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Full Length Research Paper

Soil reaction (pH) and heavy metal index of dumpsites within Uyo municipality

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The concentration of heavy metals in plants and soil of refuse dumps in Uyo, Nigeria was studied. Soil samples were collected from two dumpsites and digested with concentrated Trioxonitrate (V) acid and Tetraoxochlorate (IV) acid. The heavy metals investigated were: lead, manganese, Iron, chromium Zinc and Cadmium in two vegetables *Ipomea batatas* and *Laportea ovalifolia*. The concentrations of the heavy metals in the leaves of the vegetables were determined using Atomic Absorption Spectrophotometer (AAS). Manganese (54.3±1.4) and Iron (1013.02±8.5) were the most abundant heavy metals while Cadmium (3.7±0.2) was the least abundant across the two dumpsites. Heavy metals in plants were found to positively correlate with that present in the soil. It is therefore concluded that the consumption of leafy vegetables and crops produced on soils with elevated metal levels pose serious health risk to consumers.

Keywords: Heavy metals, pH, Dumpsites, Correlation

INTRODUCTION

Nigeria's population has increase greatly over the years; this consequently has led to the increase in human practices responsible for waste generation. Although solid waste can be an asset when properly managed, it poses the greatest threat to life amongst all the classes of waste. It has the potential of polluting the terrestrial, aquatic and aerial environments (Bishop, 2000). The Nigerian Government at all levels through their agencies (like the Federal Environmental Protection Agency-FEPA, ministry of environment and environmental sanitation authorities) has invested much in waste management and enforcement of sanitation laws but little has been achieved so far. Furthermore, the erratic growth of housing units in the urban cities, has made monitoring and management of waste difficult (Ojeshiria, 1999). These have led to indiscriminate dumping of waste at every nook and cranny of major cities in Nigeria. This study is aims at verifying if refuse dumping can substantially increase the environmental burden of heavy metals in Uyo municipality and to ascertain if eating plants from such areas pose any health threat.

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MATERIALS AND METHODS

Plant sample collection

The plant leaves used in this study were harvested from mature plants (*Ipomea batatas* and *Laportea ovalifolia*) rooted in the midst (at least 5m inwards) of the debris in two popular dump sites within Uyo metropolis. At each dump site, a total of 42 (21 leaves per species) fresh leaves were harvested and brought to the laboratory for heavy metals assay. The harvested leaves were placed under running tap to wash off the dirt. Each dumpsite had 3 groups for each species with each group consisted of 7 leaves per species of the plants used in the study.

Plant sample preparation

The leaf samples in each of the groups were air dried to remove the moisture and water droplets simultaneously. They were then dried to constant weight in an oven maintained at 105ºC, and pulverized to fine powder using a laboratory grinder. The ground leaves were collected into well labeled polythene bags and placed in a desiccator. 3.0g of each sample was carefully weighed into clean platinum crucible and ashed at 450- 500ºC then cooled to room temperature in a desiccator. The ash was dissolved in 5ml of 20% hydrochloric acid and the solution was carefully transferred into a 100ml volumetric flask. The crucible was well rinsed with distilled water and transferred to the flask and made up to the mark with distilled water and shaken to mix well. The resulting sample solutions were then taken for the determination of the heavy metal concentrations using Atomic Absorption Spectrophotometer (AAS). In all determinations, the triplicate samples agreed very well. The result given is the mean of three determinations.

Soil sample collection

Soil samples from two popular refuse dump sites in Uyo metropolis were collected in a ring form at a rooting depth of 1.35m from 6 different points (3 from each for consistency across the site) within the dump tips and stored in black polythene bags before digestion and analysis. These sites are mainly used for the dumping of domestic and sundry refuse. All the soil samples are fine to medium sand in texture.

Soil sample digestion

The temperature of the laboratory was 29.5℃ +/- (ambient temperature). Samples were ground, mixed, and divided into fine particles that could pass through a 0.5-mm sieve. Soil samples were digested by adding 2 g of soil to 15ml of concentrated nitric acid and perchloric acid at a ratio 1:1, and allowed to stand for 135 min until the mixture became colorless. The samples were filtered and washed with 15 ml of deionized water, and made up the filtrate to 100 ml in a standard flask. Six heavy metals (lead, manganese, Iron, chromium, cadmium, and nickel) were determined in the filtrate at their respective wavelengths using an atomic absorption spectrophotometer (AAS). In all determinations, the triplicate samples agreed very well. The result given is the mean of three estimations.

Laboratory procedures for soil analysis

Soil samples were analyzed following the standard procedures outlined by the Association of Official Analytical Chemist (AOAC). Soil pH were measured using Beckman's glass electrode pH meter (AOAC, 2003).

RESULTS

Site 1 pH: 8.4; Site 2 pH: 7.4

DISCUSSION

From the results shown in Table 1, it can be deduced that in the two refuse dumps, the mean concentration of cadmium is comparatively less than that obtained for the other metals. These bear similarities with the reports of other researchers (Olarinoye *et. al*., 2010). The ascending order of heavy metal content at both dump sites followed the pattern Cd<Pb<Cr<Zn<Mn<Fe.

A comparison of the mean concentrations of Fe, Pb, Zn, Mn, Cd and Cr in Table 1 with their corresponding normal range in natural soil: Fe,100-7000mg/kg; Pb,2-200 mg/kg; Zn, 10-300mg/kg; Cd, 2-200; and Cr, 2-100 mg/kg (Vacera *et al*., 1999), show that these concentrations are within their normal ranges. The mean concentrations of manganese at both sites were within the natural range in soils (20-100mg/kg) as given by Ademoroti (1990). Generally the mean concentrations of Pb, Zn and Cr are higher for soil samples from site 2 than those from site 1 with Cd, Mn and Fe as exceptions. The difference in metal concentrations between the two dump sites could simply be attributed to the nature, quality and quantity of waste deposited in the sites.

The mean levels of metals in leaves of *I. batatas* and *L. ovalifolia* is shown in Table 2. In both species, Cd ranged between 0.75to 3.25 and Pb ranged from 1.60 to 3.5 $mgkg^{-1}$. Cr present in the studied tissues had a range of 2.75 to 8.85 and Zn ranged from 5.90 to 28.10 $mgkg^{-1}$. Mn had range of values from 14.60 to 48.25 $mgkg^{-1}$ while Fe had the greatest concentrations among the metals investigated in the plant. It had values that fluctuated between 169.8 to 423.1 $mgkg^{-1}$. The relative abundances of the heavy metals as detected in the *I.batatas* and *L. ovalifolia* samples from the refuse dump sites followed the sequence: Fe>Mn>Zn>Cr>Pb>Cd. The levels of the metals in the plant were generally lower than those of the waste soils from the refuse dumpsites excepting Zn is site1 *I. batatas* and Fe in both species harvested from site 2. High soil pH can stabilize soil toxic elements resulting in decreased leaching effects of the soils toxic

Table 1. Mean (±S.E) Heavy Metal Properties of Soil of the Two Dumpsites

	Site 1	Site 2
Lead(Pb) mg/kg	16.1±0.0	17.8±0.1
Cadmium(Cd) mg/kg	4.4±0.03	3.7±0.2
Zinc(Zn) mg/kg	16.4±0.1	24.4±0.2
Chromium(Cr) mg/kg	13.9±2.6	15.8±0.75
Manganese(Mn)mg/kg	54.3±1.4	52.9±0.1
Iron(Fe) mg/kg	1013.02±7.3	143.04±0.1

Table 2. Mean (±S.E) of Heavy Metals Present in Plant Leaves from the Two Dumpsites

	Plant leaves			
	Ipomea batatas		*Laportea ovalifolia*	
	Site 1	Site 2	Site1	Site 2
Lead(Pb)mg/kg	1.70±0.1	3.5±0.2	2.6±0.1	2.0±0.1
Cadmium(Cd) mg/kg	0.85±0.05	2.2±0.1	1.0±0.1	2.4±0.0
Zinc(Zn)mg/kg	17.85±0.95	13.6±0.2	12.01±0.0	14.9±0.0
Chromium(Cr) mg/kg	8.85±0.35	6.0±0.2	8.0±0.6	5.2±0.0
Manganese(Mn) mg/kg	21.35±0.25	37.9±0.7	18.0±0.1	22.7±0.10
Iron(Fe)mg/kg	309.8±0.72	423.1±0.96	332±1.98	352.9±3.35

Table 3. Soil-Plant (Leaves) Heavy Metal Correlation Matrix

	I. ba. S_1	*I. ba.* S_1	*L.ov.* S_1	*L.ov.* S_2	Soil 1	Soil 2
I. ba. S_1	1					
I. ba. S_2	0.9998	1				
L.ov. S_1	0.9973	0.9992	1			
L.ov. S_2	0.9998	0.9995	0.9998	1		
Soil 1	0.9989	0.9999	0.9996	0.9995	1	
Soil 2	0.9643	0.9695	0.9609	0.9634	0.9606	1

elements (Li *et al.*, 2005), a possible reason for the low absorbability of the metal elements from the soil solution and subsequent translocation into plant tissues.

This study has shown that crops harvested from soils of these refuse dump sites presented higher levels of the metals when compared to similar crops from control sites. This confirms that if the level of heavy metals in soils is significantly increased, the plants have the potential of showing increased uptake of heavy metals (Amusan *et al.,* 2005). Levels of heavy metals in plants as revealed in this study; are similar with earlier reports on plants growing in roadside soils in Kaduna metropolis (Okunola et al., 2008). Correlation coefficients obtained for metals ions in plants and waste soil as shown in Table 3 revealed strong positive correlations between plants tissues and soil implying that heavy metal concentrations in plant tissues, at these dumpsites, vary with that of the soil. A Similar trend had been observed by Alloway and Ayres, 1997. This indicated the fact that, though the current metals level in the soils of these dumpsites are within permissible limits, persistent deposition of waste materials in these sites may as well increase the heavy metal content of these soils to hazardous limits. If this occurs, usage in traditional medicine or consumption of plant materials from these soils may incur serious health consequences (Awofolu, 2005).

CONCLUSION AND RECOMMENDATIONS

Heavy metal analysis of soil and plants growing in two dump sites in Uyo metropolis was carried out. This study highlights the potential accumulation of heavy metals in soils and tissues of plant growing in dump-sites.

Presently, the heavy metal content of the dumpsites could be said to pose no significant threat directly or indirectly to man or the environment, but the continuous dumping of refuse especially electronic and metallic waste, will eventually lead to an increase in the heavy metal burden of the dumpsites soils. Therefore, sorting and recycling of wastes should be intensified to reduce the quantity of these toxic metals at dumpsites. There is also a need for the establishment of a statutory body that can legislate and reinforce the environmental rules and regulations on the general public. Again, public enlightenment on proper handling of wastes in the society should be intensified in order to reduce wastes related problems along the food chain. Furthermore, modern wastes disposal facilities should be acquired by the authorities concerned and appropriate waste disposal sites chosen by experts to avoid indiscriminate dumping of wastes within our cities.

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