavy metals are absorbed by the plants and may result in bio-concentration or bio-magnification in living organisms and plants through the food web. The bioaccumulation of these metals in body or flesh could decrease the body's ability to metabolize and also leads to diseases.

Soil and crop management methods can help to prevent uptake of these pollutants by plants from soil. The soil becomes the sink, breaking the soil-plant animal or human cycle through which the toxin exerts its toxic effects [7].

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