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HEAVY METALS IN TOP SOILS OF ABEOKUTA DUMP SITES

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ABSTRACT

The concentrations of copper, zinc, cadmium, lead and iron in top soils of refuse dump sites in Abeokuta were determined in order to assess the contribution of refuse in the dump sites to environmental pollution. Twenty soil samples were collected from twenty dump sites each of which was about 100 metres away from a control site.

Study samples and controls were pre-treated, digested and analysed using flame atomic absorption spectrophotometer. Results show that the range of copper was 65.77 - 634.30 mg/kg; iron 289.30 - 360.10 mg/kg; lead: 5.52 - 145.80 mg/kg; zinc: 100.80 - 226.60 mg/kg and cadmium: 4.65 - 50.50 mg/kg in the refuse dump sites while the control sites had a range of 0.76 - 4.54 mg/kg for copper, 3.04 - 77.06 mg/kg for iron, 0.81 - 13.07 mg/kg for lead, 51.25 - 71.43 mg/kg for zinc and 0.81 - 3.64 mg/kg for cadmium.

The large difference between the results obtained for refuse dump site and control site are statistically significant, indicating that the refuse dump sites are sources of environmental metal pollution. It is recommended that indiscriminate dumping of refuse be discouraged

INTRODUCTION

The world is undergoing a silent epidemic of environmental metal poisoning from the ever increasing amount of metals being introduced to the biosphere (Alloway, 1990). Pollution by heavy metals occurs largely from industrial, domestic and agricultural wastes as well as from combustion of fossil fuels by automobiles and industries. In Nigeria and many third world countries, domestic wastes and in some cases, wastes from small-scale industries are deposited in refuse dumps. The composition of these dumps varies from site to site and depends on the peculiarities of the neighbourhood.

A typical dump consists of leaves, plastics, discarded cans, tins, pails, motor and machine parts in various stages of corrosion, rags and textiles, dry-cell batteries, paper, cardboards, wood and plants, etc. (Holderness et al., 1982). Many of the sites contain significant amount of ash due to dumping of ash and the burning of the refuse on the dump sites from time to time. These burnings get rid of the organic materials and oxidise the metals, leaving the ash richer in metal content. The process of oxidation and corrosion makes the metals soluble and leach into the soil from where they are picked up by growing plants thereby entering the food chain (Harrison and Chirgawi, 1989, Hoffman and Hodgson, 1973). It also leads to contamination of underground water (Marsha and Thibault, 1991; Fulekar and Dave, 1992; Petty John, 1975) while most of the metals get washed into streams and rivers during rain thereby contaminating the marine environment (Vasquez et al., 1993). Since these metals accumulate in fish and other aquatic organisms, they pose health risks to the consumer (Waldron, 1980).

The aim of this study was to investigate the concentration of heavy metals in the top soil in these waste dump sites and compare with natural levels in uncontaminated soil in order to determine the extent of pollution of the top soil in refuse dumps by heavy metals.

MATERIALS AND METHODS

Top soils of twenty different refuse dumps were collected while control samples were taken at a distance of about 100 metres from the refuse dump sites in Abeokuta, Ogun State, Nigeria. The samples and control were collected with plastic spoons directly into polythene bags and taken to the laboratory. The samples were spread on glass plates (5" x 5") and dried in a drying chamber at 105°C

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This paper was earlier published in volume 6/4, p. 651-653 (2000) with the omission of section on "Results and Discussion". The error is regretted.

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for 6 hours. The dried soil was ground and passed through 0.5 mm mesh sieve. They were stored in plastic bottles until they were digested.

Each sample (2g) was weighed into a beaker and digested with 50 cm^3 concentrated HNO_3 and 1 cm^3 $HClO_4$ on a hot plate with gentle boiling. At completion of digestion, the samples were evaporated to dryness and the residue mixed with 0.1M HNO_3 and filtered into a 100 ml standard flask using Whatman No. 1 filter paper (Jensen, 1992). Blank determinations were carried out simultaneously with the samples. The metals zinc, lead, copper, cadmium and iron were determined using atomic absorption spectrophotometer (Buck Model 200A).

RESULTS AND DISCUSSION

The results of the study are shown in table 1. Each value is a mean of three determinations. The values in parenthesis are for the control sites. The sample range for iron was 289.30 to 360.09 mg/kg while for the control sites the range was 3.04 to 77.07 mg/kg. The highest range was at Abo Aba, a densely populated area with high traffic density. This high value was probably due to local industrial activities such as blacksmithing and welding which discharged metal dust and fumes into the air which gradually settled on the soil. Also, wastes from blacksmithing and welding shops could have been dumped at the refuse sites. Thus prolonged accumulation of wastes before clearing by waste disposal authorities could have had a greater effect on the oxidation and deposition of the metals on the top soil. This, in addition to the long usage of the dump site would have made the soil richer in metal content.

Table 1: Concentration of metals in refuse dump soils and control sites. Values are mean ± std. deviation and are in mg/kg dry weight of soil. Values in parenthesis represent the control sites.

	Location	Iron	Copper	Lead	Zinc	Cadmium
1.	Odo-Oyo	319.50 ± 0.71 (5.77 ± 0.34)	315.76 ± 2.28 (2.56 ± 0.02)	35.02 ± 0.73 (6.01 ± 0.06)	146.27 ± 1.07 (51.25 ± 0.35)	10.28 ± 1.07 (1.25 ± 0.35)
2.	Lafenwa Road	345.15 ± 0.31 (18.26 ± 0.02)	227.68 ± 0.68 (1.79 ± 0.30)	55.35 ± 0.19 (1.75 ± 0.06)	185.04 ± 0.03 (60.75 ± 1.06)	25.51 ± 1.43 (3.28 ± 1.07)
3.	Kuto Market	345.75 ± 1.77 (9.58 ± 0.02)	315.77 ± 1.09) (5.23 ± 0.02)	39.76 ± 0.37 (2.55 ± 1.40)	195.25 ± 0.35 (64.51 ± 2.81)	26.27 ± 0.33) 1.54 ± 0.04)
4.	Lafenwa Market	352.18 ± 2.57 (12.02 ± 0.68)	528.75 ± 1.06) (3.60 ± 0.13)	145.77 ± 1.04 (2.89 ± 0.49)	220.03 ± 0.69 (71.27 ± 0.38)	50.50 ± 0.71 (3.64 ± 0.52)
5.	Idi-Aba	315.45 ± 1.20 (7.18 ± 0.11)	131.51 ± 1.40 (1.80 ± 0.29)	130.61 ± 0.52 (2.04 ± 0.65)	176.25 ± 1.06 (51.25 ± 0.35)	21.77 ± 1.04 (1.61 ± 0.07)
6.	Imala	350.56 ±0.04 (18.66 ± 0.48)	306.14 ± 0.53 (0.76 ± 0.35)	46.00 ± 0.71 (1.78 ± 0.40)	120.28 ± 13.75 (62.50 ± 0.71)	10.81 ± 1.04 (3.44 ± 1.06)
7.	NEPA Road	345.57 ± 0.09 (6.30 ± 1.05)	175.53 ± 0.66 (3.30 ± 0.37)	90.29 ± 0.30 (1.04 ± 0.68)	176.07 ± 0.69 (53.05 ± 0.73)	19.25 ± 1.06 (1.82 ± 1.05)
8.	Kuto Road	356.04 ± 0.76 (12.07 ± 0.01)	634.29 ± 1.08 (0.78 ± 0.36)	82.46 ± 1.61 (4.06 ± 0.01	226.62 ± 1.53 (66.58 ± 0.02)	24.25 ± 1.06 (1.08 ± 0.70)
9.	Ibara Housing Estate	289.30 ± 0.99 (30.82 ± 0.36)	70.81 ± 1.02 (1.82 ± 0.35)	31.58 ± 1.49 (4.07 ± 0.01)	173.52 ± 2.86 (71.43 ± 0	26.76 ± 0.33 (0.83 ± 0.07)
10.	Isale Igbein	346.05 ± 0.77 (8.02 ± 0.69)	65.77 ± 1.04 (1.79 ± 0.36)	94.76 ± 0.37 (3.05 ± 0.07)	186.00 ± 0.[illegible] (67.06 ± 0.04)	10.52 ± 1.44 (1.54 ± 0.70)
11.	Adatan	350.57 ± 0.76 (23.89 ± 0.79)	531.64 ± 1.58 (1.13 ± 0.10)	130.53 ± 0.24 (10.53 ± 0.72)	217.75 ± 3.18 (61.55 ± 0.69)	20.09 ± 0.71 (2.75 ± 0.21)
12.	Ogbe	353.77 ± 1.74 (3.07 ± 0.62)	494.75 ± 0.35 (2.87 ± 0.23)	142.27 ± 1.47 (1.26 ± 0.96)	196.07 ± 0.80 (70.79 ± 1.04)	15.56 ± 0.75 (2.10 ± 0.81)
13.	Omida	317.07 ± 0.66 (10.11 ± 0.38)	300.90 ± 0.88 (1.07 ± 0.74)	130.08 ± 0.64 (5.08 ± 0.81)	146.01 ± 0.47 (53.35 ± 1.39)	4.65 ± 0.54 (0.81 ± 0.35)
14.	Sapon	339.53 ± 0.68 (7.54 ± 0.66)	96.00 ± 0.76 (2.05 ± 0.38)	111.04 ± 0.74 (3.79 ± 0.35)	175.00 ± 1.24 (63.80 ± 0.33)	16.12 ± 1.36 (2.04 ± 0.76)
15.	Totoro I	316.07 ± 0.62 (3.04 ± 0.66)	175.02 ± 0.73 (2.29 ± 0.38)	35.70 ± 0.52 (5.29 ± 0.30)	137.09 ± 1.42 (54.14 ± 0.69)	21.10 ± 0.57 (1.29 ± 0.38)
16.	Ago-Oko	345.02 ± 0.02 (11.80 ± 0.34)	130.64 ± 0.11 (2.30 ± 0.39)	40.58 ± 0.73 (1.80 ± 0.38)	215.93 ± 0.86 (67.79 ± 1.09)	15.56 ± 0.89 (1.07 ± 0.55)
17.	Ake	347.75 ± 3.18 (56.17 ± 0.70)	146.34 ± 1.75 (4.30 ± 0.33)	9.61 ± 0.99 (1.06 ± 0.74)	106.13 ± 1.68 (53.05 ± 0.70)	25.17 ± 0.54 (1.29 ± 0.35)
18.	Liberty	350.45 ± 0.22 (34.58 ± 0.02)	163.77 ± 1.75 (4.45 ± 0.01)	12.32 ± 0.99 (0.81 ± 0.33)	108.82 ± 1.68 (54.11 ± 0.78)	5.98 ± 0.54 (1.54 ± 0.73)
19.	Totoro II	345.01 ± 0.01 (72.59 ± 1.42)	219.81 ± 1.06 (4.28 ± 0.31)	5.52 ± 0.73 (1.30 ± 0.08)	100.83 ± 0.42 (67.29 ± 0.36)	11.05 ± 1.44 (1.58 ± 0.09)
20.	Abo-Aba	360.09 ± 0.09 (77.07 ± 0.17)	150.63 ± 1.08 (4.54 ± 0.71)	10.90 ± 0.27 (1.33 ± 0.19)	101.04 ± 1.41 (66.82 ± 0.35)	25.37 ± 0.04 (1.55 ± 0.12)

Other densely populated areas including Lafenwa Road, Kuto Market, Lafenwa Market, Imala, NEPA Road, Kuto Road, Isale-Igbein, Adatan, Ogbe, Ago-Oko, Ake, Liberty, and Totoro, also had high metal values up to and exceeding 345 mg/kg. The lowest value was observed for Ibara Housing Estate dump site (289.30 mg/kg). This is a thinly populated government residential area.

A similar trend was observed for the other metals with dumps sites located in highly populated and high traffic density areas being higher in metal content than thinly populated and low traffic density areas. The only exception was cadmium where the highest concentration was found at Ibara Housing Estate and Kuto Market with values of 26.76 and 26.27 mg/kg respectively. A lot of used car tyres and waste plastic products were found at Kuto Market dump sites. Waste plastic products were also found at Ibara Housing Estate dump. Spent cadmium dry-cell batteries could have contributed to cadmium concentration at Ibara Housing Estate dump site.

Table 1 shows that the concentration of the heavy metals from the dump sites were much higher than those from the control sites. These differences are further illustrated in Figures 1-5 which is a comparison of the overall mean value of each metal from the sample sites and the control sites. T-test shows that the differences between them are statistically significant ($p < 0.001$ for iron and zinc; $p < 0.01$ for copper, cadmium and lead). This is in agreement with the observation of previous workers (Bojakowska and Kochany, 1985; Harrison and Chirgawi, 1989; Singh and Narwal, 1984; Adeniyi, 1996) and is an indication of pollution of the soil in the refuse dumps.

Table 2 shows the correlation of the metals with one another. It shows very little correlation between the metals showing that the metals were contributed from various sources. The only two metals that were slightly correlated were zinc and lead (r =

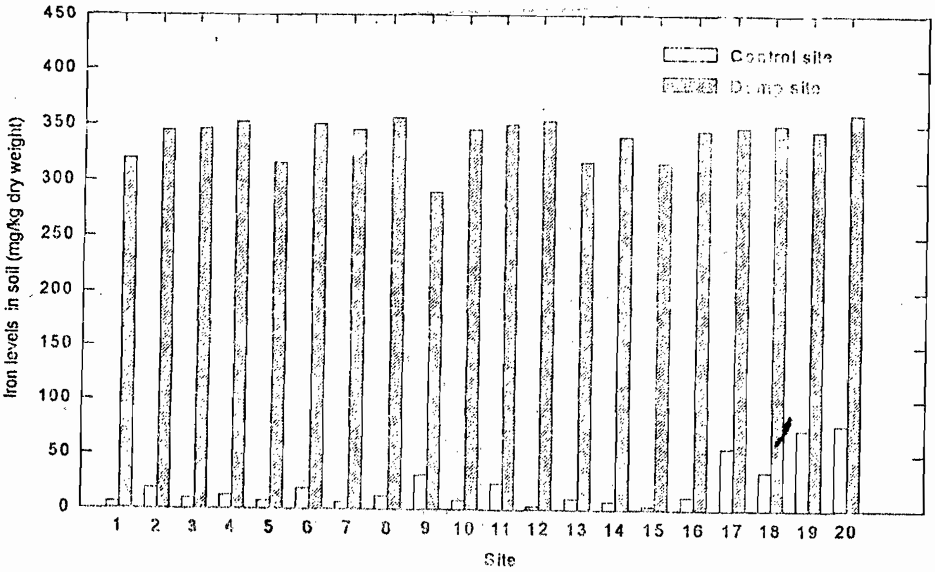

Figure 1: Iron levels in top soils of control and dump sites inn Abeokuta

0.65) which indicate that a proportion of the sources may contain the two metals.

Most of these refuse dumps are located near streams and rivers and run-off from them during rain may flow into these water bodies resulting in their pollution. These metals could leach into the soil to pollute the underground water. The concentration of the metals vary from dump site to dump site and depends on the characteristic of the refuse dumps.

RECOMMENDATION AND CONCLUSION

It is recommended that refuse dumps be located away from water bodies and the refuse be sorted out into metallic and non-metallic components. The metallic components could then be re-cycled. This would prevent soil and

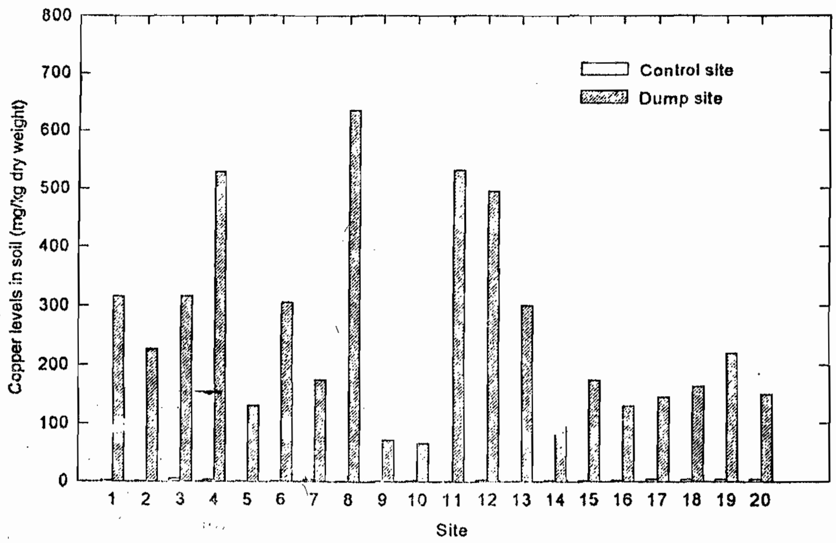

Figure 2: Copper levels in top soils of control and dump sites in Abeokuta

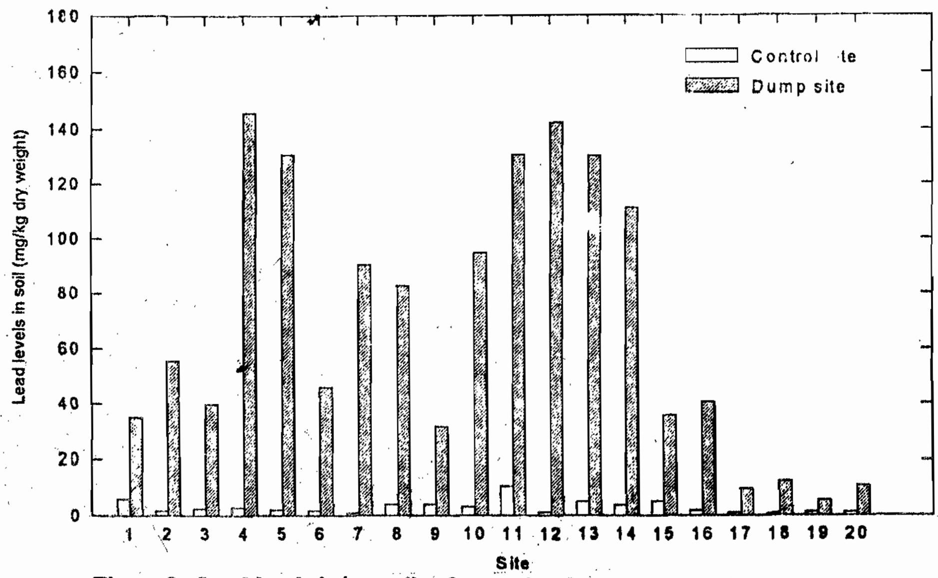

Figure 3: Lead levels in top soils of control and dump sites in Abeokuta

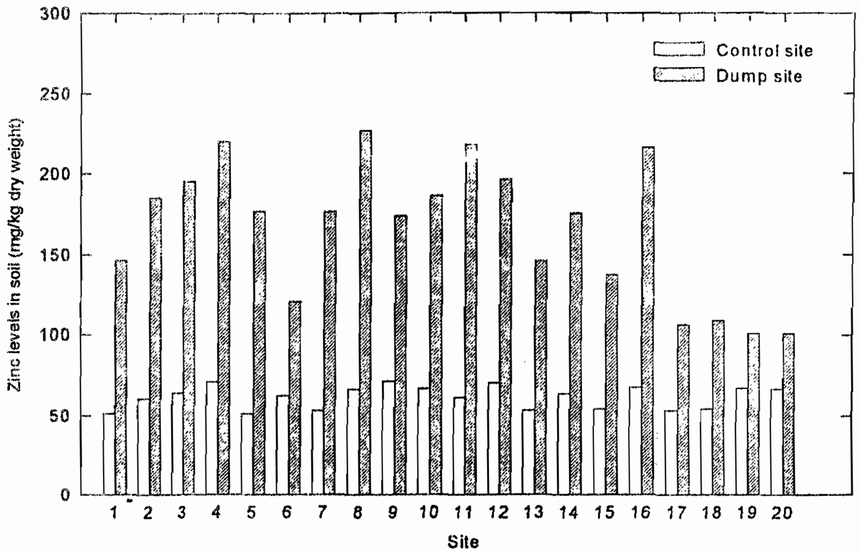

Figure 4: Zinc levels in top soils of control and dump sites in Abeokuta

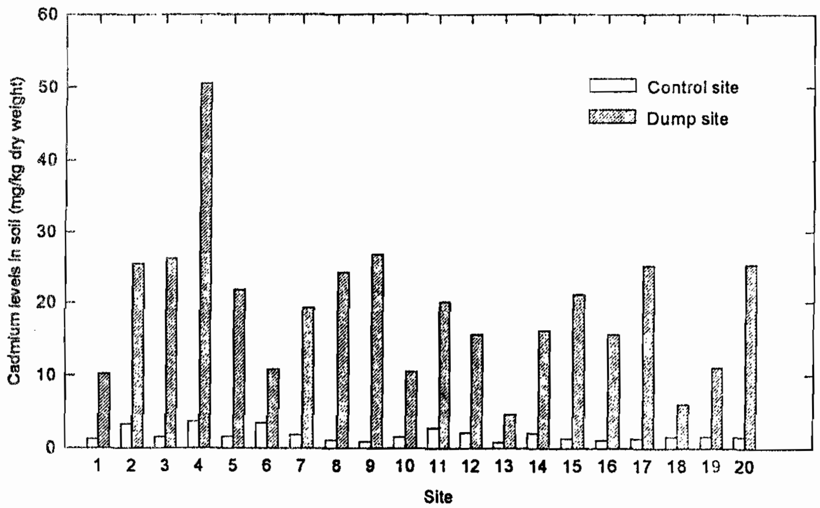

Figure 5: Cadmium levels in top soils of control and dump sites in Abeokuta

Table 2: Correlation coefficient among the metals

	Iron	Copper	Lead	Zinc	Cadmium
Iron	-				
Copper	0.38	-			
Lead	0.02	0.45	-		
Zinc	0.07	0.48	0.65	-	
Cadmium	0.10	0.29	0.18	0.41	-

water metal pollution with attendant health problems. For example, presence of lead in the body results in lead poisoning which is characterised by impairment of the efficient functioning of the nervous system. It also causes renal tubular damage (Waldron 1980). The consumption of cadmium from contaminated water and fish resulted in Itai-Itai disease in Japan. This was characterised by severe pain in the back and legs, deformities in the pelvis, decalcification and spontaneous fracture (Kazantsis 1980). Iron overload in the body leads to cirrhoses and deposition of iron in the lungs, pancreas and heart (Corine and Lawcer, 1977). It also causes disturbances in the liver function, diabetes and cardiovascular effects (Goyer, 1991).

In conclusion, it is clear that refuse dump sites constitute a source of heavy metal pollution to both soil and marine environment. It could also pollute underground water. The pollution could lead to health problems for the population. To avoid this, refuse dump sites should be located away from water bodies; the refuse should be frequently cleared and sorted into metallic and non-metallic components. The metallic components could then be recycled. This would prevent soil and water pollution from this source and the environment would be a little cleaner than it is now.

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