

Analysis of Heavy Metals and Some Physicochemical Parameters in Soil of Major Industrial Dumpsites in Akure Township, Ondo State of South Western Nigeria

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Abstract

Heavy metals and soil physicochemical parameters were identified as environmental pollutants in some major industrial dumpsites in Akure city of Ondo-State. The pH of the industrial dumpsites ranged from 4.87 to 6.74 with a mean value of 6.34. The organic carbon for the industrial dumpsites ranged from 0.07% to 0.97%, while the organic matter was between 0.13% and 1.68%. The concentration of Zn, Fe, Cu, Pb, Cd, Ni and Cr in $\mu\text{g/g}$ in all the industrial dumpsites A, B, C ranged between 237.60 – 486.00, 174.40 – 499.20, 18.00 – 114.00, 20.60 – 249.20, 1.06 – 2.65, 30.26 – 70.58, and 30.50 – 68.08 respectively. Also the contamination/pollution index of Zn, Fe, Cu, Pb, Cd, Ni, and Cr all the industrial dumpsites. A, B, C ranged between 1.69-3.47, not detected, 0.50-3.17, 0.24-2.53, 1.33-3.23, 0.86-2.01, and 0.31-0.68 respectively Pearson Correlation indicated that Fe, Zn, Ni and Pb were highly significant ($p < 0.01$).

Keywords: heavy metals, physicochemical parameters, pollutants, dumpsites

1. Introduction

Akure city lies between latitude $7^{\circ}17'N$ and longitude $5^{\circ}16'E$ in the southwestern part of Nigeria. The ancient urban city has experienced increase in population and industrial activities in the last few decades since it has become the capital of Ondo state. In order to meet up with man's daily needs, a lot of industries were established in the state capital from which quantities of solid wastes are generated from industrial activities. These extensive industrial activities in the city have led to the re-developing of dumpsites covering an expanse of land for industrial purposes (Adefemi, Awokunmi, 2009). Therefore the level of heavy metals and some physicochemical parameter in the dumpsite soil are assayed. Soil is known to be the product of climate and living organism on rocks, and its nature is determined by the composition of parent rocks, type of climate and its age. It is essential to human because it is the top layer of the earth in which all the living things both plant and animals directly and indirectly take their food (Adefemi, Awokunmi, 2009).

Heavy metal is a member of a loosely defined subsets of element that exhibit metallic properties with relative high atomic weight, density and with a specific gravity of 5.0 or greater (Ademoroti, 1996). Heavy metals have been known to disrupt ecosystem structure and functioning for a long time. They are present as part of biogeochemical framework and as an essential trace elements for way life forms but above certain concentration are toxic to species. The negative effect of heavy metals depend on the concentration as well as on series of physical and chemical soil specific characteristics such as texture, organic matter content, pH, redox potential and hydraulic conductivity etc.

The indiscriminate dumping of waste has become a common practice, and the composition of industrial waste dumps varies widely with many industrial & human activities located near the dumpsites. Hence the health risk due to heavy metals contamination cannot be overemphasized, and is widely reported (Baker et al. 2000, Duruibe et al., 2007). Therefore the aim of this study was to determine the levels of heavy metals and some

physicochemical parameters in soil of major industrial dumpsites in Akure township, the capital of Ondo-State of South Western Nigeria.

2. Materials and Methods

2.1 Sampling and Sample Collection

Soil samples within the depth of 0-15cm, 15-30cm, and 30-45cm were taken with the aid of an auger from the 3 different major dumpsites (Table 1) by Alter (Alter, N. 1989) method. The collected soil sample was carefully transferred into a black polythene bags, properly labelled and transported to the laboratory.

2.2 Sample Preservation

Samples were air-dried for about two weeks and sieved to 2 mm by mesh to prevent chemical microbial changes and to remove large mineral inclusions and organic debris. The sieved samples were stored in labelled polythene bags and used for subsequent analysis.

2.3 Metal Determination

The air-dried sample was pulverized by pounding it in a mortar. About 1g was weighed for each sample into 250ml conical flask, 25ml of the acid mixture was poured on 1g of the sample and was heated on the hot plate for about 30 minutes. After heating, it was allowed to cool for about 25 minutes. The solid was filtered using Whatman filter paper. The volume of the digest was diluted to 100ml with distilled water in a standard flask and was analyzed for heavy metals using the atomic absorption spectrophotometer (AAS).

2.4 Organic Carbon

The Walkey-Black (A. Walkey and I A. Black 1984) method was used in the determination of organic in the soil. 2g of sieved soil was weighed out accurately into conical flask depending on the organic carbon content of the soil which could be estimated from the colour and finesse of such soil samples. 10ml of 1N $K_2Cr_2O_7$ standard solution was added to the soil followed by 20ml of concentrated H_2SO_4 to prevent the interference of chloride ions. The system was allowed to stand for 30 minutes with occasional swirling. After 30 minutes the content of the conical flask was diluted with 10ml of distilled water.

The excess $K_2Cr_2O_7$ was determined by titrating with standard 1.0 N ferrous sulphate solution using ferroin as indicator. The blank titration was carried out in the same manner without the soil.

2.5 Calculations

The percentage organic carbon (air-dried basis) was calculated as follows:

$$\% \text{ organic carbon} = \frac{(M_e K_2Cr_2O_7 - M_e FeSO_4) \times 0.003 \times 100 \times F}{\text{Weight of Soil (g)}}$$

M_e = Normality of solution \times Volume (ml) of solution used

F = correlation factor = 1.33

% organic matter in soil = organic carbon \times 1.729

2.6 Soil pH

The pH of the soil sample was determined with a pH meter, model: Kent EK 7020 according to the method of Mclean [E.O. Mclean 1996].

3. Results and Discussion

Table 1 shows the sample site, the location of the dumpsite, type and the period that the site had been in existence.

Table 1. Industrial dumpsites locations within Akure metropolis.

Sample site	Location of dumpsite	Type	Year of existence
Site A	Mechanical workshop, opposite Michelin tyre Depot, Ilesha-Road, Akure.	Industrial dumpsite	18 years
Site B	Welding and metal workshop, near Fanibi junction, Ondo Road, Akure.	Industrial dumpsite	15 years
Site C	Mechanical / welding workshop near TISCO disinfectants manufacturing company Supermarket, Ado-Ekiti Road, Akure	Industrial dumpsite	15 years

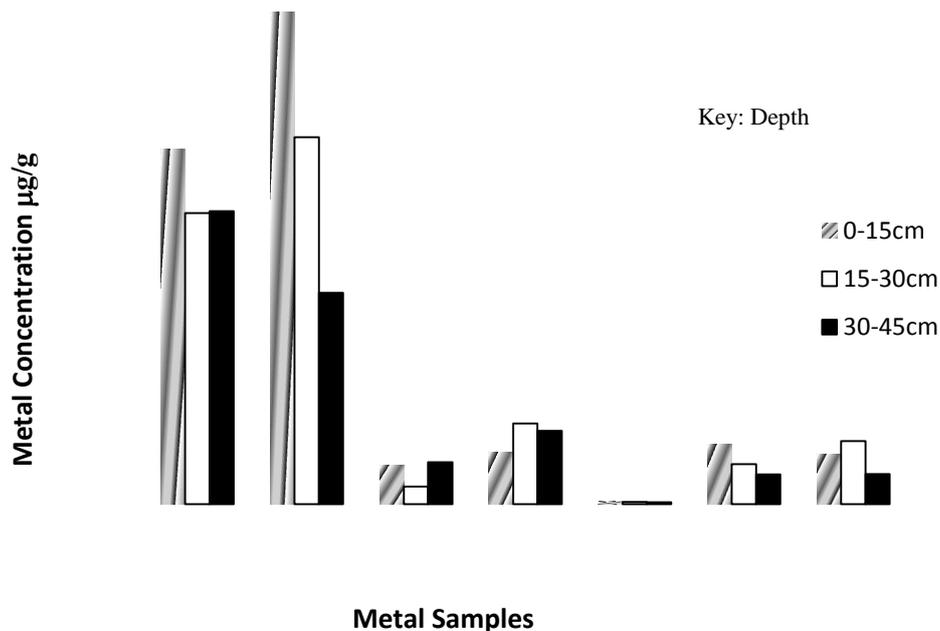
The variation of percentage organic matter with depth in site A was revealed in Table 2. The percentage organic matter which depends on organic carbon is highest at depth 0-15cm with a value of 1.68% and least at depth 30-45cm with 0.80% value. This is attributed to the fact that the top soil usually contains more plant residue and vegetation leading to greater plant productivity than lower layers of the soil. These values compare well with similar work done in Industrial Estate of Lagos-State (Ikuyajesin, A. K. 2002).

Table 2 also shows the variation of pH with depth of soil. The pH is least and with a value of 6.54 at 0-15cm depth and highest with the value of 6.70 at 15-30cm depth which is consistent with similar work done at some industrial sites in Akure (Oguntimehin, I. 2002).

Table 2. Percentage organic matter / organic carbon and pH value in site A.

Depth (cm)	Organic Matter Percentage	Organic Carbon Percentage	pH
0-15	1.68 %	0.97%	6.54
15-30	1.20%	0.69%	6.70
30-45	0.60%	0.35%	6.65

Fig. 1 shows the variation of metal concentrations with depth in site A. The concentration ranges from 2.20 $\mu\text{g/g}$ at 30 – 45cm depth to 499.20 $\mu\text{g/g}$ in Fe at a depth of 0 – 15cm. It was observed that the concentration of some metals like Fe, Zn, Ni, Pb and Cr were higher than that of Cu and Cd. Iron (Fe) was expectedly high in this area than other metals due to the proximity mechanical workshop. The high values of Fe, Zn, Ni, Pb and Cr in the soil sample from these mechanical operation activities contributed significantly to the concentration levels of the metals. The very high value for Fe was also observed in a related study by Abata et al (2013) evaluated the level of heavy metals like Cd, Cr, Fe, Ni, Pb and Zn in the sediments of Ala Rivers that runs through Akure metropolis.



Figures 1. Variation of Metal Concentration with Different In Soil in Site A

Table 3 shows the variation of organic matter with depth and pH value for industrial dumpsites B. The values range from 0.24 to 0.58%. It was observed that the percentage organic is highest with a value of 0.58 at 0-15cm depth and least with a value of 0.24 at 30-45cm depth. Table 3 also presents the variation of soil pH with depth for site B. The pH ranges between 6.20 and 6.73. It was observed to be least at the depth 15-30cm with a value of 6.20 and highest at the depth 0-15cm with a value of 6.73.

Table 3. Percentage organic matter/organic carbon values for soil in site B (Industrial dumpsite.)

Depth (cm)	Organic Matter Percentage	Organic Carbon Percentage	pH
0-15	0.58 %	0.33 %	6.74
15-30	1.42 %	0.24 %	6.20
30-45	0.24 %	0.14 %	6.45

The variation of metal concentration with different depths industrial dumpsites B were given in Figure 2 metal concentrations ranges between 1.6 $\mu\text{g/g}$ in Cd at a depth 30 – 45cm to 486 $\mu\text{g/g}$ in Zn at a depth of 0 – 15cm. In this dumpsite, the level of heavy metals like Zn, Fe, Cu, Pb, Cd, Ni and Cr were evaluated in the soil samples. The high values for Zn, Fe, Ni and Cu may be due to the nearness of the dumpsite for Zn and Fe were also observed in a similar study by Ogunmodede et al, (2013) who investigated the heavy metal and microbial loads of some dumpsites soil in Ado-Ekiti and Ijero-Ekiti.

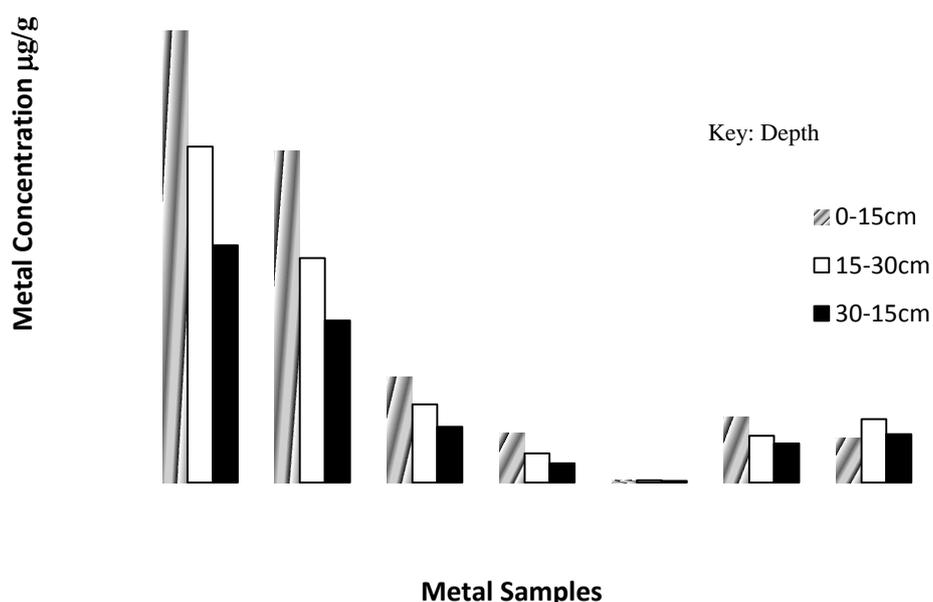


Figure 2. Variation of Metal Concentration with Different Depth in Soil Site B

Table 4 reveals the percentage organic matters/organic carbon and pH values for organic soil in site C. The percentage organic matter ranges from 0.13% to 0.58%. It is highest at depth 0-15cm depth with a value of 0.58% and least at depth 30-45cm with 0.13% value which may be attributed to the fact that top soil usually contains more plant residue and vegetation. Table 4 also shows the variation of pH with the depth of soil. The pH is least and with a value of 6.64 and 0-15cm depth which is similar to work done in a particular industrial dumpsite in Akure.

Table 4. Percentage organic matter / carbon and pH values for soil site C.

Depth (cm)	Organic Matter Percentage	Organic Carbon Percentage	pH
0-15	0.58 %	0.33 %	6.64
15-30	0.32 %	0.18 %	6.23
30-45	0.13 %	0.07 %	4.87

Figure 3 shows the variation of metal concentration with depth in industrial dumpsites C. The concentration of the metals ranges from 1.06 $\mu\text{g/g}$ in Cd at a depth 15 – 30cm to 424.80 $\mu\text{g/g}$ in Zn at a depth 0 – 15cm. High values of Zn, Fe, Pb and Cu may be due to the proximity of mechanic, battery charger and welding metal workshops around the dumpsites area.

Pearson correlation indicated that Fe, Zn, Ni and Cr were highly significant ($p < 0.01$), suggesting the anthropogenic courses of these metals in the dumpsites soil under study.

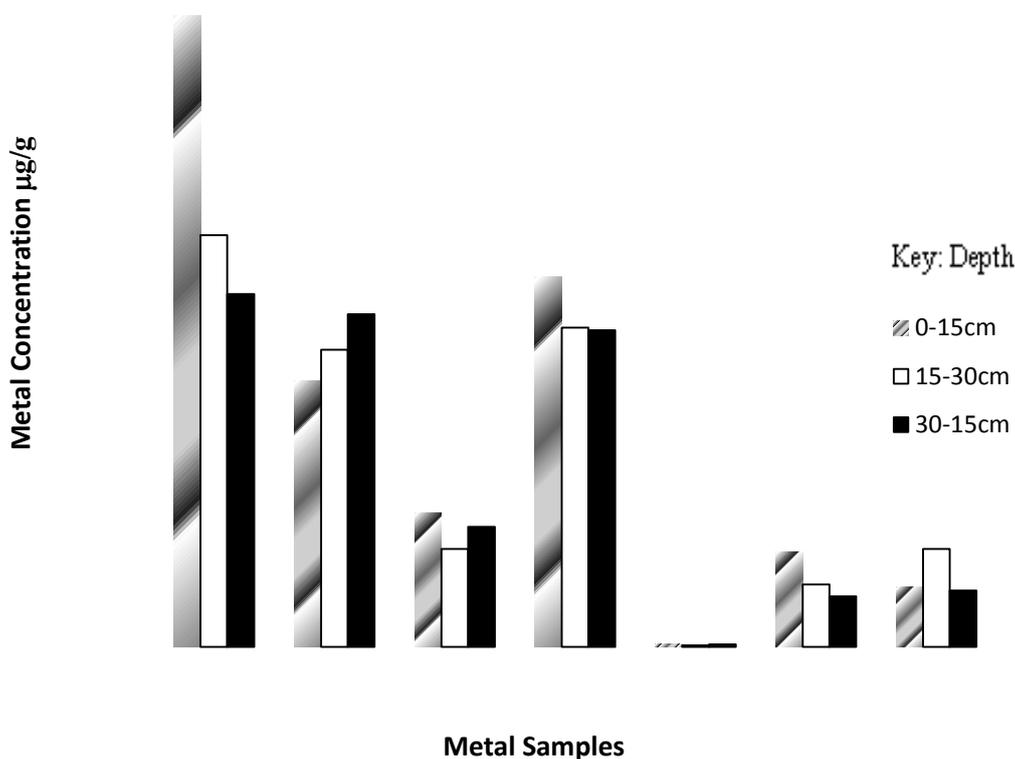


Figure 3. Variation of Metal Concentration with Different Depth in Soil Site C

Table 5 reveals the maximum allowable limit (M.A.I) for heavy metals concentration (mg/kg) use in Nigeria as set by the department of petroleum resources (DPR) in 1991.

Table 5. Values of maximum allowable limits (M.A.L) for heavy metals in soil (mg/kg) used in Nigeria.

Metals	Target value (mg/kg)	Intervention values (mg/kg)
Barium	200.00	5000.00
Cadmium	0.80	17.00
Chromium	100.00	380.00
Copper	36.00	190.00
Mercury	0.30	10.00
Lead	85.00	530.00
Nickel	35.00	210.00
Zinc	140.00	720.00
Cobalt	20.00	240.00

Source: DPR Guidelines (1991)

Table 6 reveals the contamination / pollution index for site A, B, C while Table 7 shows the significance of intervals of contamination/pollution index as reported by Department of Petroleum Resources (DPR, 1991). At a depth of 0-15cm, the pollution index values 2.57, 1.08, 3.23 and 1.74 for Zn, Cu, Cd, and Ni respectively exist at the level of pollution while the pollution index values 0.62 and 0.50 for Pb and Cr respectively exist at the level of contamination. At a depth of 15-30cm, the pollution index values 2.10, 2.28, and 1.16 for Zn, Cd, and Ni respectively confirmed the presence of the elements at pollution levels while 0.50, 0.96, and 0.64 for Cu, Pb, and Cr confirmed the presence of element at contamination levels. At a depth of 30-45cm, the values 2.12, 1.18, and 2.76 for Zn, Cu, and Cd respectively confirmed their presence at pollution level while values 0.88, 0.86, and 0.31 for Pb, Ni, and Cr confirmed their presence at contamination level.

The contamination/pollution index for industrial dumpsite B. at site B, at depth of 0-15cm, shows that Zn, Cu, Cd, and Ni with values 3.47, 3.17, 2.85, and 2.01 respectively were present at the level of pollution while Pb and Cr with values 0.62 and 0.48 respectively were present at contamination level. At depth 15-30cm Zn, Cu, Cd, and Ni with values 2.58, 2.33, 2.85 and 1.43 are present at pollution level while Pb and Cr with values 0.37 and 0.68 are present at the level of contamination. At the depth 30-45cm, Zn, Cu, Cd, and Ni with values 1.83, 1.67, 2.02, and 1.20 respectively are pollutants while Pb and Cr with values 0.24 and 0.52 respectively are contaminants.

Also, table 6 reveals the contamination/pollution index for industrial dumpsite C. At site C at a depth of -15cm, the pollution index values 3.03, 2.50, 2.53, 2.69, and 1.83 for Zn, Cu, Pb, Cd, and Ni respectively confirmed the presence of the elements at pollution levels while the value 0.41 for Cr confirmed its presence at contamination level. At a depth 15-30cm the pollution index values 1.98, 1.83, 2.50, 1.33, and 1.20 for Zn, Cu, Pb, Cd, and Ni respectively are pollutants while Cr exists at contaminants. At a depth of 30-45cm the pollution index values 1.69, 2.25, 2.50, 2.28 for Zn, Cu, Pb, and Cd respectively confirmed the presence of the elements at pollution levels while the value 0.97 and 0.08 for Ni and Cr confirmed the presence at contamination level.

Table 6. Contamination / Pollution (C/P) values for metals in sites A, B, C

	Depth (cm)	Zn ²⁺	Fe ²⁺	Cu ²⁺	Pb ²⁺	Cd ²⁺	Ni ²⁺	Cr ²⁺
Site A	0-15	2.57	0.00	1.08	0.62	3.23	1.74	0.50
	15-30	2.10	0.00	0.50	0.96	2.28	1.16	0.64
	30-45	2.12	0.00	1.18	0.88	2.76	0.86	0.31
Site B	0-15	3.47	0.00	3.17	0.62	2.85	2.01	0.48
	15-30	2.58	0.00	2.33	0.37	2.85	1.43	0.68
	30-45	1.83	0.00	1.67	0.24	2.02	1.20	0.52
Site C	0-15	3.03	0.00	2.50	2.53	2.69	1.83	0.41
	15-30	1.98	0.00	1.83	2.50	1.33	1.20	0.66
	30-45	1.69	0.00	2.25	2.50	2.28	0.97	0.38

Table 7. Significance of intervals of contamination/pollution index

C/P	Significance	Symbol
<0.1	Very Slight Contamination	v.s.c.
0.10-0.25	Slight Contamination	s.c.
0.26-0.50	Moderate Contamination	m.c.
0.51-0.75	Severe Contamination	s.c.
0.76-1.00	Very Severe Contamination	v.s.c.
1.10-2.00	Slight Pollution	s.p.
2.10-4.00	Moderate Pollution	m.p.
4.10-8.00	Severe Pollution	s.p.
8.10-16.00	Very Severe Pollution	v.s.p.
>16.00	Excessive Pollution	e.p.

Source: DPR guidelines (1991).

4. Conclusion

All the soil sites are heavily polluted with metals and the highest multiple pollution values was found with site C which has the value of 32.56 while the industrial site B is the least polluted with a multiple pollution value of 25.49. The fact that the highest observed value is from site C is exciting and might be due to everyday industrial activity that goes on around the site. The mechanics and the workers in the disinfectant manufacturing industry normally dispose their industrial waste every day.

All the metals except chromium have concentrations above the Nigerian target value as published by the Department of Petroleum Resources (DPR) in Nigeria (1991) but with none of the values reaching the intervention value.

5. Recommendation

Since all the soils have metal concentrations above the target values, (except chromium). It is therefore recommended that soil remediation techniques (Chaudri, A.M. 2001) should be carried out on all the dumpsites sampled in this research work.

Government should discourage the indiscriminating sitting of mechanics, welding workshops, and manufacturing company in places where wastes could not be centrally collected and reprocessed in an environmentally sound manner.

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