

HEAVY METAL CONTAMINATION OF SOILS AROUND MUNICIPAL SOLID WASTES DUMP IN PORT HARCOURT, NIGERIA.

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ABSTRACT

Levels of some heavy metals in soils around designated municipal solid waste dumpsite and a control site within Port Harcourt and its environs were determined. The soil samples were randomly collected and analyzed for As, Cd, Cu, Cr, Ni and Pb. Levels from the waste dumpsite were higher than those from the control site. Soils around the waste dump were also contaminated as a result of continuous dispersion of heavy metals from the waste dump by run-off water, wind and scavengers. The difference in the mean concentrations of metals between the main dump and outside the dump were not significant ($P > 0.05$) in the wet season but were found to be significant ($P < 0.05$) in the dry season. The concentrations of the metals in soils in both seasons ranged from 0.50 $\mu\text{g/g}$ to 20.5 $\mu\text{g/g}$ for As, 0.20 $\mu\text{g/g}$ to 13.0 $\mu\text{g/g}$ for Cd, 0.50 $\mu\text{g/g}$ to 100.0 $\mu\text{g/g}$ for Cr, 2.50 $\mu\text{g/g}$ to 910.0 $\mu\text{g/g}$ for Cu, 0.50 $\mu\text{g/g}$ to 34.0 $\mu\text{g/g}$ for Ni and 1.0 $\mu\text{g/g}$ to 127.5 $\mu\text{g/g}$ for Pb. The difference observed in the concentrations of Cd, Cu and Pb in both seasons are statistically not significant ($p > 0.05$) while the seasonal variations in the concentrations of As, Cr, and Ni show significant difference ($P < 0.05$). Cd, Cr, and Cu showed positive correlation with distances across the waste dump ($r = 0.9236, 0.9338, 0.3586$ respectively). The mean concentrations of Cd and Cu in the soils from the waste dumpsite are sufficiently high to cause environmental concern as their concentrations exceeded tolerable limits.

KEYWORDS: Dumpsite, solid waste, soil, heavy metals.

INTRODUCTION

In the past, quantities of wastes were relatively small in Port Harcourt and other cities in Nigeria, consisting mainly of biodegradable garbage components, which were easily disposed of by feeding pets or by composting. Today, the population explosion and urbanization have increased the quantities and types of solid wastes produced. Most cities in Nigeria including Port Harcourt are characterized by heaps of garbage and rubbish on street corners and junctions, open places and in drainages, resulting from open dumping of waste. Both the quantity and quality of solid waste generated in Nigeria vary very widely from day to day and according to the season of the year and still increasing mainly due to improper waste management. (Olayinka and Adebayo, 1989; Ademola, 1993; Osibanjo, 1995; Adeniji and Ogu, 1998). Monitoring of sites amended with municipal and agricultural wastes such as sewage sludges, sludge composts and animal manures is necessary and often required to avoid pollution of soils, crops and ground or surface waters (Sims et al. 1991).

A reliable municipal solid waste management plan requires a comprehensive information on the concentration of metals in the wastes in order to assess the limits in composts for use on agricultural soils. Axel (1994) reported that soil from waste disposal sites have wide distribution of heavy metals. Locations that have been used as disposal sites for diverse waste have been categorized as being polluted (Biotechnology, 1997). Port Harcourt waste dump (disposal) sites are situated on agricultural lands, open spaces, burrow pits and close to rivers or water bodies and untreated wastes from all sources are dumped at the same sites. Most dumpsites are later developed into residential and/or commercial areas and boreholes may be sunk in such areas for water. Port Harcourt is a highly industrialized city in Nigeria.

It is the capital and major city of Rivers State with rapid development. However, very little study if any of heavy metal contamination of soils around wastes dumps has been done in Port Harcourt and its environs. This study is conducted to create adequate public awareness of the extent of pollution of the environment by these metals. The choice of metals

included in this study is not intended to be comprehensive.

MATERIALS AND METHODS

Location of the study area

Port Harcourt lies within latitudes 4° 43' 07" and 4° 54" N and longitudes 6° 56' 04" and 7° 03' 20" E with a mean annual rainfall of over 2000mm and a mean annual temperature of about 29°C (NMS, 1998). The waste dumpsite under study (East West road by Rumuokoro) measuring approximately 150m by 80m lies between latitude 4° 52' 10" N and longitude 6° 58' 22" E. The University of Science and Technology (RSUST also known as Unitech) Port Harcourt, which serves as control, lies between latitude 4° 47' 49" N and longitude 6° 58' 52" E. These areas are shown in Fig. 1.

Sample collection and Analysis

The Dutch auger was used to randomly collect 58 topsoil samples (0-15cm depth) from 28 sampling points across the waste dumpsite and a control site. The sampling points were designated at 10m, 20m, 30m and 50m distances from the major road on transects 50m apart across the waste dump. All the samples were transferred into appropriately labeled polyethylene bags and taken to the laboratory for analysis. The samples were collected in January and July 2001 representing the dry and wet seasons.

The method used for the determination of heavy metals can release heavy metals not tightly bound in minerals. The method is justifiable since tightly bound elements are of minimal environmental concern (Lund and Fobian, 1991). All the soil samples were air-dried, ground, sieved to pass through a 1mm sieve. One gram of each of the sieved soil samples was weighed into a conical flask and digested with 10ml of 50% hydrochloric acid on a hot plate until 2-3ml of acid was left. The content was then filtered through Whatman No. 42 filter paper into a 50ml volumetric flask and made up to the mark with de-ionized water (Loganathan, 1984). The concentrations of heavy metals were determined by a Buck Scientific Atomic Absorption/Emission Spectrophotometer 200A with a hollow cathode lamp.

Table 1: Concentrations (µg/g) of heavy metals in soil at East-West road/Rumuigbo waste dumpsite.

Sample Code	Season	Heavy Metals															
		As		Cd		Cr		Cu		Ni		Pb					
		Dry	Wet	Dry	Wet	Dry	Wet	Dr y	Wet	Dry	Wet	Dry	Wet				
	Dist. From road	Om Transect															
EWS 8	10m	4.00	0.50	2.05	0.75	10.00	0.50	48.50	17.00	7.00	9.50	48.00	25.00				
EWS 7	20m	4.00	0.50	0.40	1.15	0.50	55.00	28.00	2.00	2.00	5.50	25.00	30.00				
EWS 6	30m	2.50	0.50	0.40	0.75	0.50	4.00	12.50	2.50	2.50	5.50	25.00	10.00				
EWS 5	50m	2.50	0.50	0.40	0.40	0.50	5.00	2.50	3.50	1.00	1.00	25.00	1.00				
		50 m Transect															
EWS 1	10m	0.50	11.00	0.75	1.15	0.50	40.50	33.00	8.00	10.50	15.00	15.00	30.00				
EWS 2	20m	0.50	20.50	0.55	0.75	3.00	102.00	240.00	3.50	5.50	82.00	12.50	17.50				
EWS 3	30m	0.50	11.00	1.10	0.55	6.50	47.00	404.00	8.00	2.50	40.00	17.50	1.00				
EWS 4	50m	0.50	0.50	1.10	0.55	40.00	249.00	2.50	13.00	1.00	40.00	1.00	1.00				
		150m Transect															
EWS 22	10m	0.50	0.50	0.95	1.50	43.00	65.00	44.50	42.00	9.00	10.50	65.00	95.00				
EWS 23	20m	0.50	0.50	0.55	0.95	16.50	12.00	19.50	21.50	6.00	8.00	32.00	35.00				
EWS 24	30m	0.50	0.50	1.70	1.90	80.00	13.00	66.00	54.00	12.50	12.50	76.00	80.00				
EWS 25	80m	0.50	0.50	1.50	1.90	46.50	16.00	70.00	47.00	10.50	10.50	53.50	55.00				
		Between 50 - 100m															
EWS 9	10m	0.50	20.50	2.05	1.30	33.50	62.00	63.50	53.00	3.50	20.00	35.50	52.50				
EWS 10	20m	11.00	0.50	1.30	5.20	33.50	33.00	66.50	910.0	4.50	34.00	35.50	102.50				
EWS 11	30m	11.00	0.50	1.10	0.75	66.50	0.50	188.00	31.00	9.50	7.00	95.00	12.50				
EWS 13	50m	0.50	6.50	2.25	2.80	40.75	49.00	59.50	74.50	5.50	27.00	33.00	127.50				
		Between 100 - 150m															
EWS 17/18/22	10m	1.67	0.50	1.25	1.12	45.33	22.00	54.67	30.83	9.17	8.50	56.50	38.33				
EWS 16/19/23	30m	1.67	4.00	1.17	1.27	38.83	9.67	27.50	48.83	9.80	9.17	41.83	25.00				
EWS 20/21/24	50m	5.17	0.50	1.55	1.45	41.17	4.67	52.50	60.83	10.50	13.83	69.00	50.00				
		Inside Burrow pit (100m from road)															
EWS 25	100m	0.50	0.50	1.50	1.90	46.50	16.00	70.00	47.00	10.50	10.50	53.50	55.00				
EWS 26	100m	0.50	0.50	2.25	1.75	63.00	15.50	117.50	38.00	17.50	9.50	44.00	30.50				
EWS 27	100m	0.50	0.50	1.70	1.40	33.00	15.00	95.50	36.00	10.50	8.50	35.00	22.50				
EWS 28	100m	0.50	0.50	1.80	1.15	16.50	15.00	65.00	34.00	8.50	7.00	22.50	12.50				
UCS 29	-	0.50	0.50	1.50	0.75	17.50	16.50	12.00	8.50	1.50	0.50	8.50	7.50				

CODES EWS - East-West Road (Soil),
UCS - University Control Soil

RESULTS AND DISCUSSIONS

The concentrations of metals in soil at the dumpsite and control site are shown in Table 1. The results show that the concentrations of arsenic in soil varied from 0.50µg/g to 11.00µg/g with a mean of 2.39µg/g during the dry season and 0.50µg/g to 20.50µg/g with a mean of 3.4µg/g during the wet season. The concentrations of arsenic in soil were generally low and decreased with increasing distances from the major road (r = -0.73461). The levels of arsenic 0.50µg/g from the control site did not vary in both seasons. Although the levels of arsenic at the control site suggest that the wastes dump contributed to the concentrations of arsenic in the soils, activities on the major road also contributed to it. While higher concentrations were obtained during the dry season at the 0m transect, higher concentrations were obtained during the wet season along the 50m transect. The levels of arsenic at the 150m transect did not vary.

The concentrations of cadmium in soil varied from 0.20µg/g to 13.00µg/g with a mean of 1.52µg/g during the dry season and 0.55µg/g to 5.25 µg/g with a mean of 1.27µg/g during the wet season. At the control site the concentrations of cadmium were 0.75µg/g during the wet season and 1.50µg/g during the dry season. Dry season concentrations of cadmium in soil were generally higher than wet season concentrations of cadmium. The levels of cadmium did not exhibit any special trend along transects. However in most cases, higher levels were obtained farther from the road (r = 0.923635). This suggests that the contents of the waste contributed to the levels of cadmium in the area.

The levels of chromium in soil varied between 0.50µg/g and 100µg/g with a mean of 34.82µg/g during the dry season while the wet season concentrations varied between 0.50µg/g and 65µg/g with a mean of 13.91µg/g. At the control site the

concentrations of chromium were 16.50µg/g during the wet season and 17.50µg/g during the dry season. High concentrations of chromium were observed in soil in the study area. While the concentrations in the wet season were low and constant along 0m and 50m transects, the concentrations in the dry season were generally high. However, at the 0m transect, a high concentration was recorded close to the road while the other levels were constant. Along the 50m transect, the levels in soil increased with increasing distance from the road (r = 0.933813). The highest levels of chromium were obtained along the 150m transect and between 50m and 150m transects. These observations confirm the influence of the waste dump on the concentrations of chromium in the area.

Copper levels in soil ranged from 4.00µg/g to 249µg/g with a mean of 64.75µg/g during the dry season and 2.50µg/g to 404 µg/g with a mean of 88.63µg/g during the wet season. Copper is the most prevalent metal in the waste dump. The highest concentration of 910µg/g was obtained in soil at the dump during the wet season. Copper concentrations varied with season but did not show any particular trend. For instance, highest concentration in soil was obtained at the main dump during the wet season while in the dry season, the highest concentration was observed inside a pit, 100m away from the

main dump. The concentrations of copper in soils were generally higher in the wet season than in the dry season in the study area. The concentrations of copper in soils along transects did not show any specific trend. However, higher concentrations were obtained farther from the road where the wastes are accumulated (r = 0.358644). The concentrations of copper at the control site were 8.50µg/g during the wet season and 12.00µg/g during the dry season. These observations showed that the wastes dump contributed greatly to the levels of copper in soil from the study area.

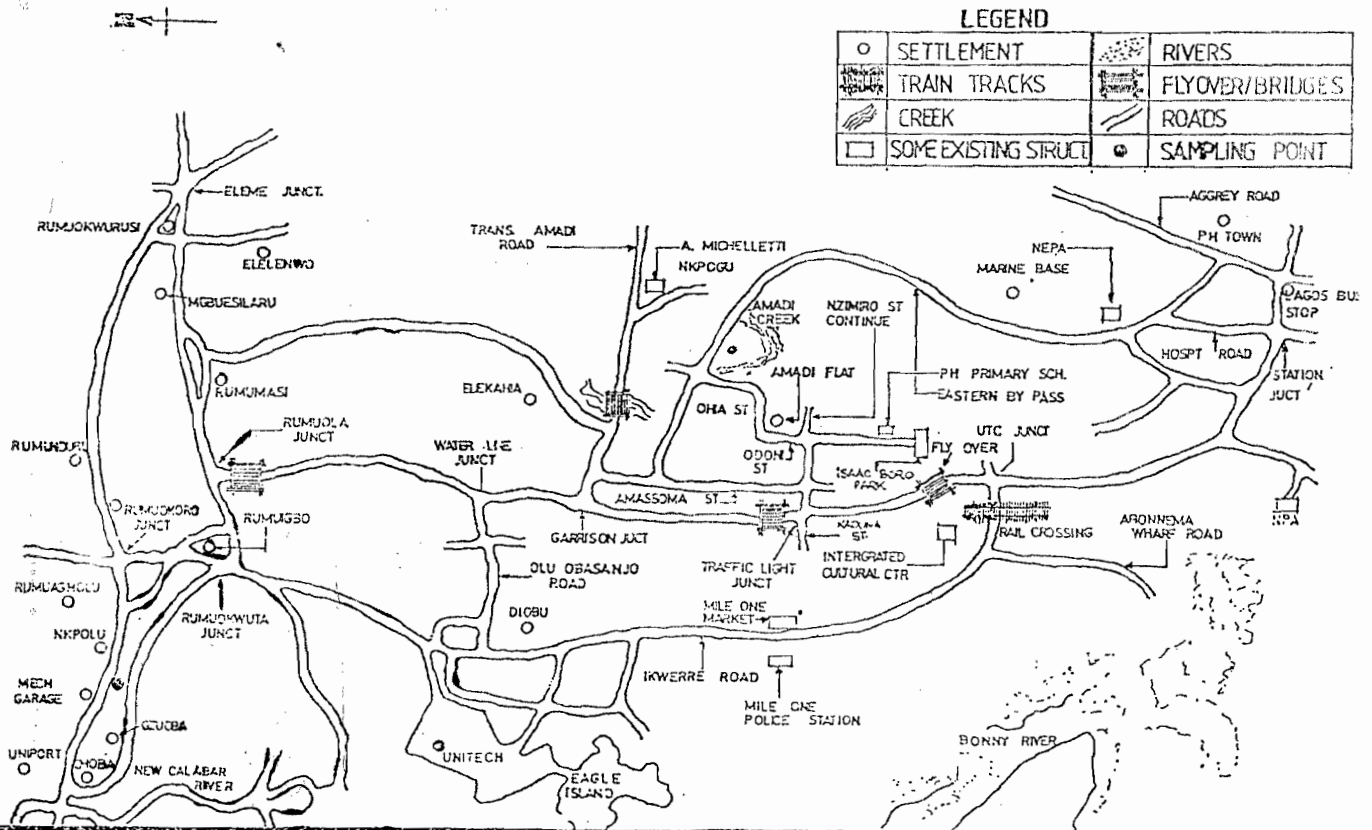


FIG. 1 MAP SHOWING SAMPLING AREAS IN PARTS OF PORT HARCOURT AND OBIO AKPO LGA'S

The levels of nickel in soils varied between 1.00µg/g and 17.50µg/g with a mean of 8.30µg/g during the dry season and 0.50µg/g to 34µg/g with a mean of 9.64µg/g during the wet season. The mean concentrations of nickel were found to be highest in soil at the main dump. The wet season concentrations in soil were generally higher than the dry season concentrations. A different trend was observed at the control site where the concentrations of nickel were 0.50µg/g during the wet season and 1.50µg/g during the dry season. The concentrations of nickel in the study area did not exhibit any regular trend along transects. However higher mean levels were obtained in soil at far distances from the road ($r = -0.23109$).

Lead levels in soil ranged from 7.50µg/g to 95µg/g with a mean of 32.55µg/g during the dry season and 1.00µg/g to 127µg/g with a mean of 32.30µg/g during the wet season. Although the highest concentration of 127µg/g was obtained during the wet season, the mean concentrations of lead in soil in the dry season were generally higher than those in the wet season. The levels of lead at the control site were 7.50µg/g during the wet season and 8.50µg/g during the dry season. A significant variation was observed between the concentrations of lead in soil from the dumpsite and the control site. The concentrations of lead were higher in soil at the main dump than those at distances away from the dump. The highest levels of lead in soil obtained were at the vicinity of the waste dump, which suggests that materials like spent batteries and other petroleum wastes contributed to the lead levels. The concentrations of lead did not show any specific trend along transects. This shows that activities on the main road are not the main source of lead in the area. This is because the effect of traffic is limited to a narrow zone from the road (Ter Haar, 1975).

In order to assess whether the concentrations of metals determined in this study are sufficiently high to cause environmental pollution, the results obtained are compared with available standards. The maximum recommended heavy metal concentrations in soils are 300µg/g As, 3µg/g Cd, 1000µg/g Cr and Pb, 250µg/g Cu and 100µg/g Ni (Brady, 1974). Also, FMEnv (1991) and RSMENR (2002) recommended permissible limits of <1µg/g Cd, 10 - 200µg/g Cr, 2 - 100µg/g Cu, 5 - 500µg/g Ni and 2 - 200µg/g Pb. The results show that only the concentrations of Cd and Cu at the waste dump exceeded permissible limits indicating heavy metal pollution of soils around the study area.

CONCLUSION

The findings of this study have shown that the wastes contributed to the levels of metals as depicted by the higher metal concentrations in soils at the wastes dumpsite than at the control. Metal concentrations in soil generally increased with increasing distance from the major traffic road. Thus, road traffic is not the major source of lead around the waste dump. In general, the level of deposition, type of waste, topography, run-off and varying rates of scavenging influenced the concentrations of the heavy metals in soils at the waste dumpsite. The concentrations of cadmium and copper in soil are high enough to cause environmental pollution hazards as their concentrations exceeded permissible limits while the other metals only contaminate the environment for now. The levels of metals obtained may adversely influence human health since vegetables and crops locally grown on the waste dump are continuously consumed. Open waste dumps are exposed to strong tropical weathering and can lead to the mobilization and migration of heavy metals into the surrounding terrestrial and aquatic environments

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