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Evaluation of Some Heavy Metals Concentrations in Some Vegetables in Kaduna Metropolis

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Abstract: This study assessed the levels of heavy metals concentration present in waterleaf (Talinum triangulare) and lettuce from three various farms in an outskirt of Sabon Tarshi within Kaduna metropolis, Kaduna State using Atomic Spectrophotometer. Six (6) samples of waterleaf and lettuce were obtained from 3 farms in the outskirt of Sabon Tarsha. The farms were located closed to industrial areas. Standard method was followed for sample treatment, digestion, and analysis of selected heavy metals: lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni) and cobalt (Co), iron (Fe), strontium (Sr), copper (Cu), zinc (Zn) and mercury (Hg).The results showed that in waterleaf and lettuce from the three farms, concentration (mg/kg) of heavy metals were: Pb (0.32-18.80), (0.47 -0.85) Cd (0.25-0.57), (0.87-2.61) Cr (0.00-2.16), (0.13-0.57) Ni (4.81-8.30), (0.70-6.30) Co (3.90-6.01), (0.09-0.52), Fe (112.3119.57), (0.09-0.46), Sr (55.20-82.22), (9.35-22.14), Cu (1.83-5.51), (0.58-1.05), Zn (0.02-0.43), (7.88-29.10), Hg (0.00-0.01), (0.00-0.0019). Heavy metals were higher in waterleaf than in lettuce except for Zn. It may be concluded that there is high tendency of exposure to heavy metals by those who consume waterleaf and lettuce in the studied locations since the levels in waterleaf and lettuce from all farms studied generally exceeded the FAO/WHO limits.

Keywords: *heavy metals; lettuce; waterleaf; digestion; bioavailability.*

Introduction: Heavy metals are generally referred to as those metals which possess relatively high density more than 5 g/cm3 and adversely affect the environment and living organisms even at low concentrations [19]. They are important constituents for plants and humans, when present only in small amount but toxic at high concentrations. For instance, fluorine (F), copper (Cu), chromium (Cr), nickel (Ni), selenium (Se), molybdenum (Mo), or zinc (Zn). Other elements such as cadmium (Cd), arsenic (As), lead (Pb) and mercury (Hg) are known to be toxic even at small concentrations [2]. Persistent heavy metals, and non-biodegradability, can neither be removed by normal cropping nor easily leached by rain water [23]. They transfer system may be from soil to ground waters or may be taken up by plants, including agricultural crops. For this reason, the knowledge of metal plant interactions is also important for the safety of the environment [4].

The need for metal assessment in public food supplied has increase rapidly. However, their concentration in bioavailability form is not necessarily proportional to the total concentration of the metal [9]. Human and natural activities altered, the ecosystem due to the heavy metals accumulation. These activities are one of the most pressing concerns of urbanization in developing countries. Nigeria is among African countries that face serious concerns and challenges on waste management which result in the problem of solid, liquid and toxic waste management [3]. Such waste may be toxic or radioactive [36, 27]. Waste management problems include heaps of uncontrolled garbage, roadsides littered with refuse, streams blocked with rubbish, prevalence of automobile workshops and service stations, inappropriately disposed toxic waste and disposal sites that constitute a health hazard to residential areas [12, 28, 22]. Wastes from automobile such as hydraulic fluids, solvents, lubricants, paints and stripped oil sludge; all results of activities such as automobile body works engine servicing and combustion, battery charging, welding and soldering, [13,8]. Occurrence of uncontrolled urban sewage farming is a common site in African cities which exposes consumers of such produce to poisoning from heavy metals [22]. Municipal solid waste landfills are a source of various environmental and health hazards. The decomposition of organic materials produces methane, which may cause explosions and produce leachates, which pollute surface and ground water. It ruins the aesthetic quality of the land [16]. Soil is the most important component of the environment, but it is the most undervalued, misused and abused one of the earth's resources [13]. Soil contamination has become a serious problem in all industrialized areas of the country. Soil is equally regarded as the ultimate route for the pollutants discharged into the environment [18].

Most plants and animals depend on soil as a growth substrate for their sustained growth and development. In many instances the sustenance of life in the soil matrix is adversely affected by the presence of deleterious substances or contaminants. The entry of the organic and inorganic form of contaminants results from disposal of industrial effluents [14]. The source of the organic and inorganic components of the soil of contaminated area was mainly from unmindful release of untreated effluent on the ground [21].

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The contamination of soils with heavy metals or micronutrients in phytotoxic concentrations generates adverse effects not only on plants but also poses risks to human health [24]. Afterwards, the consumption of contaminated vegetables constitutes an important route of heavy metal exposure to animals and humans [17].

Abandoned waste dumpsites have been used extensively as fertile grounds for cultivating vegetables, though research has indicated that the vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soils [36,30]. The type of irrigation system employed in the farmlands of Kaduna metropolis is the surface irrigation where water is applied directly to the soil surface through channel which varies in size from individual furrow to large basin. In some settlements within Kaduna metropolis, substantial amount of vegetables was produced. These farms are irrigated with waste water from Kaduna River and some other rivers and drainages within the metropolis. For the past several decades, the water from these rivers was clean. However, with the increase in the urban population and industrialization, various pollutants, among which are heavy metals are drained from this river to farmlands which have negatively affected the health of people of Kaduna Metropolis. This study is limited to waterleaf and lettuce farm within Kaduna metropolis with a view to finding solution to some of the environmental health pollutant affecting human health in our environment

Materials and methods

Materials: The instruments and reagents used in this research were of analytical grade, these materials include: Beaker, Conical flask, Crucible, Funnel, Whattman No.1 filter paper, measuring cylinder, Weighing balance (DS-75), Digestion flask and AAS spectrophotometer (PG-990).

Reagents: Perchloric acid (HCl04), Nitric acid (HN03), concentrated Sulphuric acid (H2S04), Distilled water were used.\

Samples: Some commonly consumed vegetable was used as samples for the analysis of the heavy metals, they include: Lettuce, Water leaf.

Sample Collection: Three samples each of the 2 vegetable samples were collected randomly from 3 different farms in the outskirts of Sabon Tasha, Kaduna State. Sample were transported to the laboratory for further used.

Sample Preparation: The vegetables were collected from three (3) different farms in Sabon Tasha area of Kaduna and were brought into the laboratory. The leaves were plucked from the stem and were washed with distilled/de-ionized water in order to remove dirt and impurities and then air-dried for about two weeks to remove enough amount of moisture; after which they were dried to constant weight at 105 0C in the oven. The dried samples were pulverized using a plastic mortar and pestle and stored in label plastic containers for analysis.

Digestion Procedure: The glass wares were washed and cleaned properly and were rinsed with distilled water. Five (5) grams of each sample were weighed into a beaker, 10ml each of Nitric and Perchloric acid and 1ml of Sulphuric acid were mixed into separate beaker, the acid mixtures were added to the sample in the beaker and were stirred continuously for few minutes, and 5ml of distilled water was added and was stirred again. The solution was filtered into a volumetric flask and was poured into a labeled sample bottle; the volumetric flask was rinsed with distilled water into the sample which was made up to the mark [34].

Analysis: The analysis of trace element present in the sample solution was carried out using Atomic absorption spectrophotometer (AAS) [35, 27]. Nitrous oxide in place of air result in a higher temperature and this is necessary for the estimation of certain elements [27].

Result and Discussion

Heavy Metals Concentration in Waterleaf and Lettuce: Many studies have reported the potential of heavy metals accumulation in water leaf [21, 29]. Generally, high level of pollution in the town being an industrial city, may also contribute to this. However, the levels were slightly lower compared to what is actually obtainable in a typical municipal dumpsite in Nigeria. For instance, Eze [5] reported Pb level of 20.26 to 25.10 mg/kg in waterleaf around municipal dumpsite in Gombe, Nigeria; and Ebong et al. [22] reported a level of 43.28 mg/kg for municipal dumpsite in Uyo. On the other hand, it may be concluded that heavy metal levels obtained in this study were lower compared to what many other researchers have reported due to environment differences.

Table 1: Heavy Metal concentration in Waterleaf.

	Metal Concentrations in waterleaf from the three farms (µg/g) 0r (ppm)									
	Ni	Cu	Cd	Zn	Cr	Pb	Co	Hg	Fe	Sr
A	8.30±0.25	5.51±0.82	0.48±0.11	7.88±0.82	0.00±0.00	0.76±0.02	5.85±0.81	0.00±0.00	199.57±0.02	82.22±8.20
B	4.81±0.33	2.77±0.84	0.57±0.16	29.10±7.38	2.16±0.02	18.80±1.14	6.01±0.01	0.01±0.00	121.38±0.02	78.90±0.25
C	7.21±1.63	1.83±0.51	0.25±0.04	18.52±1.09	0.18±0.02	0.32±0.06	3.90±0.10	0.00±0.00	112.34±0.82	55.20±0.00

Key: A is Rafin Romi, B represent Juji farm and C is for Station farm. (ppm) part per million

Allowable Limit of trace Metals are based on 0.04, 0.02, 0.03, 0.7, 0.003, 0.001, 0.014, 0.3, and 0.004 mg/kg for Cu, Ni, Co, Fe, Cr, Cd, Mn, Zn, and Pb, respectively USEPA [15].

Table 1 above present the concentration values of the various elements determined in water leaf (*Talinum triangulare*) vegetables in three different farms located in an outskirt of Sabon Tasha using AAS technique. Concentrations of the metals were in the order of Cr & Hg < Cd < Pb < Cu < Co < Zn < Ni < Sr < Fe. For location B the other is Hg < Cd < Cr < Cu < Ni < Co < Pb < Zn < Sr < Fe and then location C goes with the pattern Hg <Cr < Cd < Pb < Co < Cu < Co < Ni < Zn < Sr < Fe. In water the trend shows that in the three location of the farm where the samples were collected mercury (Hg) has the lowest concentration in the leaves while the highest is recorded for iron (Fe). These leaves are consumed in daily bases of which excess intake of metal from it hampers human health. The average quantity of vegetable to be taken on daily basis by adults and children were given as 0.345 and 0.232 kg/person/day respectively based on reports of Wang [32] and (FAO/WHO). This is equally established to help in reducing metal bioaccumulation in the body. The table also show a concentration variation in Fe and Sr as a result of their natural abundant value in the soil. Also, the study area is predominantly around the anthropogenic activity area which might have contributed significantly to their deposit in the soils used for the cultivation of the vegetable and absorbed by the plants during growth. In the study carried out by Ukpabio et al. [3] with regard to heavy metals in water leaf at Aba, south east of Nigeria, Fe concentrations in water leaf samples ranged from 86.0 ± 1.92 to 110 ± 0.67 ppm while Zn concentrations in water leaf samples ranged from 3.16 ± 0.87 to 76.1 ± 0.02 ppm. This values were less than the one obtained in this study which are in turn lower than the one obtained in the study of Bukar and Onoja, [1]. The explanation to this could possibly be that the environment in this study were within metropolis and using irrigation with water that might have mixed up with storm from municipality.

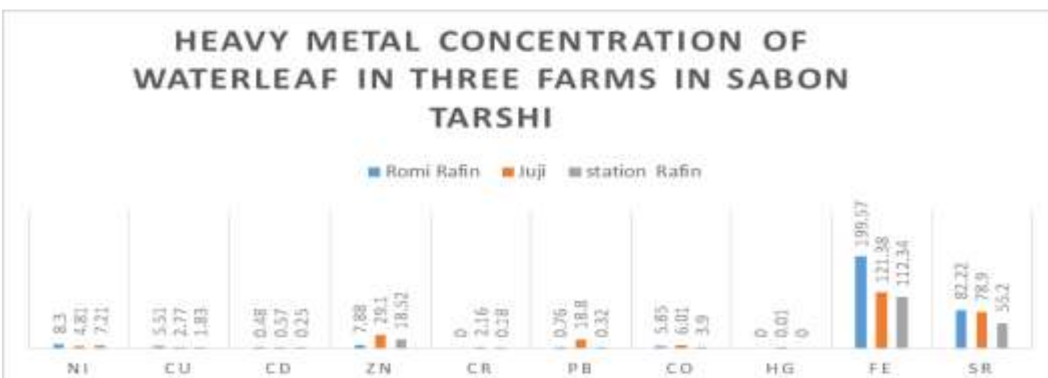

Fig. 1: Heavy metal concentration chart for the farms used in Sabon Tarsha for waterleaf.

Table 2. Heavy Metal Concentration in Lettuce.

	Metal Concentration in Lettuce from the three farms									
farm	**Ni**	**Cu**	**Cd**	**Zn**	**Cr**	**Pb**	**Co**	**Hg**	**Fe**	**Sr**
A	6.30±1.63	0.76±0.16	2.61±0.81	0.18±0.40	0.13±0.02	0.47±0.11	0.33±0.18	0.00±0.00	0.09±0.02	16.50±0.82
B	0.70±0.01	0.58±0.06	1.68±0.16	0.43±0.02	0.57±0.16	0.72±0.22	0.52±0.01	0.0019±0.00	0.46±0.24	9.35±0.24
C	0.89±0.10	1.05±0.04	0.87±0.35	0.02±0.01	0.22±0.05	0.85±0.08	0.09±0.02	0.00±0.00	0.28±0.28	22.14±0.01

Key: A is Rafin Romi, B represent Juji farm and C is for Station farm.

Results for lettuce (Lactuca sativa) are presented in table 2 and the metal concentrations are in the order of Hg < Fe < Cr < Zn < Co < Pb < Cu < Cd < Ni < Sr. for B location, the trend followed the pattern Hg < Zn < Fe < Co < Cr < Cu < Ni < Pb < Cd < Sr and for the C location the trend is Hg < Zn < Co < Cr < Fe < Pb < Cd < Ni < Cu < Sr. the trend shows that in all cases, mercury showed the least while strontium remain the highest contaminant in the sample.

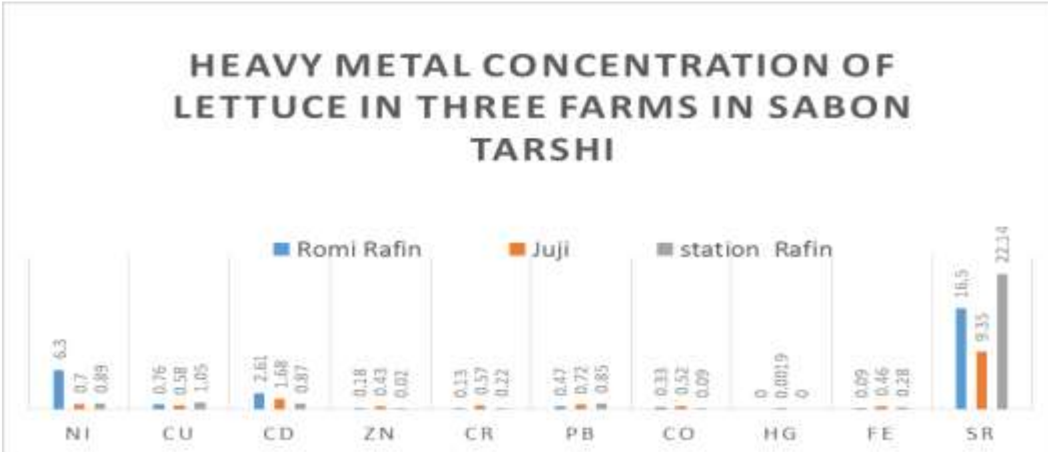

Fig. 2: Heavy metal concentration chart for the farms used in Sabon Tarsha for lettuce.

Comparison of the Metals Concentration in waterleaf and lettuce: Comparing the metal concentration level with the standard according to USEPA [15] showed that all the sample are above the acceptable limit standard. Also, comparing the result of Table 1 to that of Table 2, it showed clearly that apart from Zn that is higher in the table compare to those in Table 1. Metals in table1 are all higher than those in table 2.

Zinc is essential for normal growth, development, reproduction, and many other psychological functions in the body, although if it is beyond the limit, it will have adverse effect on the body such as anemia or reduced bone function. In this study, waterleaf have higher concentration of zinc with a total mean value of 18.5 ± 8.66, compare to 0.21± 0.17 in lettuce and this is above the 0.3-mg kg^{-1} day^{-1} recommended level by FAO/WHO for waterleaf but within limit for lettuce [6].

Lead is a highly toxic metal, and a high level of it in the body can affect the kidneys, gastrointestinal tract, joints, and reproductive system. In this study, lead was only detected in waterleaf with the total mean value (6.63mg/ kg), and this is above the recommended value of 0.004 mg kg^{-1} day^{-1} by FAO/WHO [8]. In lettuce lead total mean value stood at 0.69mg/kg. Therefore, the two sample exceed the acceptable limit of which bioaccumulation may hamper human health.

Iron is very essential for the proper functioning of the body. Most iron present in the body is found in the blood as hemoglobin that helps in oxygen transport. Excessive iron in the body can enlarge the liver and may provoke diabetes and cardiac failure. The total mean value of iron (mg/kg) was higher in waterleaf (114.43) than in lettuce (0.28). The value was above the 0.7 mg kg^{-1} day^{-1} recommended by FAO/WHO [8] for water leaf and was within the acceptable limit for lettuce.

Copper is an important mineral element for plants and animals; high dosage of it can lead to anemia, liver and kidney damage, and stomach and intestinal irritation. The total mean concentration of copper is higher in waterleaf (3.37) than in lettuce (0.80). These values are above the 0.04 mg kg^{-1} day^{-1} recommended by FAO/WHO [8].

Chromium is an important trace element essential for carbohydrate metabolism, and its deficiency can lead to impaired glucose tolerance. In this work, the total mean value of chromium was higher in waterleaf (0.78 ± 0.98) than in lettuce (0.31±0.19). These values are not above the 1.5 mg kg^{-1} day^{-1} recommended by FAO/WHO [8].

Conclusion: The result obtained showed variation in the degree of absorption of various heavy metals in water leaf and in lettuce. The bioaccumulation of the naturally abundant heavy metals Sr and Fe by waterleaf were more than the other elements. The high concentrations of Sr and Fe as indicated in Table 1 and that of Sr in table 2 absorbed by lettuce could be attributed to the fact that these elements were naturally abundant, most of the small and medium scale industries within the metropolis utilized materials that contain these heavy metals in addition to them being utilized by almost every household on a daily basis, thus, this might have generated a lot of waste containing these heavy metals and disposed along the bank of river Kaduna a or be transported directly to the farmlands used for cultivation through rain storm, wind and erosion. It can also be observed that the maximum concentration values of Fe, Cr, Co and exceed the FAO/WHO maximum permissible limit (MPL), hence the consumption of water leaf and lettuce cultivated in the study sites might cause heavy metals to accumulate in human organs and constitute health risk. Therefore, there is the need for periodic investigation to ascertain the level of bioaccumulation of heavy metals in the crops to be cultivated in the study area. Also frequent investigation on bioaccumulation of heavy metals in water leaf cultivated in the study sites is needed to avoid unnoticeable buildup on the metals within the MPL values that might leads to potential health risks. The levels of Cr were within the FAO/WHO [31] limit of 2.30 mg/kg in leafy vegetables, while those of Cd were slightly higher than the limit (0.2 mg/kg). The FAO/WHO [8] standard for Pb in the vegetable is 0.3 mg/kg.

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References:

[1] P. H. Bukar, and M. A. Onoja, Assessment of heavy metals in water leaf (TalinumTriagulare) cultivated on Fadama soils through irrigation in Nigeria. International Research Journal of Public and Environmental Health 7 (3) (2020) 74-80,

[2] A. Gamar, T. Z air, M. El Kabriti, F. El Hilali Contamination of heavy metals and metalloids1 of groundwater in the vicinity to the wild landll of El Hajeb city (Morocco). Int J Eng. Sci Technol 12 (4) (2020)41–53.

[3] C. Ukpabi, C. Stephen, E. Ejike, I. Nwachukwu, M. Chukwu, and M. Ndulaka Determination of Heavy Metals in Leafy Vegetables Cultivated and Marketed in Aba, Nigeria. European J. Basic Appl. Sci. 3(1) (2016) 42-51

[4] A. Godwin, E. Oghenekohwiroro, Leachate characterization and leachate pollution index from landll dump sites in Warri Metropolis, Nigeria. Int Lett Nat Sci (2016). P.57.

[5] M. O. Eze, Evaluation of Heavy Metal Accumulation in Talinum triangulare grown around Municipal solid waste dumpsites in Nigeria. Bulletin of Environment, Pharmacology and Life Sciences 4 (1) (2014) 92-100.

[6] C. Hansson, L. Heiskala, Investigation of heavy metal pollution and health risks due to farming activities on a former dumpsite in Dar es salaam, Tanzania (2014).

[7] P. B. Utang, O. S. Ehidogin, and C. L. Ijekeye, Impacts of Automobile Workshops on Heavy Metals Concentrations of Urban Soils of Obio/Akpor LGA, Rivers State, Nigeria. African Journal of Agricultural Research, 8(26) (2013). 3476 - 3482.

[8] Evaluation of Certain Food Additives and Contaminants Seventy-seventh report of the Joint FAO/WHO Expert Committee on Food Additives (JECFA) met in Rome, Italy from 4 to 13 June (2013).

[9] O.D. Opaluwa, M.O. Aremu, L.O. Ogbo, J. I. Magaji, I.E. Odiba. and E.K.Ekpo, Assessment of Heavy Metals in Water, Fish and Sediments from UKE Stream. Nasarawa State, Nigeria. Current World Environment, 7(2) (2012) 213-220.

[10] A. I. Tsafe, L. G. Hassan, D. M. Sahabi, Y. Alhassan, and B.M. Bala, Evaluation of Heavy Metals Uptake and Risk Assessment of Vegetables Grown in Yargadama of Northern Nigeria, Journal of Basic and Applied Scientific Research, 2(7) (2012) 6708 6714.

[11] FAO/WHO Codex Alimentarius Commission. Joint FAO/WHO Food Standards Programme Codex Committee on Contaminants in Foods. Fifth Session. 21-25 March 2011.Working Document for Information and Use in Discussions Related to Contaminants and Toxins in the GSCTFF (Prepared by Japan and the Netherlands) CF/5 INF/1. The Hague, The Netherlands, (2011) p. 89

[12] M. B. Adewole, and L. U. Uchegbu, Properties of Soils and Plants Uptake within the Vicinity of Selected Automobile Workshops in Ile-Ife, South Western Nigeria, Ethiopian. Journal of Environmental Studies and Management, 3(3) (2010) 23-28.

[13] K. Gokulakrishnan, and K. Balamurugan, Advanced technology like reverse osmosis in tannery effluent treatment to enhance the reusing stages of tanning process, International Journal of Applied Environmental studies, 5(2) (2010) 146- 158.

[14] S. S. Gowd, M. R. M. Reddy, and P. K. Govil, Assessment of heavy metal contamination in soil at Jajmau (Kanpur) and Unnao Industrial areas of the Ganga plain, Uttar Pradesh, India, Journal of Hazardous materials, 174 (57) (2010) 113-121.

[15] USEPA Integrated Risk Information System. (IRIS). United States Environmental Protection. Available online: http://www.epa.gov/iris/index.html(2010). (accessed on 4 October 2011).

[16] O. Oyelola, A. I. Babatunde, and A. K. Odunlade, Health implications of solid waste disposal: case study of Olusosun dumpsite, Lagos, Nigeria. International Journal of Pure and Applied Sciences, 3(2009) 1-8.

[17] K. Sajjad, F. Robina, S. Shagufta, A. K. Mohammed, and S. Maria, Health Risk Assessment of Heavy Metals for Population via Consumption of Vegetables, World Applied Sciences Journal, 6(12) (2009) 1602-1606.

[18] R. Shokoohi, M.H. Saghi, H.R. Ghafari, and M. Hadi, Biosorption of iron from Aqueous solution by dried biomass of activated sludge. Iran Journal of Environmental Health Science and Engineering, 6(2) (2009) 107-114.

[19] E. Uwah, N. P. Ndahi, and V. Ogugbuaja. Study of the levels of some agricultural pollutants in soils and water leaf (Talinum triangulare) obtained in Maiduguri, Nigeria. Journal of Applied Sciences in Environmental Sanitation. (2009). 4.

[20] S. Uba, A. Uzairu, O. J. Okunola, Content of heavy metals in lumbricus terrestris and associated soils in dump sites. Int. J. Environ. Res., 3(3) (2009).353-358.

[21] M. Rajkumar, N. Ae, and H. Freitas, Endophytic bacteria and their potential to enhance heavy metal phytoextraction. Chemosphere 77 (2009) 153–160

[22] G. A. Ebong, M. M. Akpan, and V. N. Mkpenie, 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, 5 (2008) 281-290. 56

[23] R. Khadeeja, A. Sobin, R. Umer, I. Muhammad, H. Saadia, I. Tehreema, A. G Murugesan, S. Maheshwari, and G. Bagirath, Biosorption of cadmium by Live and Immobilized cells of Spirulina platensis, Journal of Environmental Resource, 2(3) (2008) 307-312.

[24] A.G. Murugesan, S. Maheswari, and G. Bagirath, Biosorption of Cadmium by Live and Immobilized Cells of Spirulina Platensis. Int. Journal. Environ. Res., 2 (3) (2008) 307-312.

[25] U. Divrikli, N. Horzum, M. Soylak and L. Elci, Trace Heavy Metal Contents of Some Spices and Herbal Plants from Western Anatolia, Turkey, Int. Journal of Food Sci. Technol, 41(2006) 712-716.

[26] United Nations Development Programme, UNDP Practical Action. Technology Challenging Poverty. United Nation Development Programme Report. (2006).

[27] E. Obuobie, B. Keraita, G. Danso, P. Amoah, O.O. Coie, L. RaschidSally, and P. Drechsel, Irrigated Urban Vegetable Production in Ghana: Characteristics, Benefits and Risk. IWMIRUAF-CPWF, Accra, Ghana: IWMI, (2006) pp 150
[28] K. H. Rotich, Y. Zhao, and J. Dong, Municipal solid waste management challenges in the developing countries (2006).
[29] U. Divrikli, N. Horzum, Soylak, Mustafa and L. Elci, Trace Heavy Metal Contents of Some Spices and Herbal Plants from Western Anatolia-Turkey. Int. Journal of Food Sci & Technol. 41 (2006) 712 - 716.
[30] N. U. Benson, and G. A. Ebong, (2005). Heavy metals in vegetables commonly grown in a tropical garden ultisol. Journal of Sustainable Tropical Agric. Res, 16 (54) 77- 80.
[31] FAO/WHO: Fruits and Vegetables for Health Report of Joint FAO/WHO Workshop Kobe, Japan, September, 1-3, (2005) p.39.
[32] X. S. Wang, Y. Qin, and S. X. Sun, Accumulation and sources of heavy metals in urban topsoil: A case study from the city of Xuzhou, China, Environ. Geology, 48(2005)101-107
[33] L. Jarup, (Hazards of heavy metal contamination, British Medical Bulletin 68(2003)167–182.
[34] R. Milacic, and B. Kralj, Determination of Zn, Cu, Cd, Pb, Ni and Cr in some Slovenian foodstuffs Eur. Food Res. Technol., 217 (2003) 211-21
[35] M. Agrawal. Enhancing food chain integrity: quality assurance mechanisms for air pollution impacts on fruit and vegetable system. Final Technical Report II submitted to Department of International Development, UK, R 7530.
[36] G. P., Cobb, K. Sands, M. Waters, B. G. Wixson, and E. Dorwardking, Accumulation of heavy metals by vegetables grown in mine waste. Environmental Toxicology and Chemistry,19(3) (2000) 600-607.
[37] A. G. Onibokun, and A. J. Kumuyi, Urban poverty in Nigeria: towards sustainable strategies for its alleviation. Centre for African Settlement Studies and Development, Ibadan, Nigeria. CASSAD Monograph Series (1996).