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Heavy Metals Accumulation by *Talinum triangulare* grown on Waste Dumpsites in Uyo Metropolis, Akwa Ibom State, Nigeria

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Abstract: The accumulation of some heavy metals by *Talinum triangulare* grown on waste dumpsites in Uyo Metropolis was studied using atomic absorption spectrophotometer. Results obtained indicated the following ranges for the metals in dumpsite soil: Cd: 1.85-8.65 mg kg^{-1}; Pb: 42.05-60.85 mg kg^{-1}; Ni: 11.05-20.55 mg kg^{-1}; Fe: 183.00-237.20 mg kg^{-1} and Zn: 11.35-119.30 mg kg^{-1}, while the ranges in *Talinum triangure* were Cd: 0.10-0.30 mg kg^{-1}; Pb: 0.33-1.55 mg kg^{-1}; Ni:0.05-0.45 mg kg^{-1}; Fe: 223.43-260.00 mg kg^{-1} and Zn: 2.20-29.95 mg kg^{-1}. These results indicated higher levels of the metals in soils and plants from dumpsites than the values recorded in the Control samples. In the dumpsite soil and plant samples, Fe recorded the highest mean concentrations in both samples while Cd and Ni concentrations were the lowest in soil and plant respectively. Although, the ranges obtained for the metals in plant and soil were within the recommended limits except for Cd in soil and Fe in plant, it maybe risky to consume water leaf grown on dumpsites since it can accumulate much of these toxic metals. The results obtained also revealed that apart from Cd, the concentrations of other metals analyzed for in plant and soil correlated positively at $p = 0.05$. The transfer Ratio between dumpsite soil and plant samples indicated the following trend: Fe>Zn>Cd>Pb>Ni showing that the rate of metal uptake by *T. triangulare* was greatest with Fe, while the rate of Ni uptake was the least. Relative standard deviations in the distribution of the metals in plant and soil samples from one dumpsite to the other were also studied; results obtained showed a high degree of variability in the distributions of the metals in both samples with the locations.

Key words: Heavy metals, *Talinum triangulare,* dumpsite-soil, contamination, correlation, Uyo

INTRODUCTION

Heavy metals concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities such as agricultural practices, industrial activities and waste disposal methods (Ndiokwere and Ezehe, 1990; Zauyah *et al*., 2004; Usman *et al*., 2002; Eja *et al*., 2003). Contamination and subsequent pollution of the environment by toxic heavy metals has become an issue of global concern due to their sources, widespread distribution and multiple effects on the ecosystem (Nriagu, 1990).

Studies have shown that soils at refuse dumpsites contain different kinds and concentrations of heavy metals, depending on the age, contents and location (Udosen *et al.,* 1990; Odukoya *et al*., 2000). In recent times, it has been reported that heavy metals from waste dumpsites can accumulate and persist in soils at an environmentally hazardous levels (Alloway, 1996; Amusan *et al*., 2005). In Nigeria, leachates from refuse dumpsites constitute a source of heavy metal pollution to both soil and aquatic environments (Odukoya *et al*., 2000 and Oni, 1987). Nevertheless, most abandoned waste dumpsites in Nigeria and Uyo have been used extensively as fertile grounds for cultivating varieties of vegetables. Even though, research works have indicated that some common vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soils (Cobb *et al*., 2000; Xiong, 1998; Garcia *et al*., 1981; Benson and Ebong, 2005). This constitute serious health and environmental concern because of the phytotoxicity of these metals to the plants and the potentially health implications to humans and animals consuming such vegetables (Ellis and Salt, 2003; Pillay *et al*., 2003; Micieta and Murin, 1998).

Transfer Coefficients or bio-concentration factor (BCF) which is the ratio of the metal concentration in plant to the metal concentration in the soil environment is a convenient and reliable way of quantifying the relative differences in bio-availability of metals to plants (Haynes and Toohey, 1998; Canterford *et al*., 1978; McEldowney *et al*., 1994). However, soil pH, organic matter content, plant specie, age, binding capacity can have marked influence on plant uptake (Alloway and Ayres, 1997; Kabata-Pendias and Pendias, 1984).

Uyo Metropolis with high population density generated large quantities of waste of about 150 million tonnes per week in 1999 and the volume of is expected to

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be higher now (AKSEPA, 1999). However, the city as most cities in Nigeria does not have any environmentally friendly method of wastes disposal. Consequently, wastes are being indiscriminately and improperly disposed of within the metropolis. Thus the levels of heavy metals in both soil and plants grown within the metropolis are expected to be considerably high. This research work was undertaken to evaluate the quality of soil and plants grown on dumpsites and extrapolate the results obtained on the suitability or otherwise of such plants for human consumption. This was carried out by analyzing spectrophotometrically the levels of Cd, Pb, Ni, Fe and Zn in samples of *Talinum triangulare* and soil collected from dumpsites within Uyo metropolis.

MATERIALS AND METHODS

Samples of *Talinum triangulare* (water leaf) and soils were collected from 5 dumpsites within Uyo Metropolis, Nigeria and from a farmland which served as the Control sample. This study was carried out during the month of November, 2006 which is part of the dry season in the area under investigation. The study area lies on latitude 4° 59ˡ N and longitude 7° 54ˡ E. A total of fifteen plants and soil samples were collected from the five different dumpsites (three samples per dumpsite) into pre-cleaned polyethylene bags, the samples were air-dried for 12 days to remove moisture and later homogenized into five composite samples.

0.5 g of dried, disaggregated and sieved plant and soil samples were placed separately in 50 mL Teflon beakers and then digested with 10 mL of HNO_3-$HCLO_4$-HF to near dryness at 80-90°C on a hot plate. The digests were filtered into a 50 mL volumetric flask using Whatman No. 42 filter paper (Radojevic and Baskin, 1999; Umoren and Onianwa, 2005).

Concentrations of cadmium (Cd), lead (Pb), nickel (Ni), iron (Fe) and zinc (Zn) in the dumpsite and Control samples were determined using atomic absorption spectrophotometer model sp-9 (Pye Unicam). The mean values of three determinations per sample were recorded.

The relationship between heavy metal concentrations in soils and *Talinum triangulare* was established using Pearson's correlation coefficient method. Transfer Ratios in the soil-plant system were also calculated according to the methods of Canterford *et al.* (1978) and Oyedele *et al.* (1995).

RESULTS AND DISCUSSION

Ranges recorded for the concentration of heavy metals in soil samples from dumpsite-soil were Cd, 1.85-8.65 mg kg^{-1}; Pb, 42.05-60.85; Ni, 11.05-20.55 mg kg^{-1}; Fe, 183.00-237.20 mg kg^{-1} and Zn, 11.35-119.30 mg kg^{-1}, while the ranges of heavy metals in *Talinum triangulare* grown on dumpsite-soil were; Cd, 0.10-0.30 mg kg^{-1}; Pb, 0.33-1.55 mg kg^{-1}; Ni, 0.05-0.45 mg kg^{-1}; Fe, 223.43-260.00 mg kg^{-1} and Zn, 2.20-29.95 mg kg^{-1}.

The ranges obtained in this study for Cd; Pb; Fe and Zn in dumpsite- soil are lower than 4.65-50.50; 5.52-145.27; 289.30-360.09 and 100.85-226.62 mg kg^{-1} respectively reported in dumpsite-soil by Odukoya *et al.* (2000). While the range of Ni obtained is also higher than 7.92-19.12 μg g^{-1} reported by Alegria *et al.* (1991).

The concentrations of these metals in dumpsite soil and plant were significantly higher than their corresponding concentrations in the Control samples (Table 1 and 2). The high levels of heavy metals in the dumpsite soils and plants could be attributed to huge amounts of waste products disposed of at the dumpsites, although aerial deposition of these metals could be another source to soil and plants (Onianwa, 2001; Onianwa and Egunyomi, 1983; Yusuf *et al.*, 2003).

Cadmium levels recorded in *T. triangulare* ranged between 0.10 and 0.30 mg kg^{-1}, these low concentrations in the plant maybe attributed to the metal being non essential for plant growth and metabolism (Shauibu and Ayodele, 2002). However, levels of cadmium recorded in *T. triangulare* from dumpsite were relatively higher than the levels in the control sample; this could be attributed to the presence of Cd accumulated wastes in the dumpsites. Cadmium range recorded in *T. triangulare* is however not high enough to cause phytotoxicity. According to Vecera *et al.* (1999), phytotoxicity can occur above the range of 0.10-1.20 mg kg^{-1}. Nevertheless, the range of Cd in plant recorded in this study is higher than 0.03-0.05 μg g^{-1} but lower than 1.13-1.67 mg kg^{-1} reported by Udosen *et al.* (2006) and Yusuf *et al.* (2003), respectively.

Ranges obtained for other heavy metals in *T. triangulare* from dumpsites were 0.33-1.55; 0.05- 0.45; 223.43-260.00 and 2.20-29.95 mg kg^{-1} for Pb, Ni, Fe and Zn respectively.

The obtained Pb range is lower than 34.97-83.92 μg g^{-1} reported in *Talinum triangulare* from dumpsite by Amusan *et al.* (2005), but higher than 0.34-0.71 μg g^{-1} reported in dumpsite plant by Udosen *et al.* (2006). The highest Ni level (0.45 mg kg^{-1}) reported in this study is not in agreement with 1.33 μg g^{-1} recorded by Yusuf *et al.* (2003). Minimum and maximum concentrations of Fe accumulated by *T. triangulare* were 223.43 and 260.00 mg kg^{-1} (Table 2). Udosen *et al.* (2006), reported a range of 630.10-742.00 μg g^{-1} for Fe in *Manihot Utilissima* grown on a municipal dumpsite-soil in Nigeria.

Table 1: Levels of heavy metals (mg kg^{-1} DM) in soil samples from some waste dumpsites in Uyo metropolis

Sample location	Cd	Pb	Ni	Fe	Zn
DSS_1	8.65±1.31	50.60±7.35	2.15±0.23	237.20±28.62	11.35±0.55
DSS_2	3.05±0.14	42.05±5.91	15.90±0.85	193.15±11.43	41.95±4.76
DSS_3	1.85±0.02	47.30±4.53	11.05±1.18	183.30±21.87	119.30±23.11
DSS_4	5.15±0.17	60.85±9.85	20.55±5.44	261.90±14.33	50.25±2.07
DSS_5	2.90±0.12	45.85±6.72	14.45±2.31	205.90±29.45	96.35±5.54
Mean	4.32	49.33	12.82	216.29	63.84
Standard deviation	2.70	7.13	6.87	32.59	43.45
Range (n = 5)	1.85-8.65	42.05-60.85	11.05-20.55	183.00-237.20	11.35-119.30
Relative standard deviation (%)	63	15	54	15	68
Control	0.15	BDL	0.10	124.00	24.20

Table 2: Levels of heavy metals (mg kg^{-1} DM) in *Talinum triangulare* from some waste dumpsites in Uyo metropolis.

Sample location	Cd	Pb	Ni	Fe	Zn
DSP_1	0.10±0.04	1.55±0.13	0.05±0.01	241.03±32.53	24.43±2.41
DSP_2	0.23±0.01	1.08±0.02	0.05±0.03	253.25±19.92	2.20±0.11
DSP_3	0.15±0.03	0.33±0.01	0.10±0.01	239.00±14.87	29.95±0.86
DSP_4	0.18±0.01	1.35±0.02	0.45±0.03	260.00±12.90	23.63±1.24
DSP_5	0.30±0.07	0.55±0.01	0.15±0.02	223.43±25.71	10.55±0.04
Mean	0.19	0.97	0.16	243.34	18.15
Standard deviation	0.08	0.52	0.17	14.11	11.41
Range (n = 5)	0.10-0.30	0.33-1.55	0.05-0.45	223.43-260.00	2.20-29.95
Relative standard deviation (%)	40	53	105	6	63
Control	0.03	BDL	0.03	78.38	0.63

However, the Fe range obtained in this study is higher than the range of 44.09-88.18 μg g^{-1} reported in *T. triangulare* from a dumpsite in Obafemi Awolowo University, Ife, Nigeria by Amusan *et al.* (2005). The range obtained for Zn in this study is higher than 19.23-24.73 μg g^{-1} also reported in *T. triangulare* from Ife dumpsite by Amusan *et al.* (2005). Variations in the concentrations of these metals in this study with previous works could be attributed to difference in the study area, age and composition of dumpsite, age of plant, soil and environmental conditions. Nevertheless, the general findings in this study are in agreement with the reports by Odukoya *et al.* (2000), Udosen (1994), Udosen *et al.* (2006), Amusan *et al.* (2005) and Yusuf *et al.* (2003), that dumpsite soils and plants have higher metal concentrations than their corresponding levels in soil and plants samples from Control sites.

Ranges obtained in this study except for Fe were within the recommended ranges in plants, 0.10-5.00, 0.10-5.00, 20-100 and 15-200 mg kg^{-1}, respectively by Vecera *et al.* (1999). The elevated range of Fe in *T. triangulare* obtained in this study could be attributed to the importance of the metal in plant growth, the high availability of iron containing wastes and the abundance of the metal in the earth crust (Ebong *et al.*, 2004; Harrison and Chirgawi, 1989). However, since *T. triangulare* is widely used in Uyo, the elevated Fe levels calls for concern as it can cause some health implications such as vomiting, upper abdominal pain, pallor, cyanosis, diarrhea, dizziness, shock, haemochromatosis, diabetes, diseases of liver, lungs and kidney, haepatoma and cardinomyopathy to the consumers (Dupler, 2001; Ferner, 2001). These concentrations were also higher than values recorded in *T. triangulare* obtained from a neighbouring garden (Table 2). This indicates that dumpsites contributed significant levels of these metals to the environment.

The mean concentrations of heavy metals in the dumpsite soil were 4.32, 49.33, 12.82, 216.29 and 63.84 mg kg^{-1} for Cd, Pb, Ni, Fe and Zn. These results indicate that dumpsites contributed considerable amounts of these metals to the soil environment and this should be closely monitored and controlled to forestall the health effects associated with the toxicity of these metals. The Control samples recorded relatively lower concentrations of the metals than their corresponding levels in dumpsite which also confirmed that dumpsites contributed some amounts of these metals to the environment.

The distribution pattern of heavy metals between the different dumpsite soils and plants were highly variable. This could be attributed to the variations in age and contents of the dumpsites. This could also be attributed to the impacts of the dumpsites on the environment.

Results obtained from this study revealed that Fe concentrations in *T. triangulare* from dumpsites were relatively higher than their corresponding levels in the dumpsite soils. Iron was predominantly detected in soil and plant samples more than other metals.

The relationship between heavy metal concentrations in soil and *T. triangulare* was determined using Pearson's correlation coefficient at p = 0.05. The following Results

Table 3: Transfer ratio of heavy metals from dumpsite-soil to *T. triangulare*

Sample location	Cd	Pb	Ni	Fe	Zn
DS_1	0.012	0.031	0.023	1.016	2.152
DS_2	0.074	0.026	0.003	1.311	0.052
DS_3	0.081	0.007	0.009	1.304	0.251
DS_4	0.034	0.022	0.022	0.993	0.470
DS_5	0.104	0.012	0.010	1.085	0.110
Mean	0.062	0.020	0.013	1.142	0.607
Range	0.012-0.104	0.007-0.031	0.003-0.023	0.993-1.311	0.052-2.152

were obtained -0.60, 0.45, 0.68, 0.49 and 0.13 for Cd, Pb, Ni, Fe and Zn respectively. These results indicate that apart from Cd, other metals correlated positively with the rate of their uptake by *T. triangulare*. The negative value recorded by Cd indicates that as the concentration of Cd in soil increases, the rate of its uptake by *T. triangulare* decreases. The rate of metal uptake by the plant could have been affected by other factors such as plant age, plant specie, soil pH, nature of soil and climate (Alloway and Ayres, 1997).

Transfer ratio or bio-accumulated factor (BCF) of heavy metals from dumpsite soil and *T. triangulare*: Transfer ratio of the metals from soil to *T. triangulare* was calculated based on the methods of Canterford *et al.* (1978) and Oyedele *et al.* (1995). The trends recorded for BCF in *T. triangulare* were Fe> Zn>Cd>Pb>Ni. While ranges obtained for the transfer ratios of heavy metals in soil-plant system were Cd 0.012-0.104, Pb 0.007-0.031, Ni 0.003-0.023, Fe 0.993-1.311 and Zn 0.052-2.152 (Table 3). These results indicate that *T. triangulare* has the potential of accumulating more Fe while it can accumulate less Ni. Although some environmental factors such as pH, exchange and binding capacities might have contributed to their low transfer rates between the soil and *T. triangulare* (Udosen *et al.*, 2006).

Relative Standard Deviations (RSD) of Heavy Metal Contents in Soil and *T. triangulare*: According to Zhang *et al.* (1995), one of the best methods of assessing the variations of variables in environmental research is the use of relative standard deviations. In the dumpsite soils, Zn has the largest RSD value of 68% and this was closely followed by Cd and Ni with RSD values of 63 and 54% respectively. Lead and iron recorded the same and least value of 15% each. The differences in the degree of variability by heavy metals in the dumpsite soil maybe attributed to differences in the natural conditions of the substrate from the dumpsites (Udosen *et al.*, 2006),

In the plant samples collected from dumpsites, Ni recorded the largest RSD value of 105% followed by Zn and Pb with values of 63 and 53% respectively. Cadmium recorded RSD value of 40% while Fe recorded the least value of 6.0%. This shows that the variations in the concentration of Fe in *T. triangulare* were low. The trends in variability in soil and *T. triangulare* were Zn > Cd > Ni > Pb = Fe and Ni > Zn > Pb > Cd > Fe, respectively. The computed statistical data on the obtained levels of heavy metals in soil and *T. triangulare* are presented in Table 1 and 2 respectively.

CONCLUSIONS

The results obtained from this study have shown high levels of heavy metals in soil and *Talinum triangulare* obtained from the various dumpsites. It has also revealed that concentrations of most of the metals analyzed for in plants varied positively with their corresponding levels in soil. Although the levels obtained for most of the metals were within the acceptable standards, indiscriminate dumping of refuse and cultivating edible plants on dumpsite soils should be discouraged as an unpleasant situation may result.

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