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Full Length Research Paper

Effect of leaching on heavy metals concentration of soil in some dumpsites

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Study on the effect of leaching on heavy metals concentration at dumpsites was conducted by analyzing samples of soil collected from different dumpsites located within Ikere and Ado Ekiti metropolis, South Western Nigeria. The samples were analyzed for concentrations of Cd, Co, Cr, Cu, Fe, Pb, Mn, Ni, Sn and Zn. Control soil samples were taken at 200 m away from the last sampling point on each dump site down the slope and were also analyzed for the presence of these heavy metals. The results of the analyses show a significant difference in the concentration of these metals from the centre of each dumpsite at interval of 10 – 70 m down the slope ($p < 0.05$). The dumpsites were found to contain significant amount of toxic heavy metals. Hence, phytoremediation processes were suggested.

Key words: Leaching, heavy metals, soil, dumpsites.

INTRODUCTION

Heavy metals pollution represent serious problem for human health and for life in general. The disposal of heavy metals is a consequence of several activities like chemical manufacturing, painting and coating, mining, extractive metallurgy, nuclear and other industries. Those metals exert a deleterious effect on fauna and flora of lakes and streams (Eddy, 2004a).

The introduction of industrial and municipal solid waste into our environment has contributed greatly to the increase in levels of heavy metals in soil and vegetations grown in dumpsites. The soil and plants on these dumpsites will constitute a serious threat to the health of people living around such areas (Adefemi and Awokunmi, 2009).

According to FEPA (1995), solid wastes are useless, unwanted or discarded materials that arise from man's activities and cannot be discarded through sewer pipe. The non-flowing or sticky nature of solid waste gives rise to the accumulation of solid waste on some habitable parts of the earth surface. Places with accumulated solid waste are called refuse dumps but a designated place for dumping of refuse is known as dumpsite.

Although, solid waste is an asset when properly managed, its volume has continued to increase tremendously in recent times in Nigeria as a result of socio-economic development including wage increases. In Nigeria, much has been, and is being invested on municipal solid waste management in cities. But, little progress has been made because of severe financial, technological and institutional constraints within the public and private sectors apart from erratic growth of housing units in the inner core or urban cities (Ojeshina, 1999).

Despite the best attempts at waste avoidance, reduction, reuse and recovery (recycling, compositing and energy recovery), landfill and waste disposal sites are still principal focus for ultimate disposal of residual waste and incineration residues world-wide. The placement and compaction of municipal in landfills facilitates the development of facultative anaerobic conditions that promotes biological decomposition of land filled wastes. Hence, leachates of divers composition are produced, depending on site construction and operational practices, age of the land filled (Campell, 1993).

The extent of soil pollution by heavy metals and base metal ions some of which were soil micronutrients is very alarming. It has been observed that the larger the urban area, the lower the quality of the environment (Eddy, 2004a). This has been one of the reasons why problems of solid waste disposal and management have reached a critical stage in major towns and cities of Nigeria, most especially in Ado and Ikere Ekiti towns of

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Table 1. Heavy metals concentration (mg/kg) in soil samples from Aba Egbira dumpsite.

Location	Cd	Co	Cr	Cu	Fe	Pb	Mn	Ni	Sn	Zn
AB1	3300.00a	810.00a	1810.00a	1188.0a	8310.00a	5530.00a	491.00a	300.00a	9310.00a	1323.00a
AB2	5530.00a	489.00a	292.00b	9100.00b	1311.00b	2100.00	660.00b	1620.00b	118.60a	8100.00b
AB3	1500.00c	650.00c	1590.00c	118.400	7800.00c	5440.00b	426.00b	289.00b	8876.00c	1201.00c
AB4	5020.00c	422.00bc	272.00c	8800.00d	1122.00d	5020.00c	422.00bc	272.00c	8800.00d	1122.00d
AB5	5000.00c	418.00c	266.00d	8780.00e	1109.00e	5000.00c	418.00c	266.00d	8780.00e	1109.00e
AB6	4980.00e	418.00c	265.00d	8662.00f	1100.00f	1420.00f	610.00f	1573.00fe	116.40f	7780.00e
AB7	1380.00g	608.00g	1560.00f	115.20f	7620.00f	4030.00f	412.00d	252.00e	6540.00g	1022.00g
Control	N.D	N.D	N.D	102.00g	1221.00g	N.D	212.00e	18.00f	N.D	360.00h
Mean	10958	545	865	4608	3699	4077	456	573	6077	2752
SD	7194	104	201	4534	3492	1596	136	630	4168	7201
CV(%)	6.52	19.2	23.25	98.4	94.4	38.5	29.9	109.8	68.6	261.7

*Values with the same alphabet are not significantly different at $p < 0.05$.

Ekiti state.

In Nigeria, it is generally believed that individuals, government and environmental agencies pay little or no attention to the environmental impact of waste disposal and management, even when it is a statutory responsibility of the parties concerned. Agencies like the Federal Environmental Protection Agency (FEPA), Ministry of Environment, Ekiti State Environmental Protection Agency (EKSEPA) and even local authorities are responsible for planning a defined line of action for disposal and management of waste generated on daily basis in our society. Unfortunately, they have failed in this regard. Umekuka and Mba (199) reported that poor management of refuse has caused traffic delays in some strategic parts of our urban centres.

The present study is aimed at analyzing solid samples at different dumpsites for their heavy metals concentration. Such study could aid in quantifying information on the environmental impact of these metals and suggesting various techniques that could be used to clean-up these metals from the environment. The data generated will serve as baseline data for future studies.

MATERIALS AND METHODS

Soil samples were collected from four different dumpsites (two from each local government) located within Ikere and Ado Ekiti metropolis, South Western Nigeria. The samples were collected from seven points at interval of 10 m on each dumpsite, starting from the centre of the dumpsite to the bottom of the slope. Control samples were collected at 200 m away from last sampling point on the dumpsites. The samples were transported to the laboratory for analysis.

In the determination of the availability and composition of heavy metals in the decomposed waste deposited at each sampling station, the digestive method, as recommended by Nwajei and Gagophein (2000) was used. 1 g of dried and homogenized soil obtained from each decomposed humus of the dumpsite between 15 – 20 cm depth from the soil surface was weighed into 150 ml conical flask, a mixture of HNO_3 : $HClO_4$: HF in ratio 3:1:3 was added. The mixture was placed on hot plate for 3 h at 80°C. The digest was filtered into 100-ml standard flask and made to the mark with de-ionized water. The procedure was repeated for soil samples obtained at 200 m away from the last sampling point on the dumpsite (control). The concentrations of heavy metals were determined by atomic absorption spectrophotometer (Perkin Elmer Model 306).

Statistical analysis

All determinations were performed in triplicate. The statistical analyses were conducted using analysis of variance (ANOVA) and by calculating mean, standard deviation and coefficient of variation of each set of values.

RESULTS AND DISCUSSION

The concentration of cadmium, cobalt, chromium, copper, iron, lead, manganese, nickel, tin and zinc from seven locations on each dumpsites at distance of 10 m interval from the centre of the dumpsite to the bottom of the slope (AB1 to AB7) and control taken at 200 m away from the dumpsite are shown in Tables 1, 2, 3 and 4.

Metals considered in the study includes those which are micro-nutrient such as copper, manganese, iron and zinc and the non essential /toxic heavy metals which are toxic to plants present in the soil at concentrations above tolerance level. This latter class of heavy metals include, cadmium, cobalt, chromium, lead, nickel and tin.

Based on the results obtained, there was a gradual decrease in the concentration of heavy metals from the centre of the dumpsite to the bottom of the slope. In most cases from locations (1 - 7), there was a significant differrence between the concentrations of most metals at the centre of the dumpsite to the bottom of the slope.

The range of the concentration of cadmium in the soil was 219 – 330 mg/kg while at 200 m away from the dumpsite cadmium was not detected.

The results obtained are within the natural studies carried out by Amusan et al. (2005) for soils of Obafemi

Table 2. Heavy metals concentration (mg/kg) in soil samples from Atikankan dumpsite.

Location	Cd	Co	Cr	Cu	Fe	Pb	Mn	Ni	Sn	Zn
AT1	2300.00a	2200.00a	2020.00a	102.00a	9610.00a	6400.00a	512.00a	335.00a	8310.00a	832.00a
AT2	6310.00b	10.00a	333.00a	8100.00b	830.00a	6310.00b	10.00a	333.00a	8100.00b	830.00a
AT3	6180.00c	500.00b	329.00b	7800.00d	785.00b	6180.00c	500.00b	329.00b	7800.00d	785.00b
AT4	6100.00d	490.00c	302.00c	7900.00c	742.00c	6100.00d	490.00c	302.00c	7900.00c	742.00c
AT5	6080.00e	482.00d	300.00cd	7786.00e	702.00d	6080.00e	482.00d	300.00c	7786.00e	702.00d
AT6	6050.00f	480.00d	300.00cd	7780.00f	700.00d	6050.00f	480.00d	300.00cd	7780.00f	700.00d
AT7	6000.00g	47100e	298.00d	7620.00g	700.00d	6000.00g	47100e	298.00d	7620.00g	700.00d
Control	N.D	230.00f	20.00e	N.D	350.00e	N.D	230.00f	20.00e	N.D	350.00e
Mean	5574	607	487	6726	1802	6160	396	277	7899	705
SD	1447	666	627	3177	3158	284	181	105	232	153
CV(%)	26	1.1	128.7	47.2	175.2	4.6	0.46	38	3.0	21.8

Values with the same alphabet are not significantly different at $p < 0.05$.

Table 3. Heavy metals concentration (mg/kg) in soil samples from Igbehin street dumpsite.

Location	Cd	Co	Cr	Cu	Fe	Pb	Mn	Ni	Sn	Zn
IG1	562.00a	500.00a	1660.00a	133.10a	10921.67a	6860.00a	513.00a	221.00a	7860.00a	1426.00b
IG2	6720.00b	529.00a	219.00ab	7720.00b	1396.00c	562.00a	110.00c	1650.00b	131.7b	9810.00b
IG3	6530.00c	529.00a	217.00bc	7630.00c	1395.00c	551.00b	120.00b	1590.00c	130.90c	9330.00c
IG4	6400.00d	520.00b	217.00bc	7630.00c	1391.00d	550.00b	110.00c	1590.00c	130.00d	9200.00d
IG5	6350.00e	519.00b	215.00cd	7620.00d	1391.00d	550.00b	109.00cd	1589.00cd	130.00d	9100.00e
IG6	6000.00f	519b.00b	215.00cd	7620.00d	1300.00e	550.00b	109.00cd	1589.00cd	130.00d	9100.00e
IG7	6000.00f	510.00c	212.00d	7000.00e	1250.00f	6000.00f	510.00c	212.00d	7000.00e	1250.00f
Control	N.D	N.D	N.D	18.00f	1500.00g	N.D	20.00d	N.D	N.D	3002.00
Mean	5509	518	422	5671	2568	2232	200	1206	2215	6527
SD	2197.2	10.3	545.9	3461.3	3376	2864.1	194.8	676.2	3570.6	3878.8
CV(%)	39.9	1.99	129.4	61.0	131.5	128.3	97.4	56.1	161.1	59.4

* Values with the same alphabet are not significantly different at $p < 0.05$.

Awolowo University central refuse dumpsite.

There was significant difference between the concentrations of cadmium at different locations on the dumpsites ($p < 0.05$). However, at Igbehin street dumpsite, concentration of cadmium did not significantly vary at locations IG1-IG5 as shown in (Table 3).

The range of concentrations of cobalt was (105 - 810 mg/kg as shown in Tables 1, 2, 3 and 4. The highest range of concentration of cobalt was obtained at Aba Egbira dumpsite. The values obtained were higher than the ones reported by Adefemi and Awokunmi (2009) from their studies on some dumpsites located within Ado Ekiti metropolis. This might be due to the indiscriminate disposal of cobalt containing waste on the dumpsite. In most cases, there was significant difference in the concentration of cobalt at the seven locations separated 10 m away on the dumpsite, with concentration decreasing down slope. The concentration of cobalt did not significantly vary at locations AT2, AT3, AT4 on Atikankan dumpsite, IG2, IG4, and IG5, on Igbehin street dumpsite and Mo3, Mo4 on Moshood road dumpsite.

The concentration of chromium in soils of these dumpsites was found to range from 900 – 2000 mg/kg. These concentrations vary and decrease down the slope in all the locations starting from zone 1 to 7, except at zones IG3, IG4, IG5 on Igbehin street dumpsite and Mo5, Mo6, and Mo7 on Moshood road dumpsite whose concentrations did not vary significantly .However, chromium was not detected at 200 m away from the centre of each of the dumpsite. Eddy (2004b) reported that automobiles and electronic waste introduced metallic chromium into the soil. This could be the reason for high concentrations of chromium at Atikankan dumpsite, where automobile and electronic wastes have been dumped for many years.

The natural range for concentration of copper in soils is 7 – 80 mg/kg. From Tables 1, 2, 3 and 4, the concentrations ranged between 18.00 - 133.10 mg/kg. The highest concentration of copper (133.10 mg/kg) was obtained at the centre of Igbehin street dumpsite. In all zones, the concentration of copper was higher than the permissible limit. This might be due to the indiscriminate disposal of

Table 4. Heavy metals concentration (mg/kg) in soil samples from Moshood road dumpsite.

Location	Cd	Co	Cr	Cu	Fe	Pb	Mn	Ni	Sn	Zn_
MR1	317.00a	210.00a	1000.00a	111.00a	6810.00a	4180.00a	2210.00a	170.00a	5186.00a	3052.00a
MR2	316.00a	120.00c	990.00b	111.00a	7020.00a	4100.00b	2200.00b	168.00ab	5100.00b	1132.00b
MR3	289.00b	110.00d	920.00c	113.33a	6640.00a	3990.00c	2180.00c	166.00b	4990.00c	1121.00c
MR4	287.00b	112.00d	902.00d	110.00a	4630.00a	3900.00d	2150.00d	165.00bc	4120.00d	1114.00d
MR5	250.00c	135.00b	901.00d	100.00b	6612.00a	3870.00e	2112.00e	162.00c	3822.00e	1106.00e
MR6	240.00d	102.00e	900.00e	100.00b	6600.00a	3512.00f	2017.00f	161.00d	3521.00f	1103.00ef
MR7	219.00e	111.00d	900.00e	100.00b	5900.00a	3500.00g	2022.00g	150.00e	3511.66g	1100.00f
Control	N.D	N.D	N.D	18.00c	1100.00b	N.D	N.D	N.D	N.D	N.D
Mean	274	128	930	95	5664	3865	2127	163	4321	1389
SD	38.2	37.4	44.8	31.8	1994.1	267.4	80.5	6.6	751.3	777.1
CV(%)	14	29.1	4.8	33.3	35.2	6.9	3.8	4.1	17.4	52.8

* Values with the same alphabet are not significantly different at $p < 0.05$.
AB - Aba Egbira; IG-Igbehin street; AT- Atikankan; MO-Moshood road.

copper containing waste (Ademoroti, 1996) at the dumpsites.

It has been reported by Dara (1993) that a biodegradable waste introduced metallic copper into soil at a level slightly above the natural levels for soils. This might be responsible for high concentration of copper in soils of these dumpsites.

There was a significant difference between the concentration of copper in almost all the zones ($p < 0.05$), with the exception of zones: AT3, AT4, at Atikankan dumpsite, IG4, IG5 and IG6, IG7 at Ighehin street dumpsite and MO1, 2, 3, 4 and MO5, 6, 7. The concentration of copper gradually reduces from centre of the dump (10 m away on dumpsite) to a distance of 20 m away from the last sampling point on the dumpsite (control).

The natural level of iron concentration ranged between 3,000 - 5,000 mg/kg. In all zones, concentration of iron ranged between 1100 and 10,920 mg/kg. The highest concentrations of iron (10,920 mg/kg) was found at the centre of Igbehin street dumpsite. These values fell within the permissible level of iron for soil.

Studies carried out by Udeme (2001) and Akaeze (2001) for soils along Aba-Ikot Ekpene road in Uyo metropolis (Akwa Ibom State, Nigeria) using different methods at different sample locations revealed results that are comparable to those obtained in this study.

There was no significant difference between the concentration of iron at Moshood road dumpsite ($p < 0.05$). At Aba Egbira, Atikankan and Igbehin street dumpsites, concentration of iron vary significantly at $p < 0.05$. However, it has been confirmed that natural soil contains significant concentration of iron (Ademoroti, 1996; Aluko et al., 2003; Dara, 1993; Eddy, 2004a; Adefemi and Awokunmi, 2009). Eddy et al. (2004) suggested that the pollution of the environment by iron cannot be conclusively linked to waste materials alone but other natural sources of iron must be taken into consideration.

Though concentration of lead in soil at dumpsite ranged from 3500 – 6860 mg/kg, lead was not detected 200 m away from the last sampling point on each dumpsite. The concentration of lead vary significantly at distance of 10 m away from the centre of the dumpsite down the slope, except at AB1, AB2 (5530±2.64 mg/kg) and AT6, AT7 (6000±2.64 mg/kg). However, the highest concentration of lead (6860 mg/kg) was obtained at the centre of Igbehin street dumpsite. The major source of lead pollution is industrial source (Dara, 1993), consequently the significant increase in the concentration of lead in these locations where much economic activities concentrate is not surprising. Aluko et al. (2003) reported the mean concentration of lead in soil at Ibadan dumpsite to range from 1340 - 1693 mg/kg.

There was significant difference between the concentration of lead in soil in all seven locations on each dumpsite ($p < 0.05$). This shows that the waste at the dumpsite contains significant amount of lead and must have been leached to some distance away from the centre of the dumpsite.

The permissible range for the concentration of manganese in soils is 200 to 9,000 mg/kg (Eddy et al., 2004). In all dumpsites, the concentration of manganese ranged from 20 – 2210 mg/kg. However, manganese was not detected at 200 m away from the last sampling point on Moshood road dumpsite, where the highest range of concentration (2022 - 2210 mg/kg) was detected. Udeme (2001) reported concentration in the range of 263.95 - 406.00 mg/kg at dumpsite and a range of 19.21 - 485.00 mg/kg 100 m away from a dumpsite located within Akwa Ibom state.

There is no significant variation in the concentration of manganese in virtually all the dumpsites except for Moshood road dumpsite ($p < 0.05$). This shows that the observed concentration of manganese might have been due to background concentration. Manganese may be found in most soils since it is one of the elements in the earth crust (Dara, 1993).

Nickel was found in the range 18 – 335 mg/kg at all locations on the dumpsite except for 200 m away from the last collection point on Igbehin street and Moshood road dumpsite. The highest concentration (335 mg/kg) was obtained at the centre of Atikankan dumpsite. These concentrations vary significantly ($p < 0.05$) at a distance away from the centre of each dumpsite. However, at Igbehin street dumpsite, the concentration of nickel did not vary at AT3 and AT4 as well as AT5 and AT6. Nickel has been reported by Adefemi and Awokunmi (2009) at some selected dumpsites within Ado-Ekiti metropolis ranging from 590 to 2360 mg/kg. These concentrations were also shown to vary significantly with distance from centre of the dumpsite.

Tin was not detected 200 m away from the centre of all dumpsites but was found in the concentration range of 3511.66 – 9310 mg/kg. The highest value was obtained at Aba Egbira dumpsite. These concentrations vary significantly at $p < 0.05$ in all dumpsites, showing that these dumpsites are rich in tin containing waste.

The concentration of zinc was detected at 350 – 3052 mg/kg in all locations on all dumpsites. The highest concentration (3052 mg/kg) was obtained at Moshood road dumpsite. The natural range of zinc is 10 – 300 mg/kg as reported by Eddy et al. (2004). In most cases, the concentrations of zinc were not within the natural range of zinc. However, zinc was not detected at 200 m away from the centre of Moshood road dumpsite. Aluko et al. (2003) reported that the mean concentration of zinc in soils at some dumpsites in Ibadan ranged from 1.423 - 2.428 mg/kg.

There was a significant difference between the concentrations of zinc in all seven locations on each dumpsite at $p < 0.05$. This shows that waste at these dumpsites contain significant amount of zinc.

Conclusion

The concentrations of heavy metals were obtained to be highest at the centre of each dumpsite and vary significantly at a distance of 10 m away from the centre of these dumpsites to 70 m down slope. However, leaching of heavy metals was found to have taken place but not to a distance as long as 200 m from the last sampling point on each dumpsite. The dumpsite also contained increased concentrations of toxic heavy metals, which may reach toxic levels through the food chain.

It is very important to analyze waste for their physico-chemical parameters before their disposal.

Phytoremediation of these heavy metals is also suggested for cleaning-up the environment of these toxic wastes.

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