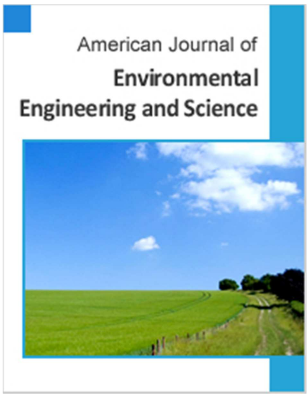
American Journal of Environmental Engineering and Science
2015; 2(6): 100-108

ISSN: 2381-1153 (Print); ISSN: 2381-1161 (Online)

American Association for Science and Technology



Keywords
Metal,
Bioaccumulation,
Human Health,
Risk Assessment,
Ibii

Received: November 8, 2015
Revised: November 20, 2015
Accepted: November 22, 2015

Health Risk Assessment of the Quality of Plants Cultivated Around Eluogo and Agboogo Ibii Aged Dumpsites in Ibii, Afikpo North L.G.A. of Ebonyi State, Nigeria

N. A. Obasi[1, 2, *], S. E. Obasi[2], R. I. Igbolekwu[2], J. O. Nkama[2], S. O. Eluu[2]

[1]Department of Medical Biochemistry, Federal University Ndufu-Alike, Ikwo-Ebonyi State, Nigeria
[2]Department of Science Laboratory Technology, Akanu Ibiam Federal Polytechnic Unwana-Ebonyi State, Nigeria

Email address
naobasi@yahoo.com (N. A. Obasi)

Citation
N. A. Obasi, S. E. Obasi, R. I. Igbolekwu, J. O. Nkama, S. O. Eluu. Health Risk Assessment of the Quality of Plants Cultivated Around Eluogo and Agboogo Ibii Aged Dumpsites in Ibii, Afikpo North L.G.A. of Ebonyi State, Nigeria. *American Journal of Environmental Engineering and Science.* Vol. 2, No. 6, 2015, pp. 100-108.

Abstract

This study investigated the uptake of heavy metals by edible plants cultivated around Eluogo and Agboogo Ibii dumpsites in Ibii, Afikpo North, Ebonyi State, Nigeria using standard protocols. The mobile and lethal fractions of the total metals in the dumpsites soils in the plants' ecosystem were also investigated. The samples were obtained from the vicinity of Eluogo and Agboogo Ibii dumpsites in Ibii and a nearby farm land (control site). Results showed that total extractable metals were significantly higher ($P < 0.05$) in the dumpsites compared to control site. Results of speciation indicated that Mn, Fe, Zn, Pb, Cd and Ni had more than 70% non-residual fractions. The mean order of mobility and bioavailability of the metals were: Mn > Fe > Zn > Cd > Pb > Cr > Ni > Cu in the sites. Total mean metal concentration in *Amaranthus hybridus*, *Telfeleria occidentalis*, *Talinum triangulare*, and *Ipomea batatas* were significantly higher ($P < 0.05$) in the dumpsites samples compared to control site. The different plants' metals absorption and translocation indices varied and indicated that the plants have varied potentials for phytoextraction and phytostabilization of the metals. The health risks implications of the results were discussed based on established regulatory standards.

1. Introduction

The effects of solid waste on health and environment have been a concern of the global world over the years, Ogwueleka, (2009) [1], Abul, (2010) [2]. Solid wastes are sources of pollution because they introduce substances such as heavy metals and organic products into the environment at levels that impact negatively to the ecosystem. Environmental metals are non-biodegradable and they are toxic to flora and fauna in the ecosystem when they exceed their threshold limit, Krissanakriangkrai *et al.*, (2009) [3], Ozturk *et al.*, (2009) [4], Benjamin and Mwashote, (2003) [5], Ikem *et al.*, (2003) [6],. Dumpsites depending on age support flora and fauna due to the high organic manure contents which makes the soil fertile.

In Nigeria especially in the South-East as in most undeveloped countries of the world, most refuse dumpsites are extensively used for cultivating varieties of edible vegetables and plant based food stuffs. These plants accumulate varying degrees of metals in these dumpsites, Obasi *et al*., (2014) [7], Obasi *et al*., (2012) [8], Benson and Ebong, (2005) [9], Cobb *et al*., (2000) [10]. Reports have shown varying levels of toxicity effects of these metals in food chain and food web within the ecosystem, Ellis and Salt, (2003) [11], Jarup, (2003) [12]. Routine assessment of the heavy metal contents of plants grown on refuse dumpsites do not only provide data on the safety and wholesomeness of such edible plants but also provides an invaluable data on the heavy metals phytoaccumulation potentials of such plants, McIntire and Lewis, (1997) [13], Raskin *et al*., (1997) [14].

Ibii community is suburb in Afikpo North L.G.A., Eboyi State, Nigeria. Eluogo and Agboogo Ibii dumpsites are the two major dumpsites in Ibii community where the residents dump all sorts of their domestic refuse for over the years. The preoccupation of the residents in these areas is farming and they extensively use these dumpsites and their surrounding as arable lands for cultivating varieties of edible vegetables and plant-based foodstuff. Since there is no routine assessment of the associated health risks, there may be danger along the food chain and food web due to the non-biodegradable nature and associated toxic effects of heavy metals. This research is therefore aimed at providing baseline data on soil-plant transfer of heavy metals in this area in order to assess the futuristic health risks associated with such practice.

2. Materials and Methods

2.1. Refuse Waste Soil Collection

Refuse waste soils were collected from two dumpsites, Eluogo Ibii (Latitude 06° 59′ 07.41″, Longitude 007° 26′ 18.25″) and Agboogo Ibii (Latitude 06° 58′ 52.23″, Longitude 007° 25′ 54.15″) and from the control site (Latitude 06° 58′ 11.26″, Longitude 007° 25′ 14.35″), which is a farm land situated within the region. Triplicate sample from each dumpsite and control site were collected ten meters within the vicinity of the sites and composite samples were made in the laboratory. The samples were air dried, ground using manual soil grinder (DGSI Geotechnical instrumentation Model S-178), sieved (using 2mm sieve), put in polythene bags and kept in glass desiccators (Baroda Scientific Glass Works) until analysis. During soil sample collection, care was taken to ensure that top soil at 0-20 cm depth from the rhizosphere of the studied plants were obtained from each site from where plant samples were rooted.

2.2. Dumpsite/Control Site Plant Sample Collection

Four cultivated edible plant species within each study location: *Amaranthus hybridus*, *Telfeleria ocidentlis, Talinum triangulare*, and *Ipomea batatas* were obtained and used for the study. A total of 6-10 plant samples of each plant species were randomly uprooted and collected from each of the dumpsite and control site and separately mixed to form a composite sample, placed in labeled pre-cleaned polythene bags and transported within 14 hrs to the Chemistry Laboratory of National Research Institute for Chemical Technology, Zaria, Nigeria for further analysis. Before analysis, plant roots and a mixture of the stems and leaves (shoots) were carefully removed and washed (for 2-3 minutes approximately) with tap water and deionized water to remove any soil and surface dust. Plant samples were dried at room temperature for a day, oven dried at 80°C to constant weight and pulverized to fine powder using milling grinder (Thomas Wiley Model 4). Ground plant samples collected in labeled pre-cleaned polythene bags were stored in glass desiccators (Baroda Scientific Glass Works).

2.3. Physicochemical Analysis of Samples

Soil pH was determined using digital pH meter (Jenway 3015) at a ratio of 1:2.5 soil/water according to the procedure described by Bates (1954) [15]. Soil electrical conductivity was determined using digital electrical conductivity meter (Jenway 615D) according to the procedure outlined by Whitney (1998) [16] with some modifications. The soil moisture content was determined according to the procedure outlined by APHA (1998) [17] while the cation exchange capacity of the soil samples were determined by ammonium saturation method described by Dewis and Freitas (1970) [18]. Organic carbon and organic matter were determined according to the procedure outlined by Osuji and Adesiyan (2005) [19] while total nitrogen was determined as described by Yeomans and Bremmer (1991) [20]. SO_4^{2-} was quantified by the procedure described by Butters and Chenery (1959)[21] and PO_4^{3-} was determined by procedure described by Olsen and Sommers (1982) [22] respectively.

2.4. Sequential Extraction of Heavy Metals

The conventional method developed by Tessier *et al.* (1979) [23] as outlined with modifications in Obasi (2012) [24] was employed for the sequential extraction of heavy metals.

2.5. Determination of Heavy Metals in Plant Species

The mineral elements comprising cadmium (Cd), copper (Cu), manganese (Mn), lead (Pb), zinc (Zn), iron (Fe), nickel (Ni) and chronium (Cr) were determined according to the procedure described by Obasi (2012) [24] using atomic absorption spectrophotometer (Bulk Scientific Model 210 VGP).

2.6. Determination of Phytoremediation Quotient

The translocation factor (TF) defined as the ratio of heavy metals in plant shoot to that in plant root was calculated using the procedure described by Cui *et al.* (2007) [25].

i.e. Translocation factor (TF) $=[\text{Metals}]_{\text{shoot}} / [\text{Metals}]_{\text{root}}$

The biological concentration factor (BCF) was calculated as metal concentration ratio of plant roots to soil as described by Yoon *et al.* (2006) [26].

i.e. Biological concentration factor (BCF) $= [\text{Metals}]_{\text{root}} / [\text{Metals}]_{\text{soil}}$

Biological accumulation coefficient (BAC) was calculated as a ratio of heavy metal in shoots to that in soil as described in the procedure by Li *et al.* (2007) [27].

i.e. Biological accumulation coefficient (BAC) $= [\text{Metals}]_{\text{shoot}} / [\text{Metals}]_{\text{soil.}}$

2.7. Statistical Analysis

The experimental results were expressed as mean ± standard deviation (SD) of triplicate determinations. Analysis of variance for all the measured variables was performed by SPSS version 9.2 (Inc., Chicago, USA) software and significant differences were shown at $P < 0.05$ (Kerr *et al.*, 2002) [28].

3. Results

The results of soil physico-chemical properties are shown in Table 1. Results obtained showed that mean pH, electrical conductivity, moisture, cation exchange capacity, total organic carbon, total organic matter, total nitrogen, phosphate, and sulphate, were significantly higher ($P < 0.05$) in the dumpsites compared to control site. The results also showed that the values obtained for all the physicochemical parameters were significantly higher ($P < 0.05$) in Eluogo Ibii dumpsites compared to the values obtained at Agboogo Ibii dumpsites except for total sulphate and carbon:nitrogen ratio whose values were significantly lower ($P < 0.05$) in Agboogo Ibii dumpsites compared that that in Eluogo Ibii dumpsite. The results of the sequential extractions of the heavy metals are shown in Tables 2a and 2b. The results indicated that total extractable metals were significantly ($P < 0.05$) higher in all the dumpsites compared to the control site. The results indicated that the total extractable Cd, Cu, Mn, Zn and Fe were higher at Eluogo Ibii dumpsite than at Agboo Ibii dumpsite while that for Pb, Ni and Cr were higher at Agboogo Ibii dumpsite than at Eluogo Ibii dumpsite. Higher percentages (%) of the non-residual fraction were observed for all the metals studied except Cu in all the sites as shown in Fig 1. The mean percentage order of mobility and bioavailability of these metals (Fig 1) were: Mn > Fe > Zn > Cd > Pb > Cr > Ni > Cu.

The results of total heavy metals concentration (mg/kg) in roots and shoots of plant species are shown in Tables 3a and 3b. Total mean concentration of metals in different parts of *Amaranthus hybridus*, *Telfeleria ocidentalis, Talinum triangulare* and *Ipomea batatas* were significantly higher ($P < 0.05$) in the dumpsites compared to control site. The results also showed that different plant species absorbed metals at varying concentrations in their various parts (Tables 3a and 3b). The results (Fig 2) indicated that Translocation Factor (TF) values vary from one plant species to another and from one heavy metal to another. The results indicated that *A. hybridus* and *T. ocidentalis* had TF > 1 for all the metals except Cu and Pb in all the sites, *T. triangulare* had TF > 1 for all the metals except Cu in all the sites while *I. batatas* had TF > 1 for all the metals in all the sites (Fig 2). Fig 3 shows the results of Biological Concentration Factor (BCF) of the four plant species for the different metals. The results (Fig 3) showed that all the plants had BCF >1 for Cd and Cu only in all the sites and that the BCF of the plants was always higher in control sites than in dumpsites. The results of Biological Accumulation Coefficient (BAC) are shown in Fig 4. The results (Fig 4) showed that all the plants had BAC> 1 for Cd in all the sites with the plants in the control sites having higher BAC values than those in the dumpsites in all cases.

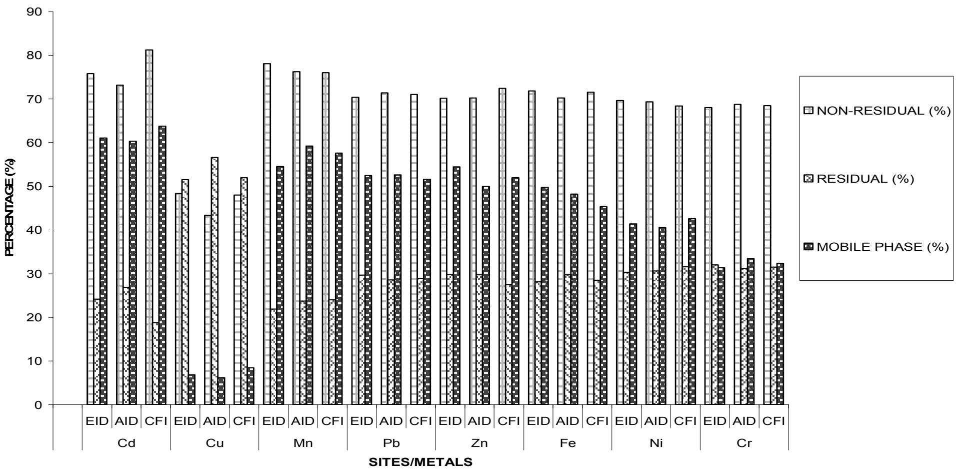


Fig. 1. Percentage (%) non-residual, residual and mobility (bioavailable) metals of waste soils in studied dumpsites.

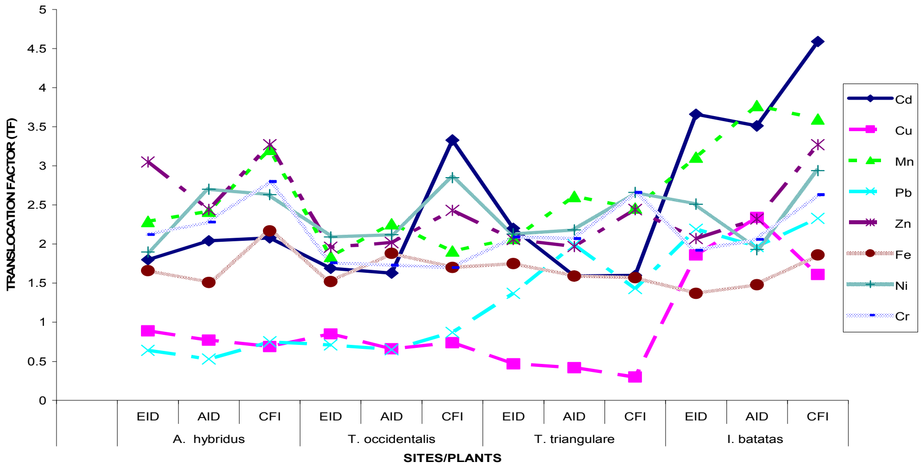


Fig. 2. Translocation factor (tf) of plants for all the metals in the studied sites.

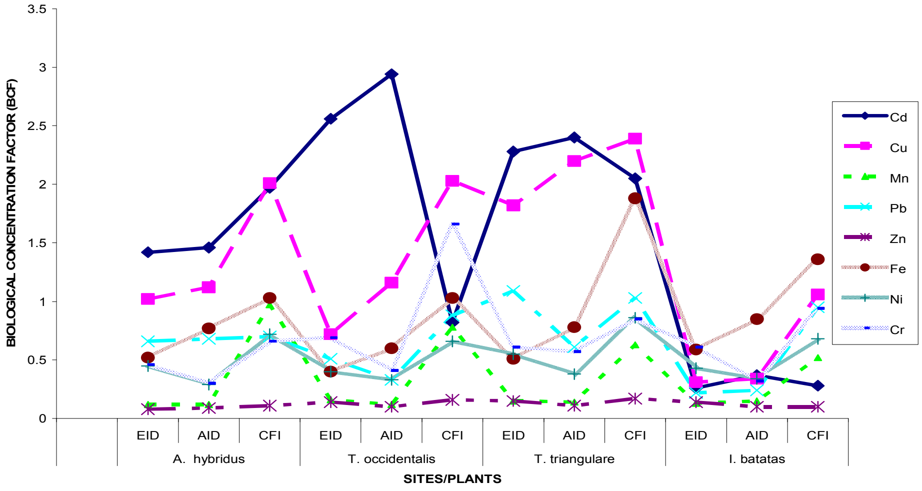


Fig. 3. Biological concentration factor (bcf) of plants for all the metals in the studied sites.

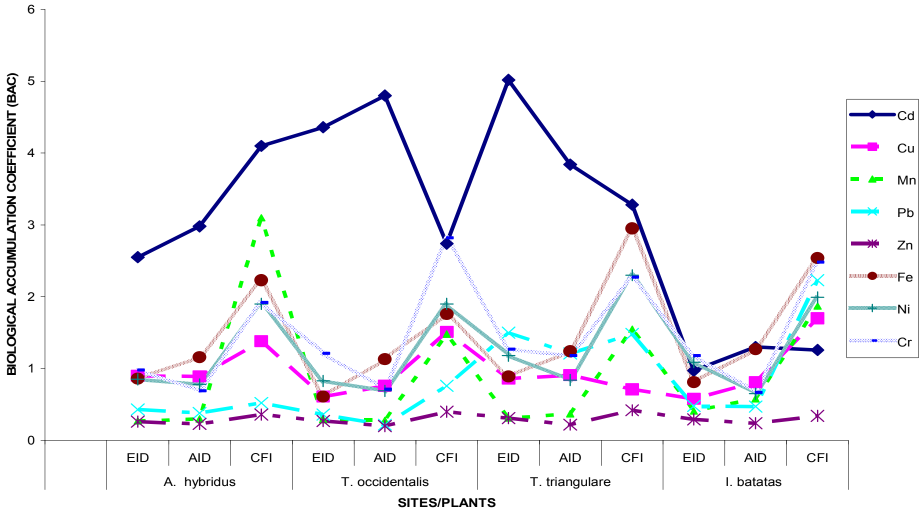


Fig. 4. Biological accumulation coefficient (bac) of plants for all the metals in the studied sites.

4. Discussion

The pH of the dumpsites showed that the soils were alkaline. Similar reports on dumpsites abound, Uba *et al*., (2008) [29], Obasi, (2012) [24], Obasi *et al*., (2014) [7], Obasi *et al*., (2012) [8]. The high conductivity value of the waste soil (Table 1) is an indication that there are high soluble salts in the soil and this may be due to the presence of metal scraps in the refuse dumpsite, Karaca, (2004) [30], Arias *et al*., (2005) [31], Obasi, (2012) [24]. The moisture content was generally high and this may be due to the overall climatic condition of the area under study. The cation exchange capacity fall within permissible range for agricultural lands and this may have contributed to the fertility of the soil, Yoo and James, (2002) [32]. Cation exchange capacity directly influences the capacity of heavy metals absorption and since the absorption behavior depends on a combination of the soil properties and the specific characteristics of the element, the high cation exchange capacity values obtained in this study implicates that the dumpsites soils will contain high concentrations of heavy metals. The mean percentages of total organic carbon (TOC) and total organic matter (TOM) values were high compared to those reported by Enwezor *et al*. (1988) [33]. TOC and TOM serve as an important indicator of the soil as a rooting environment, Okalebo *et al*., (1993) [34]. The high concentration of the total nitrogen, PO_4^{3-}, SO_4^{2-} and the high ratio of carbon to nitrogen (C:N) in the refuse waste soils may have contributed to overall fertility of the soils which is an indication that the soils would support plant species diversity and growth, Okalebo, (1993) [34], Obute *et al*., (2010) [35].

Table 1. *Physico-Chemical Parameters of Waste Soils In Studied Dumpsites.*

SITES/PARAMETER	EID	AID	CFI
pH(H_2O)	7.11 ± 0.12^{a}	7.14 ± 0.04^{b}	7.04 ± 0.07^{bc}
Electrical Conductivity (mScm-1)	2.08 ± 0.06^{c}	2.52 ± 0.32^{b}	1.08 ± 0.05^{a}
Moisture (%)	80.20 ± 0.05^{c}	81.45 ± 0.05^{bc}	79.60 ± 0.14^{a}
Cation Exchange Capacity (Cmol/kg)	10.32 ± 0.14^{c}	11.18 ± 0.21^{b}	9.44 ± 0.08^{a}
Total Organic Carbon (%)	2.31 ± 0.08^{c}	2.46 ± 0.07^{bc}	1.37 ± 0.13^{a}
Total Organic Matter (%)	3.98 ± 0.17^{c}	4.24 ± 0.18^{b}	2.36 ± 0.05^{a}
Total Nitrogen (%)	0.28 ± 0.08^{c}	0.30 ± 0.07^{bc}	0.15 ± 0.04^{a}
PO_4^{3-}(%)	182.66 ± 0.22^{c}	189.45 ± 0.11^{b}	171.08 ± 0.07^{a}
SO_4^{2-}(%)	12.16 ± 0.11^{c}	11.87 ± 0.05^{b}	9.95 ± 0.21^{a}
C:N RATIO	8.25^{a}	8.2^{b}	9.13^{a}

Values are mean of three (n=3) replicates ± standard deviation
EID= Eluuogo Ibii dumpsite, AID = Agboogo Ibii dumpsite, CFI = Control Farmland Ibii
Figures followed by the same alphabets along the row are not significantly different at $P < 0.05$ using Ducan Multiple Range Test (DMRT)

Table 2a. *Heavy metal concentrations (mg/kg) in each fraction of waste soils in studied dumpsites.*

SITES/FRACTIONS	Cd			Cu			Mn			Pb		
	EID	AID	CFI	EID	AID	CFI	EID	AID	CFI	EID	AID	CFI
EXCHANGEABLE	4.72 ±0.01	4.98 ±0.12	0.69 ±0.03	0.64 ±0.04	0.43 ±0.03	0.05 ±0.02	14.05 ±0.15	12.57 ±0.05	0.46 ±0.01	6.44 ±0.05	8.12 ±0.09	0.38 ±0.02
ACID SOLUBLE	4.09 ±0.03	2.35 ±0.02	0.17 ±0.01	0.41 ±0.02	0.31 ±0.02	0.12 ±0.04	5.35 ±0.03	3.18 ±0.11	0.32 ±0.07	3.58 ±0.04	2.96 ±0.03	0.28 ±0.03
REDUCIBLE	1.39 ±0.01	1.01 ±0.03	0.19 ±0.02	3.87 ±0.05	3.01 ±0.02	0.33 ±0.01	2.46 ±0.07	1.66 ±0.03	0.08 ±0.03	2.26 ±0.05	2.84 ±0.11	0.14 ±0.06
OXIDIZABLE	1.32 ±0.02	0.84 ±0.05	0.16 ±0.02	2.51 ±0.13	1.45 ±0.05	0.46 ±0.05	2.65 ±0.04	2.09 ±0.17	0.09 ±0.01	1.15 ±0.03	1.11 ±0.02	0.11 ±0.02
RESIDUAL	3.67 ±0.31	3.37 ±0.11	0.28 ±0.01	7.92 ±0.03	6.78 ±0.08	1.04 ±0.02	6.89 ±0.04	6.08 ±0.05	0.30 ±0.02	5.66 ±0.05	6.02 ±0.13	0.37 ±0.05
TOTAL EXTRACTABLE METALS	15.19^{c} ±0.13	12.55^{b} ±0.05	1.49^{a} ±0.03	15.35 ±0.09	11.98^{b} ±0.11	2.00^{a} ±0.05	31.40^{b} ±0.12	25.58^{c} ±0.08	1.25^{a} ±0.04	19.09^{c} ±0.13	21.05^{b} ±0.15	1.28^{a} ±0.08
NON-RESIDUAL (%)	75.84	73.15	81.21	48.40	43.41	48.00	78.06	76.23	76.00	70.35	71.40	71.09
RESIDUAL (%)	24.16	26.85	18.79	51.60	56.59	52.00	21.94	23.77	24.00	29.65	28.60	28.91
MOBILE PHASE (%)	58.00	58.41	57.72	6.84	6.18	8.50	61.78	61.57	62.4	52.49	52.64	51.56

Values are mean of three (n=3) replicates ± standard deviation
EID= Eluuogo Ibii dumpsite, AID = Agboogo Ibii dumpsite, CFI = Control Farmland Ibii
Figures followed by the same alphabets along the row are not significantly different at $P < 0.05$ using Ducan Multiple Range Test (DMRT) for each metal

Table 2b. *Heavy metal concentrations (mg/kg) in each fraction of waste soils in studied dumpsites continued.*

SITES/FRACTIONS	**Zn**			**Fe**			**Ni**			**Cr**		
	EID	**AID**	**CFI**	**EID**	**AID**	**CFI**	**EID**	**AID**	**CFI**	**EID**	**AID**	**CFI**
EXCHANGEABLE	48.05 ±0.05	44.60 ±0.04	3.58 ±0.04	51.33 ±0.07	43.15 ±0.03	16.13 ±0.05	1.28 ±0.02	1.83 ±0.11	0.37 ±0.03	3.56 ±0.02	4.84 ±0.03	0.28 ±0.03
ACID SOLUBLE	42.16 ±0.11	29.70 ±0.05	2.44 ±0.05	44.40 ±0.05	26.31 ±0.05	7.85 ±0.02	1.14 ±0.04	1.22 ±0.06	0.29 ±0.09	3.09 ±0.07	3.96 ±0.05	0.19 ±0.02
REDUCIBLE	5.65 ±0.06	8.03 ±0.03	1.28 ±0.05	10.14 ±0.03	7.72 ±0.11	2.23 ±0.03	1.11 ±0.08	1.28 ±0.03	0.28 ±0.05	0.44 ±0.04	1.91 ±0.07	0.08 ±0.05
OXIDIZABLE	10.33 ±0.03	6.11 ±0.07	1.52 ±0.03	8.75 ±0.09	3.45 ±0.02	2.62 ±0.05	0.78 ±0.05	0.88 ±0.05	0.12 ±0.04	2.96 ±0.05	3.21 ±0.05	0.19 ±0.04
RESIDUAL	45.17 ±0.33	37.50 ±0.15	2.72 ±0.17	44.96 ±0.17	34.18 ±0.08	11.47 ±0.09	1.77 ±0.05	2.30 ±0.06	0.49 ±0.02	4.73 ±0.07	6.32 ±0.02	0.34 ±0.06
TOTAL EXTRACTABLE METALS	151.36^{c} ±0.15	125.94^{b} ±0.09	10.24^{a} ±0.13	159.58^{c} ±0.23	114.81^{a} ±0.17	40.30^{b} ±0.07	5.84^{b} ±0.05	7.51^{b} ±0.02	1.55^{a} ±0.11	14.78^{b} ±0.07	20.24^{c} ±0.15	1.08^{a} ±0.04
NON-RESIDUAL (%)	70.16	70.22	72.46	71.83	70.23	71.54	69.69	69.37	68.39	68.00	68.77	68.52
RESIDUAL (%)	29.84	29.78	27.54	28.17	29.77	28.46	30.31	30.63	31.61	32.00	31.23	31.48
MOBILE PHASE (%)	59.60	59.00	58.79	59.99	60.50	59.50	41.44	40.61	42.58	44.99	43.48	43.52

Values are mean of three (n=3) replicates ± standard deviation
EID= Eluuogo Ibii dumpsite, AID = Agboogo Ibii dumpsite, CFI = Control Farmland Ibii
Figures followed by the same alphabets along the row are not significantly different at $P < 0.05$ using Ducan Multiple Range Test (DMRT) for each metal

Table 3a. *Total heavy metals concentration (mg/kg) in roots and shoots of plant species in the studied sites.*

Plant Species Sites	***Amarathus hybridus***		***Telfeleria occidentalis***		***Talinum triangulare***		***Ipomea batatas***	
	ROOTS	**SHOOTS**	**ROOTS**	**SHOOTS**	**ROOTS**	**SHOOTS**	**ROOTS**	**SHOOTS**
EID	21.50±0.13	38.74±0.03	39.15±0.05	66.18±0.04	34.67±0.09	76.25±0.11	4.01±0.05	14.68±0.09
Cd AID	18.36±0.05	37.42±0.07	36.94±0.05	60.23±0.17	30.11±0.03	47.75±0.03	4.66±0.02	16.34±0.07
CFI	2.94±0.01	6.11±0.03	1.22±0.03	4.08±0.06	3.06±0.03	4.89±0.13	0.41±0.03	1.88±0.09
EID	15.64±0.07	13.86±0.05	11.09±0.02	9.42±0.06	27.98±0.09	13.18±0.07	4.76±0.05	8.87±0.10
Cu AID	13.93±0.09	10.72±0.11	13.80±0.06	9.11±0.05	26.36±0.05	10.95±0.12	4.12±0.09	9.64±0.05
CFI	4.02±0.05	2.76±0.03	4.07±0.02	3.02±0.02	4.78±0.02	1.42±0.05	2.11±0.13	3.39±0.10
EID	3.68±0.11	8.44±0.09	4.96±0.03	9.12±0.07	4.76±0.06	9.87±0.9	4.09±0.03	12.74±0.07
Mn AID	3.16±0.07	7.64±0.03	3.14±0.11	7.09±0.05	3.66±0.07	9.54±0.05	3.92±0.09	14.78±0.10
CFI	1.21±0.01	3.88±0.01	0.97±0.09	1.85±0.03	0.79±0.11	1.94±0.11	0.65±0.05	2.34±0.02
EID	12.68±0.11	8.12±0.07	9.78±0.09	6.92±0.21	20.84±0.03	28.57±0.03	4.15±0.11	9.07±0.03
Pb AID	14.32±0.07	7.52±0.11	7.03±0.07	4.58±0.09	12.76±0.11	25.43±0.09	5.02±0.07	9.87±0.05
CFI	0.89±0.03	0.67±0.03	1.12±0.11	0.97±0.11	1.32±0.05	1.89±0.05	1.21±0.04	2.86±0.09

Values are mean of three (n=3) replicates ± standard deviation
EID= Eluuogo Ibii dumpsite, AID = Agboogo Ibii dumpsite, CFI = Control Farmland Ibii

Table 3b. *Total heavy metals concentration (mg/kg) in roots and shoots of plant species in the studied sites contnued.*

Plant Species Sites	***Amarathus hybridus***		***Telfeleria occidentalis***		***Talinum triangulare***		***Ipomea batatas***	
	ROOTS	**SHOOTS**	**ROOTS**	**SHOOTS**	**ROOTS**	**SHOOTS**	**ROOTS**	**SHOOTS**
EID	12.86±0.05	39.05±0.13	20.56±0.05	40.27±0.07	22.76±0.15	46.86±0.17	21.09±0.12	43.69±0.07
Zn AID	11.78±0.17	28.76±0.06	12.44±0.10	25.17±0.13	13.94±0.09	27.43±0.09	12.97±0.09	30.11±0.05
CFI	1.12±0.07	3.66±0.03	1.68±0.03	4.09±0.07	1.75±0.42	4.27±0.21	1.06±0.08	3.47±0.13
EID	82.97±0.05	137.99±0.05	63.65±0.05	96.89±0.13	80.68±0.13	141.45±0.21	93.78±0.05	128.92±0.09
Fe AID	88.65±0.11	133.54±0.11	69.18±0.06	129.87±0.11	89.75±0.11	142.77±0.17	98.55±0.21	145.89±0.13
CFI	41.34±0.03	89.77±0.07	41.67±0.03	70.96±0.07	75.89±0.05	118.93±0.09	54.86±0.11	102.31±0.05
EID	2.62±0.21	4.98±0.0.7	2.33±0.05	4.86±0.09	3.23±0.09	6.89±0.11	2.54±0.03	6.37±0.13
Ni AID	2.17±0.11	5.86±0.05	2.46±0.11	5.21±0.21	2.89±0.10	6.31±0.21	2.53±0.11	4.88±0.05
CFI	1.12±0.05	2.94±0.03	1.03±0.05	2.94±0.07	1.34±0.05	3.57±0.09	1.05±0.05	3.09±0.11
EID	6.87±0.11	14.55±0.17	10.15±0.10	17.88±0.05	8.98±0.07	18.73±0.11	9.07±0.07	17.44±0.07
Cr AID	6.13±0.08	13.98±0.21	8.34±0.13	14.44±0.13	11.56±0.05	23.94±0.21	6.57±0.13	13.51±0.09
CFI	0.74±0.13	2.07±0.05	1.79±0.05	3.05±0.09	0.92±0.03	2.45±0.05	1.02±0.05	2.68±0.21

Values are mean of three (n=3) replicates ± standard deviation
EID= Eluuogo Ibii dumpsite, AID = Agboogo Ibii dumpsite, CFI = Control Farmland Ibii

The observed high values of total extractable metals may be attributed to dumping of numerous metal containing wastes such as cadmium and lead acid batteries, metal scraps among others in the dumpsites. These observed values were however below the permissible limits allowable for agricultural lands except for Cd, CCME, (1991) [36], MAFF, (1992) [37], CEC, (1986) [38], USEPA, (1986) [39]. The high percentage of Cd in the mobile fractions suggests that Cd in these soils was potentially more bioavailable for plants uptake, Kuo *et al.*, (1983) [40], Gupta and Sinha, (2006)[41]. Cu was mostly found in the residual phase (i.e. bound to silicates and detrital materials) which implicates association with the oxidizable fraction (bound to organic matter) as in organic copper complexes, Stumm and Morgan, (1981) [42]. High percentage of Mn, Pb, Zn and Fe in the mobile phase (exchangeable and acid soluble phases) indicates high bio-availability and higher risks to the ecosystem, Kuo *et al.*, (1983) [40]. Most of the Ni and Cr were found in the residual and oxidizable fractions and this may be attributed to the alkaline stabilization process of the soils leading to organic complexation that impair their mobility, Tokalioglu *et al.*, (2000) [43], Alvarez *et al.*, (2002) [44]. The high mobility of these metals in the studied dumpsites makes them potential contaminants in the dumpsites and these may pose serious risk in the biogeochemical cycling and ecological interactions of flora and fauna in that environment. Thus, the use of the soil for the cultivation of edible and medicinal plants should be discontinued to forestall future health hazards.

The uptake of an element by a plant is primarily dependent on the plant species, its inherent controls, soil quality and metal concentrations in their habitual soil environment, Chunilall *et al.*, (2005) [45]. This assertion is in line with the observed results. This study showed that the plant species significantly influenced the rate of their metal uptake, storage and distribution to various parts. This may be due to the genetic variability in the plant species and the metal distribution in the environment, Shauibu and Ayodele, (2002) [46], Ebong *et al.*, (2008) [47], Zhu *et al.*, (1999) [48], Ghosh and Singh, (2005) [49]. The results showed that the plants studied had varying degrees of metal uptake and that the rate of metal uptake was influenced by their habitual environment (different dumpsites). Since the rate of metal uptake is greatly influenced by plant species, the transfer factors of the metals by each plant species are desirable for classification of the plants' phytoaccumulation, photostabilization and phytoextarction potentials, Ayari *et al.*, (2010) [50], Malik *et al.*, (2010) [51].

The ability of plant species to accumulate high level of metals is due to the ability of the plants to evolve mechanisms that could enhance its phyto-accumulation potentials and metal detoxification, Vecera *et al.*, (1999) [52], Assuncao *et al.*, (2003) [53]. The results showed that the plants studied accumulated relatively high amount of metals. This could be hazardous if the farmers depend on these plants as their source of food for a long period of time as the metals would be introduced to the ecosystem. However, this study revealed that the level of metals in the dumpsites soils and plants did not exceed the established critical permissible limits. Similar findings have been reported, Shanker *et al.*, (2005) [54], Alloway, (1996) [55].

A critical value greater than one (>1) for plants' Translocation Factors (TF), Biological Concentration Factors (BCF) and Biological Accumulation Coefficient (BAC) is used to evaluate the potentials of plant species for phytoextraction, phytostabilization and phyto-remediation respectively, Yoon *et al.*, (2006) [26], Cui *et al.*, (2007) [25], Li *et al.*, (2007) [27]. High root to shoot translocation (TF > 1) as observed for some of the metals in some of the studied plants is an indication that some of these plants have vital characteristics to be used in phyto-extraction, Ghosh and Singh, (2005) [49]; Malik *et al.*, (2010) [51]. This high metal translocation quotient may be attributed to a well-developed metal detoxification mechanism in the plants species and the environmental conditions among other edaphic factors, Ghosh and Singh, (2005) [49], Cui *et al.*, (2007) [25]. These plant species with high TF values for phyto-extraction may be suitable for phyto-extraction due to their ability to translocate heavy metals to easily harvestable parts (shoots). This is in line with the reports of others, Yoon *et al.*, (2006) [26], Cui *et al.*, (2007) [25], Li *et al.*, (2007) [27]. Elevated concentration of heavy metals in roots of plants species and low translocation into above ground parts (BCF) indicate their suitability for phyto-stabilization, Ghosh and singh, (2005) [49]. The study revealed that the plant species with BCF>1 and TF<1 may be useful for phyto-stabilization of one, two or more of the metal contaminants of the study area. Plants with well-developed cellular mechanisms for heavy metal detoxification and tolerance (BAC > 1) are used as an indicator of high heavy metals accumulator plant species, Ghosh and Singh, (2005) [49]. When a plant is able to accumulate up to 1000mg/kg of metal and above, the plant is classified as a hyper-accumulator, Baker and Brooks, (1989) [56]. The BAC values in this study showed that the plants exhibited varying levels of phyto-accumulation potentials. However, none of the edible plants studied is a hyper-accumulator of any of the metals based on the critical set limit, Baker and Brooks, (1989) [56].

5. Conclusion

The metal pollution index and health risks associated with Eluogo Ibii and Agboogo Ibii dumpsites in Afikpo North, Ebonyi State, South-East, Nigeria have been highlighted. The dumpsites were observed to fertile with higher percentage of non-residual fraction for all the metals studied except for Cu. The metals showed mobility and bioavailability in this order: Mn > Fe > Zn > Cd > Pb > Cr > Ni > Cu. Mean total extractable metals in the dumpsites were higher than the control site and implicated the pollution from anthropogenic sources. The edible plants (*A. hybridus*, *T. ocidentalis*, *T. triangulare*, and *I. batatas*) accumulated metals in varying degrees in their various parts and exhibited phyto-extraction, phyto-stabilization and phyto-accumulation potentials. This is an indication of health risks along food chain and food web in the ecosystem. The toxicological effects of dependence on edible dumpsite plants as sources of plant-based foodstuff need further investigation.

References

[1] Ogwueleka TC. Municipal solid waste characteristics and management in Nigeria. Iran Journal of Environmental Health Science and Engineering, 2009; 6(3):173-180.

[2] Abul S. Environmental and health impact of solid waste disposal at Mangwaneni dumpsite in Manzini: Swaziland. Journal of Sustainable Development in Africa 2010; 12(7): 64-73.

[3] Krissanakriangkrai O, Suparpacboon W, Juwa S, Chacwong S, Swaddiwudhipong W. Bioavailable cadmium in water, sediment and fish, in a highly contaminated area of Thai-Myammy border. Thammasat Int. J. Sci. Technol., 2009; 14:60-68.

[4] Ozturk M, Ozozen G, Minareci O, Minareci E. Determination of heavy metals in fish, water and sediments of Avsar dam Lake in Trukey. Iran J. Environ. Health Sci. Eng., 2009; 6:73-80.

[5] Benjamin M, Mwashot M. Levels of caesium and lead in water, sediment and selected fish species in Mombasa Kenya Western Indian. Oceanic J. Mar. Sci., 2003; 2:25-34.

[6] Ikem A, Egiebog NO, Nyavor K. Trace Elements in water, fish and sediment from Tuskegee Lake, Southeastern USA. Water, Air Soil Pollut., 2003; 149:51-75.

[7] Obasi, NA, Elom, SO, Edeogu, CO, Alisa, CO, Obasi, SE. Soil Environmental metals speciation and associated health risks in selected edible leafy plants on Amaéchi and Four-corner dumpsites in Enugu of Enugu State, Nigeria. International Journal of Life Sciences Biotechnology and Pharma Research, 2014; 3(4):152-165.

[8] Obasi NA, Akubugwo EI, Ugbogu OC, Chinyere GC. Heavy Metals Bioavailability and Phyto-accumulation Potentials of Selected Plants on Burrow-pit Dumpsites in Aba and Ntigha Dumpsite in Isiala Ngwa of Abia State, Nigeria. Nigerian Journal of Biochemistry and Molecular Biology, 2012; 27(1): 27-45.

[9] Benson NU, Ebong GA. Heavy metals in vegetables commonly grown in a tropical garden ultisol. Journal of Sustainable Tropical Agricultural Resources, 2005; 16:77-80.

[10] Cobb, GP, Sands, K, Waters, M, Wixson, BG, Dorward-King, E. Accumulation of heavy metals by vegetables grown in mine wastes. Environmental Toxicological Chemistry, 2000; 19:600-607.

[11] Ellis DR, Salt DE. Plants, selenium and human health. Current Opinion Plant Biology, 2003; 6:273-279.

[12] Jarup L. Hazards of heavy metals contamination. British Medical Bulletin, 2003; 68:167-182.

[13] McIntire, T, Lewis, GM. The advancements of phytoremediation as innovative environmental technology for stabilization, remediation and restoration of contaminated sites. Journal Soil contamination, 1997; 6:227-231.

[14] Raskin, I. Smith, RD, Salt, DE. Phytoremediation of metals: using plants to remove pollutants from the environment. Current Opinion Biotechnology, 1997; 8:221-226.

[15] Bates RG. Electromeric pH determination. New York: John Willey and Sons Inc., 1954.

[16] Whitney DA. Micronutrients: zinc, iron, manganese, and copper. In: Brown JR, editor. Recommended chemical soil test procedures for the north central region. Missouri: Missouri Agric. Experiment Station Bulletin, 1998:41-44

[17] American Public Health Association (APHA). Standard methods of examination of water and waste water. USA: Washington, D.C., 1998.

[18] Dewis J, Freitas F. Physical and chemical methods of soil and water analysis. (Soil Bulletin 10) Rome: FAO, 1970.

[19] Osuji CL, Adesiyan SO. The Isiokpo oil pipeline leakage: Total organic carbon/organic matter contents of affected soils. Chemical Biodiversity, 2005; 2:1079-84.

[20] Yeomans JC, Bremmer JM. Carbon and Nitrogen analysis of soils by automated combustion techniques. Commum Soil Sci. Plant Anal., 1991; 22:843-50.

[21] Butters B, Chenery EM. Determination of sulphate in soil, plant materials and water by the turbidimetric method. Analyst Lond., 1959; 84:239-242.

[22] Olsen SR, Sommers LE. Determination of available phosphorus. In: Page FL, Miller RH, Keeney DR, editors. Methods of soil Analysis (Vol.2). Madison: American Society Agronomy, 1982:403-07.

[23] Tessier A, Campbell PGC, Bissom M. Sequential extraction procedure for the speciation of particulate trace metals. Analytical Chemistry, 1979; 51(7): 844-51.

[24] Obasi NA. Biochemical Studies on Soil and Air Quality Assessment of Dumpsites on the Enugu-PortHarcourt Expressway, South-East, Nigeria (Ph.D Thesis). Nigeria: Abia State University Uturu (ABSU). 2012.

[25] Cui S, Zhou Q, Chao L. Potential hyper-accumulation of Pb, Zn, Cu and Cd in endurant plants distributed in an old semetery, northeast, China. Environmental Geology, 2007; 51:1043-1045.

[26] Yoon J, Cao X, Zhou Q, Ma LQ. Accumulation of Pb, Cu and Zn in native plants growing on a contaminated Florida Site. Science of the Total Environment, 2006; 368:456-464.

[27] Li MS, Luo YP, Su ZY. Heavy metals concentrations in soils and plant accumulation in a restored manganese mine land in Guangxi, South China. Environmental pollution, 2007; 147:168-175.

[28] Kerr AW, Hall HK, Kozub SA. Doing Statistics with SPSS. London: SAGE Publications Ltd, 2002.

[29] Uba S, Uzairu A, Harrison GFS, Balarabe ML Okunola OJ. Assessement of heavy metals bioavailability in dumpsites of Zaira metropolis, Nigeria. African Journal of Biotechnology, 2008; 7(2): 122-130.

[30] Karaca A. Effect of organic wastes on the extractability of Cadmium, Copper, nickel and Zinc in Soil. Geoderma, 2004; 122: 297- 303.

[31] Arias ME, Gonzalez-Perez JA, Gonzalez-Villa FJ, Ball AS. Soil health: A new challenge for microbiologists and chemists. International Microbiology 2005, 8: 13-21.

[32] Yoo MS, James BR. Zinc extractability as a function of pH in organic waste-Contaminated soils. Soils Sci., 2002; 167: 246-59.

[33] Enwezor WO, Ohiri AC, Opubaribo EE, Udoh EJ. A review of soil fertility investigators in south eastern Nigeria. Nigeria:HFDA, Lagos, 1988.

[34] Okalebo JR, Gathua KW, Woomer PL. Laboratory methods of soil and plant analysis: A working manual. Kenya: Marvel EPZ Ltd, Nairobi, 1993.

[35] Obute GC, Ndukwu BC, Eze E. Changes in species diversity and physico-chemical properties of plants in abandoned dumpsites in parts of Por-Harcourt, Nigeria. Scientia Africana, 2010; 9(1): 181-193.

[36] Canadian Council of Ministers of the Environment (CCME). Interim Canadian environment quality criteria for contaminated sites. Canada: Report CCME EPC-CS3, 1991.

[37] Ministry of Agricultural, Forestry and Fisheries (MAFF). Code of good agricultural practice for the protection of soil, Welch Office Agriculture Department, Draft Consultation Document. London: Ministry of Agricultural, Forestry and Fisheries, 1992.

[38] Council of the European Communities (CEC). Directive of 12th June, 1986 on the protection of the environment and in particular soil when sewage sludge is used in agriculture. Official Journal European Community, 1986; L181:6-12.

[39] United State Environmental Protection Agency (USEPA). Test methods of evaluation of solid waste. In: Contaminated land policies in some industrialized countries. United State: TCB report RO2, 1986.

[40] Kuo S, Heilman PE, Baker AS. Distribution and forms of Cu, Zn, Cd, Fe and Mn in soils near a Copper smelter. Soil Sci., 1983; 135: 101-109.

[41] Gupta AK, Sinha S. Chemical fractionation and heavy metal accumulation in the plant of *Sesamum indicum* (L.) Var. T55 grown on soil amended with tannery sludge: selection of single extractants. Chemosphere, 2006; 64: 161-173.

[42] Stumm W, Morgan JJ. Aquatic chemistry: An introduction emphasizing chemical equalibria in natural water (2nd ed.) New York: John Wiley and Sons, 1981.

[43] Tokalioglu S, Kantal S, Elci L. Determination of heavy metals and their speciation in lake sediments by flame atomic absorption spectrophotometer after a four stage sequential extraction procedure. Analytical Chemistry Acta, 2000; 413: 33-40.

[44] Alvarez EA, Mochon MC, Sanchez JCJ, Rodriguez MT. Heavy metal extractable forms in sludge from waste-water treatment plants. Chemosphere 2002; 47:765-775.

[45] Chunilall V, Kindness A, Johnalagada SB. Heavy metal uptake by two edible *Amaranthus* herbs grown on soils contaminated with lead, mercury, cadmium, and nickel. Journal of Environmental Science and Health, 2005; 40:375-385.

[46] Shauibu UO, Ayodele JT. Bio-accumulation of four heavy metals in leaves of *Calostropis procera*. Journal Chemical Society of Nigeria, 2002; 27: 26-27.

[47] Ebong GA, Akpan MM, Mkpenie VN. Heavy metal contents of municipal and rural dumpsite soils and rate of accumulation by *Carica papaya* and *Talinum triangulare* in Uyo, Nigeria. E-Journal of chemistry, 2008; 5(2): 281-290.

[48] Zhu YL, Pilon-Smits EA, Tarun AS, Weber SV, Jouanin L, Terry N. Cadmium tolerance and accumulation in Indian mustard is enhanced by over expressing gamma-glutarmyl cysteine synthetase. Plant Physiology, 1999; 121:1169-78.

[49] Ghosh M, Singh SP. A review of phytoremediation of heavy metals and utilization of it's by- products. Applied Ecology and Environmental Research, 2005; 3(1): 1-18.

[50] Ayari F, Hamdi H, Jedidi N, Gharbi N, Kossai R. Heavy metal distribution in soil and plant in municipal solid waste compost amended plots. International Journal Environment, Science and Technology, 2010; 7(3):465-472.

[51] Malik RN, Husain SZ, Nazir I. Heavy metal contamination and accumulation in soil and wild plant species from industrial area of Islamabad, Pakistan. Pakistan Journal Botany, 2010; 42(1):291-301.

[52] Vecera Z, Mikaska P, Zdrahal Z, Docekal B, Buckora M, Tynova Z, Parizek P, Mosna J, Marek J. Environmental analytical chemistry, Institute of Analytical Chemistry, Academy of Sciences of the Zech Republic, Brno. Veveric, 1999; 97:61-142.

[53] Assuncao AGL, Schat H, Aarts MGM. *Thlaspi caerulescens*, an attractive model species to study heavy metal hyper-accumulation in plants. New Phytol., 2003; 159:351-360.

[54] Shanker AK, Cervantes C, Loza-Tavera H, Avadainayagam S. Chromium toxicity in plants. Environment International, 2005; 31:739-753.

[55] Alloway BJ. Heavy metals in soils. London: John Wiley and Sons Inc., 1996.

[56] Baker AJM, Brooks RR. Terrestrial higher plants which hyperaccumulative metals. New York: CAB International, 1989.