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Short communication

Seasonal variations in heavy metals concentrations in *Chromolaena odorata* (L.) King & Robinson foliage and soil at a solid waste dump site in Osun State, Nigeria

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Abstract

Variations in Fe, Pb, Cd, Cr, and Cu concentrations in *Chromolaena odorata* foliage and soil from a waste dumping site in Nigeria were determined. The data showed that all metals present in the sediments were represented in the foliage too. There were, however, significant variations in the concentrations of various metals at different sites, perhaps due to differences in land gradient. Generally higher values were noted in the wet season than in dry season. The average concentrations of Pb in the sediment (6.04±0.01 $\mu g \cdot g^{-1}$ in dry season and 7.2±0.05 $\mu g \cdot g^{-1}$ during wet season) were lower than the values observed for other metals like Fe (122±10.68 $\mu g \cdot g^{-1}$ in dry season and 146±0.44 $\mu g \cdot g^{-1}$ in wet season) and Cd (8.56±0.05 $\mu g \cdot g^{-1}$ in dry season and 10.8±0.00 $\mu g \cdot g^{-1}$ in wet season). A significant deduction from this study is that plant tissues generally increase heavy metal contamination with increasing levels of contaminants in the waste and could be an entry port of heavy metals in the food chain. The important interactive roles of *C. odorata* in waste site may therefore provide information for heavy metal decontamination.

Keywords: Bioaccumulation, Heavy metal contamination, Seasonal variations

Migration and bioaccumulation of heavy metals to the extent of damaging the ecological balance are consequences of environmental pollution (Akinola and Ekiyoyo, 2006). Several authors have investigated heavy metal contamination of soil and vegetation in the vicinity of industries (Abul-Kashem and Bal Ram, 1999) and in cultivated areas (Lokeshwari and Chandrappa, 2006). However, comprehensive analysis of sediments and vegetation in the vicinity of waste site are few in Nigeria (Adewuyi, 2004; Adesoji and Farinde, 2004). Most developing countries also lack ground impermeability data to detect possible heavy metal contamination for quick management interventions. Plants growing in the vicinity of waste dumping sites, however, absorb such heavy metals. Siam weed (*Chromolaena odorata* (L.) King & Robinson), an invasive plant (Muniappan et al., 2005) which grows widely in and around waste dumps, thus can function as an environmental monitor and may play a potential role in phytoremediation too. The present study was undertaken to assess the extent of heavy metal contamination in a waste dumping site in Nigeria and to investigate the uptake of five heavy metals by *C. odorata*.

Chromolaena odorata plants and soil samples were collected from four different locations in the vicinity of a waste dumping site at Ede in Osun State, Nigeria ($7^o15''$ to $7^o30''$ N and $4^o32''$ to $4^o7''$ E, ~1500 m above sea level; Fig. 1). Ede is a medium sized town with population less than 100,000 (Adesoji and Farinde, 2004). The climate of Ede is influenced by tropical maritime and tropical continental air masses and supports tropical rainforest vegetation. Mean annual

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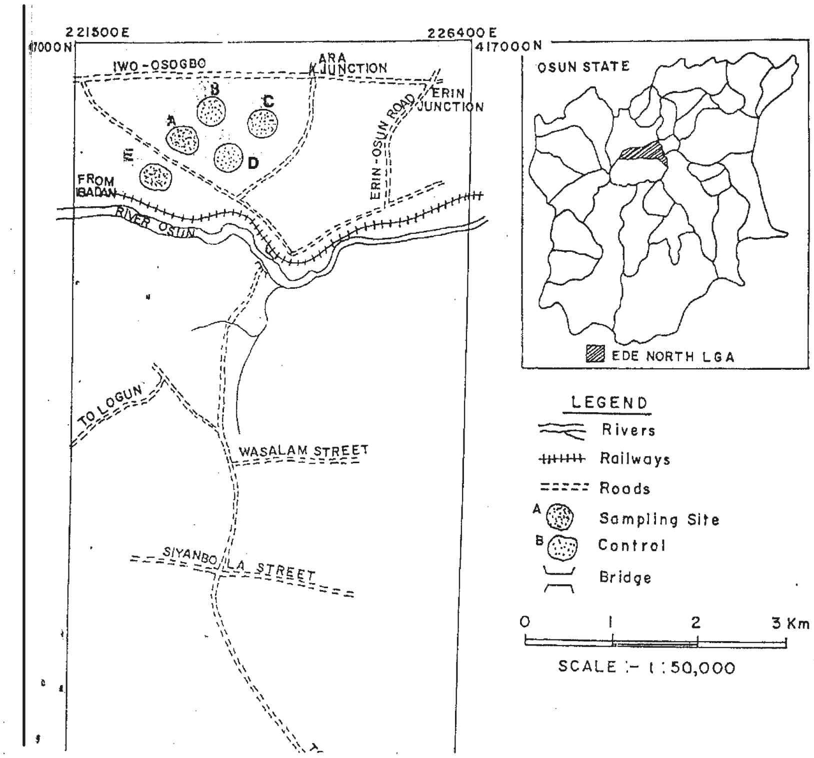

Figure 1 Locations and sampled areas in Ede North Osun State, Nigeria.

rainfall is ~1413 mm, while the mean annual temperature ranges from 22.5 to 31.4°C. Basic descriptions of the sampling sites are as follows: Site A, with large quantities of organic matter (green leaves used for wrapping foods) on raised flat section of the entire dumping site; Site B, located on a more elevated ground with mixed organic materials and other waste products such as chemical containers, beverage bottles, and other unidentified matters; Site C, predominantly consisting of house-hold products such as discarded mattresses, waste furniture, and other materials; Site D, with pharmaceutical wastes, old hospital equipment, bedding fabrics, various assorted spent cartridges, cans and mixed unidentified materials; and Site E (control), represents the nearby non-polluted area of secondary regrowth on flat lands. These locations were selected on the basis of continual waste dumping and abundance of *C. odorata*. Sites A to D were located within a radius of ~50 m, while the control site was about 2 km away from the other four sites. These sites were originally designed to function as sanitary landfills, since 1975, but now turned more into open dumps where a host of human scavengers make a living under unhygienic conditions (Salami, 1995). Although the Osun State Environmental Protection Agency (OSEPA) was set up in 1985 for effective management of solid wastes, political interference and bureaucratic ineptitude are major banes (Salami, 1995), leading to ineffective waste management.

Triplicate soil samples from the five locations in the general dumping site were collected using a 2.5 cm diameter soil auger from random soil heaps at each site (0 to 30 and 30 to 60 cm depths). Sample collection was done in the dry (January to May) and wet (July to October) seasons of 2006 and the samples stored in sterile polythene bags. For *C. odorata* sampling, 10 random line transects were laid out in each 20 × 20 m sample plot, and at 1 m intervals along the line transect, a pin-point rod was dropped. Leaf samples were collected from 20 systematic points along each transect hit by the rod. The leaves were washed in the laboratory and oven-dried at 80°C till constant weights. The dried samples were pulverized into a fine powder in an SNA 505 (Peppink Deventer) laboratory stainless grinder for chemical analysis. To extract the metals, 2.0 g of ground samples were ashed in a furnace for 3 h at 6000°C, cooled to room temperature in a dessicator, and the ash dissolved in 5 ml HCl. A Perkin Elmer Analyst 300 flame atomic absorption spectrometer (AAS) was used to quantify Fe, Pb, Cd, Cr, Cu concentrations using a specific lamp for each metal at wavelengths of 248, 283, 229,358, and325 μm respectively (Perkin Elmer Corporation, 1996). Limits of detection were 0.1 μg and recovery of spike samples were 92–98%. Statistical analyses of the data were performed using paired *t*-test, employing SPSS statistical package. Means of duplicate analysis from 10 samples of each plants and sediments are reported.

As can be seen from Table 1, the values obtained for *C. odorata* foliage for all elements in the wet season were markedly higher than those of the dry season. Fe concentrations exceeded that of Pb, Cd, Cr, and Cu in both wet and dry seasons (Table 1). Site D also had the highest contaminant levels in both seasons, which was significantly superior to A and C ($p<0.05$). Metal accumulation in *C. odorata* observed in the present study is consistent with the results of previous studies. For example, Garay et al. (1998) observed that *Phaseolus vulgaris* is a good accumulator of Pb and Cd. Likewise, Smirnoval et al. (2006) found that *Brassica juncea* (Indian mustard) accumulates Pb, Cr, Cd, Cu, Ni, Zn, B, and Se.

Heavy metal concentrations in the sediment during dry and wet seasons and at different depths are shown in Table 2. Sites C and D, which showed high metal

Table 1. Concentrations of heavy metals in *Chromolaena odorata* foliage in two seasons at Ede, Osun State, Nigeria.

Sample	Fe		Pb		Cd		Cr		Cu	
Sites	Dry	Wet	Dry	Wet	Dry (µg·g^{-1})	Wet	Dry	Wet	Dry	Wet
A	38±5.10	45.8±8.21	4.15±0.04	4.83±0.13	0.10±51	1.61±52	1.24±0.8	1.11±0.20	1.68±0.10	1.80±0.9
B	36.25±4.35	43.32±6.45	2.13±0.04	2.25±0.01	2.45±0.20	1.82±0.31	1.01±0.42	1.16±0.68	1.63±0.22	2.50±0.30
C	56.24±2.28*	58.65±5.17*	6.02±0.28	6.55±1.06	2.42±0.33	1.85±0.05	2.10±0.37	2.15±0.20	1.35±0.01	1.83±0.31
D	66.95±19.60*	80.65±8.60*	8.375±1.32	10.82±0.53	1.61±0.66	1.98±0.16	2.05±1.30	3.09±0.21	1.74±0.08	1.84±0.02
E	20.20±1.70	22.24±3.28	2.50±0.63	2.92±0.01	BDL	BDL	BDL	BDL	0.27±0.02	0.18±0.41

Site A, large quantities of organic matter on raised flat section; Site B, more elevated ground with mixed organic materials and other waste products; Site C, consisting of house-hold products; Site D, with pharmaceutical wastes, old hospital equipment, bedding fabrics, various assorted spent cartridges, cans and mixed unidentified matters; and Site E (control), nearby non-polluted area of secondary regrowth on flat lands.
* Significantly different from control $p<0.05$; BDL = Below Detection Level; wet and dry denote wet and dry seasons.

Table 2. Soil concentrations of heavy metals at two depths and in two seasons at Ede, Osun State, Nigeria.

Sample	Fe		Pb		Cd		Cr		Cu	
Sites	Dry	Wet	Dry	Wet	Dry (µg·g^{-1})	Wet	Dry	Wet	Dry	Wet
A_1	122±10.68*	145±44*	6.04±0.01	7.2±0.05	8.56±0.05	10.8±0.00	4.02±0.06	7.87±0.12	2.15±0.08	3.47±0.66
A_2	126±9.53*	154±82.5*	7.12±0.01	8.52±0.54	8.72±0.2	10.±0.44	4.70±0.03	5.85±0.11	2.92+0.12	3.21±0.38
B_1	126±7.26*	151±12*	3.21±0.11	3.60±0.01	8.02+0.01	10.1±1.15	3.25±0.09	4.15±0.05	2.50±0.01	2.9±0.38
B_2	138±10.38*	166±92*	5.52±0.60	6.24±0.41	8.57±0.14	12.47±3.36	4.89±0.08	7.47±0.14	2.67±0.05	3.66±0.01
C_1	156±12.99*	187±102*	8.07±0.14	9.6±1.5	9.72±0.74	11.28±0.02	4.02±0.01	6.37±1.01	2.54±0.11	3.37±0.01
C_2	155±9.24*	150±45*	9.50±0.72	10.48±1.01	6.09±0.61	7.01±0.07	4.05±0.16	5.13±0.01	3.42±0.02	2.56±0.25
D_1	193±10.54*	232±59*	10.02±0.01	12.47±3.36	10.12±0.00	12.6±0.06	4.42±0.11	6.65±0.02	2.51±0.01	3.14±0.32
D_2	209±8.74*	251+105*	12.95±0.23	15.39±0.54	12.0±20.06	14.35±0.54	5.57±0.20	6.34±0.04	3.72±0.20	3.85±2.2
E_1	25.08±1.01	30±9.4	2.50±0.62	3.6±0.01	3.09±0.62	5.15±0.05	BDL	BDL	BDL	BDL
E_2	22.84±0.0	26±2	2.89±0.10	3.66±0.01	3.24±0.08	6.55±2.40	BDL	BDL	BDL	BDL

Site A, large quantities of organic matter on raised flat section; Site B, more elevated ground with mixed organic materials and other waste products; Site C, consisting of house-hold products; Site D, with pharmaceutical wastes, old hospital equipment, bedding fabrics, various assorted spent cartridges, cans and mixed unidentified matters; and Site E (control), nearby non-polluted area of secondary regrowth on flat lands. Wet and dry denote wet and dry seasons.

$_1$= 0 – 30 cm depth
$_2$= 30 – 60 cm depth
BDL = Below Detection Level
* =significantly different from control $p<0.05$.

concentrations in *C. odorata* foliage during both seasons, also had higher levels of metal contamination in the soil than other sites and could possibly be the result of having varying quantities of chemicals and mixed organic matter contents. However, average concentration of Pb in the sediment (6.04±0.01 $\mu g \cdot g^{-1}$ in the dry season and 7.2±0.05 $\mu g \cdot g^{-1}$ in the wet season) was lower than the values observed for Fe (122±10.68 $\mu g \cdot g^{-1}$ during dry season and 146±0.44 $\mu g \cdot g^{-1}$ in the wet season) and Cd (8.56±0.05 $\mu g \cdot g^{-1}$ in dry season and 10.8±0.00 $\mu g \cdot g^{-1}$ in wet season; Table 2). Seasonal variations in Pb and Fe in the sediment were also significant ($p<0.01$); higher values were noted during the wet season compared to the dry season.

Terrestrial plants can be used to assess the impacts of contaminants and may yield useful information regarding heavy metal uptake. Concentrations detected in *C. odorata* foliage showed a one-to-one correspondence with the background concentrations of the heavy metals. The consistent trends suggest the potential use of *C. odorata* as a metal accumulator and a screening tool to identify heavy metal contamination in the environment. Furthermore, bioaccumulation of metals from waste dump sites provides baseline data and there is need for intensive sampling and monitoring of these sites to prevent potential health hazards–of metals entering the food chain.

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