

Turnitin Originality Report

•
•
•
•

bjast_14479_v2 By X X

3% match
(publications)

Similarity Index

23%

Similarity by Source

Internet Sources:	16%
Publications:	15%
Student Papers:	5%

"Mobility and Bioavailability of Pb, Cr, Zn, Cd, Mn and Cu from Waste Soils of Refuse Dumpsites in Kano Metropolitan City, Nigeria", Journal of Applied Sciences Research/1816157X, 20110801

3% match (Internet from 26-Oct-2010)

http://www.akamaiuniversity.us/PJST11_1_616.pdf

2% match (Internet from 18-Apr-2014)

http://www.ejournalofscience.org/archive/vol2no2/vol2no2_7.pdf

1% match ()

<http://www.isfae.org/scientficjournal/2009/issue3/pdf/environment/37.pdf>

1% match (publications)

Kii, Benjamin L., Ogbonna, David N. and Youdeowei, Patrick O.. "Some physico-chemical and Heavy metal levels in soils of waste dumpsites in Port Harcourt Municipality and Environs", World Bank assisted National Agricultural Research Project (NARP) - University of Port Harcourt, 2010.

1% match (Internet from 22-Aug-2010)

<http://www.mdpi.org/sensors/papers/s8042413.pdf>

1% match (Internet from 31-May-2013)

<http://209.238.2.121/fulltext/?doi=ajaps.2012.342.356&org=12>

1% match (Internet from 29-Mar-2003)

http://scielo.sa.cr/scielo.php?script=sci_arttext&pid=S0034-77442000000100026&lng=es&nrm=iso

1% match (Internet from 15-Jul-2013)

<http://www.iisc.ernet.in/currsci/sep102006/622.pdf>

1% match (publications)

[Adaikpoh, Edwin Ozor, and Abel N. Kaizer. "Trace Metal Enrichment in Sediments from Otofure and Teboga Waste Dump Sites in Benin City, Nigeria", International Journal of Chemistry, 2012.](#)

< 1% match (publications)

[Anthony George Kachenko. "Heavy Metals Contamination in Vegetables Grown in Urban and Metal Smelter Contaminated Sites in Australia", Water Air and Soil Pollution, 01/2006](#)

< 1% match (Internet from 28-Apr-2012)

<http://intouch.emeraldinsight.com/tag/cairo>

< 1% match (Internet from 20-Sep-2014)

http://www.researchersworld.com/vol4/issue4/vol4_issue4_2/Paper_10.pdf

< 1% match (Internet from 28-Feb-2014)

<http://rpublishing.org/Journal/IJEER/Vol2Issue2/eer2201.pdf>

< 1% match (Internet from 28-Mar-2014)

<http://journal.chemistrycentral.com/content/5/1/64>

< 1% match (publications)

[G. A. Ebong. "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](#)

< 1% match (publications)

[J. O., Oti Wilberforce, and Nwabue F. I.. "Heavy Metals Effect due to Contamination of Vegetables from Enyigba Lead Mine in Ebonyi State, Nigeria", Environment and Pollution, 2012.](#)

< 1% match (publications)

[Osumanu Haruna Ahmed. "Ammonia volatilization and ammonium accumulation from urea mixed with zeolite and triple superphosphate", Acta Agriculturae Scandinavica Section B - Plant Soil Science, 6/2008](#)

< 1% match (Internet from 13-Apr-2012)

<http://article.sapub.org/10.5923.j.chemistry.20120201.04.html>

< 1% match (publications)

[Mansour, Sameeh A.. "Monitoring and Health Risk Assessment of Heavy Metal](#)

Contamination in Food", Practical Food Safety, 2014.

< 1% match (publications)

Baraud, Fabienne, and Lydia Leleyter. "Prediction of phytoavailability of trace metals to plants: Comparison between chemical extractions and soil-grown radish", Comptes Rendus Geoscience, 2012.

< 1% match (Internet from 25-Dec-2013)

<http://ijappjournal.com/wp-content/uploads/2012/576-578.doc.pdf>

< 1% match (publications)

Ahmad, Kafeel, Zafar Iqbal Khan, Asma Ashfaq, Muhammad Ashraf, Nudrat Aisha Akram, Sumaira Yasmin, and Muhammad Sher. "Assessment of Heavy Metals and Metalloids in Solanum tuberosum and Pisum sativum Irrigated with Urban Wastewater in the Suburbs of Sargodha City, Pakistan", Human and Ecological Risk Assessment An International Journal, 2014.

< 1% match (student papers from 20-Jul-2013)

Submitted to Higher Education Commission Pakistan on 2013-07-20

< 1% match (publications)

Abdelhafez, Ahmed A., and Jianhua Li. "Environmental Monitoring of Heavy Metal Status and Human Health Risk Assessment in the Agricultural Soils of the Jinxi River Area, China", Human and Ecological Risk Assessment An International Journal, 2014.

< 1% match (publications)

Zhuang, Ping, Huanping Lu, Zhian Li, Bi Zou, and Murray B. McBride. "Multiple Exposure and Effects Assessment of Heavy Metals in the Population near Mining Area in South China", PLoS ONE, 2014.

< 1% match (publications)

Prabu, P. C.. "IMPACT OF HEAVY METAL CONTAMINATION OF AKAKI RIVER OF ETHIOPIA ON SOIL AND METAL TOXICITY ON CULTIVATED VEGETABLE CROPS", Electronic Journal of Environmental, Agricultural & Food Chemistry/15794377, 20091001
< 1% match (publications) Zainon Najib, Nor Wahidatul Azura; Mohammed, Syakirah Afiza; Ismail, Saffaatul Husna and Amneera Wan Ahmad, Wan Amiza. "Assessment of Heavy Metal in Soil due to Human Activities in Kangar, Perlis, Malaysia", International Journal of Civil & Environmental Engineering, 2012.
< 1% match (student papers from 29-Nov-2014) Submitted to Federal University of Technology on 2014-11-29
< 1% match (student papers from 13-Jan-2011) Submitted to Atlantic International University on 2011-01-13
< 1% match (publications) Drouza, S.. "Investigation of soils developed on volcanic materials in Nisyros Island, Greece", Catena, 20070801
< 1% match (student papers from 06-Feb-2014) Submitted to Universiti Putra Malaysia on 2014-02-06
< 1% match (student papers from 25-Nov-2012) Submitted to University of the West Indies on 2012-11-25
< 1% match (publications) Hu, Wenyou, Yong Chen, Biao Huang, and Silvana Niedermann. "Health Risk Assessment of Heavy Metals in Soils and Vegetables from a Typical Greenhouse Vegetable Production System in China", Human and Ecological Risk Assessment

[An International Journal, 2014.](#)

< 1% match (Internet from 04-Sep-2013)

<http://www.sciencealert.co.uk/fulltext/?doi=rjet.2013.18.28&org=10>

< 1% match (publications)

[Adebiyi, F. M., E. A. Oluyemi, and A. A. Akande. "Measurements of Physicochemical, Elemental, and Total Petroleum Hydrocarbon Contents as Pollution Indicators of Soils in Petroleum Products Retailing Station Surrounding Areas", Energy Sources Part A Recovery Utilization and Environmental Effects, 2015.](#)

< 1% match (Internet from 16-Jun-2012)

<http://www.m.elewa.org/JABS/2011/40/7.pdf>

< 1% match (Internet from 01-Jan-2015)

<http://www.intechopen.com/books/soil-processes-and-current-trends-in-quality-assessment/leachability-and-vegetable-absorption-of-heavy-metals-from-sewage-sludge-biochar>

< 1% match (Internet from 29-Sep-2014)

[http://journalofscience.net/zip.php?file=File_Folder/398-406\(jos\).pdf&id=110&quat=4](http://journalofscience.net/zip.php?file=File_Folder/398-406(jos).pdf&id=110&quat=4)

< 1% match (publications)

[Arocena, J.M.. "Properties of hydrocarbon- and salt-contaminated flare pit soils in northeastern British Columbia \(Canada\)", Chemosphere, 200507](#)

< 1% match (Internet from 07-Sep-2014) http://www.bioline.org.br/request?ja11035
< 1% match (Internet from 08-May-2014) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3685757/
< 1% match (Internet from 19-Dec-2014) http://www.arcjournals.org/pdfs/ijarps/v1-i6/5.pdf
< 1% match (Internet from 27-Nov-2014) http://infinitypress.info/index.php/cas/article/download/786/354
< 1% match (Internet from 04-Dec-2013) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3575243/
< 1% match (Internet from 03-Nov-2014) http://theijes.com/papers/v2-i2/P02201230129.pdf
< 1% match (Internet from 14-Jul-2012) http://trisanita.org/jases/asespaper2011/ases47v6n4y2011.pdf
< 1% match (publications) <u>Liu, Cheng-Chung, and Ying-Chen Lin. "Reclamation of copper-contaminated soil using EDTA or citric acid coupled with dissolved organic matter solution extracted from distillery sludge", Environmental Pollution, 2013.</u>
< 1% match (publications)

Bi, Y.. "Influence of early stages of arbuscular mycorrhiza on uptake of zinc and phosphorus by red clover from a low-phosphorus soil amended with zinc and phosphorus", Chemosphere, 200302
< 1% match (publications) N. Gupta. "Heavy metal accumulation in vegetables grown in a long-term wastewater-irrigated agricultural land of tropical India", Environmental Monitoring and Assessment, 12/02/2011
< 1% match (publications) Hossain, E.. "Elevated levels of plasma Big endothelin-1 and its relation to hypertension and skin lesions in individuals exposed to arsenic", Toxicology and Applied Pharmacology, 20120301
< 1% match (publications) D. G. Westfall. "Efficient and Environmentally Safe Use of Micronutrients in Agriculture", Communications in Soil Science and Plant Analysis, 1/1/2005
< 1% match (publications) Seid-mohammadi, Abdolmotaleb; Roshanaei, Ghodratollah and Asgari, Ghorban. "Heavy Metals Concentration in Vegetables Irrigated With Contaminated and Fresh Water and Estimation of Their Daily Intakes in Suburb Areas of Hamadan, Iran", Journal of Research in Health Sciences, 2014.
< 1% match (publications) Li, Zhaojun, Hua Yang, Yupeng Li, Jian Long, and Yongchao Liang. "Cross-Species Extrapolation of Prediction Model for Lead Transfer from Soil to Corn Grain under Stress of Exogenous Lead", PLoS ONE, 2014.
< 1% match (publications) "Effects of Bitumen Deposit on Soil Physico-Chemical Characteristics", Soil and Sediment Contamination, 02/2011

Heavy Metal Concentrations in Some Vegetables Grown in a Farm Treated With Urban 2 Solid Waste in Kuru Jantar, Jos South, and Plateau State

Abstract

The use of dumpsite soils as organic manure is wide spread in developing countries like Nigeria. This study investigates the concentration of some heavy metals in vegetables grown in a farm treated with dumpsite soils in Kuru Jantar, Jos-South. Soil samples and vegetables from the farm were collected and prepared using standard analytical procedures. The concentrations of metals in both soil and vegetables were determined using atomic absorption spectrophotometer (AAS). The results showed that the farm was polluted with the metals (Cd, Cr, Cu, Mn, Fe, Pb, Zn, Ni) determined. The Enrichment Factor (E/F) showed that some metals had minimal enrichment while Cd (13.93) had significant enrichment at the farm. The Pollution index (P/I) calculations showed that at the farm, the pollution ranged from very slight contamination to very severe contamination. The overall order of the metals at the dumpsite was $Fe > Mn > Zn > Cu > Cr > Ni > Pb > Cd$ while the order of the metal concentrations at the farm was $Fe > Mn > Zn > Ni > Cd > Pb$. The data obtained in the study were analyzed using Pearson correlation analysis. The results showed perfect positive correlation values above 0.9 between the farms and the dumpsites, which indicated that there was a strong association or similarity between them. In spinach plant species, metal concentrations decreased in the order $Fe > Zn > Mn > Cd > Pb$, in Cabbage $Mn > Fe > Zn > Cu > Cd$; in Radish, $Fe > Mn > Cu > Cr > Zn$, in pepper $Fe > Cu > Mn > Ni$. In general, the metal concentrations were within the recommended limit of USEPA and FEPA standards for agricultural soils and vegetables except Cd in vegetables. The concentrations were however higher in the farm than in the control. Thus, the farm was polluted with heavy metals from the dumpsite soils.

Keywords: Heavy metals, dumpsite, vegetables, pollution, organic manure, Enrichment Factor

INTRODUCTION

The use of dumpsite soils as organic manure is widespread in Plateau state, Nigeria. This practice has been shown to improve soil properties such as organic matter, nutrients, porosity, aggregate stability, bulk density and water retention and as a result, increase plant productivity [1, 2]. It is however a known fact that some of the waste products contain hazardous metals such as Ni, Pb, Cd, Zn, and Hg [3], which perturb the distribution and concentration of these metals in the environment. Recent studies have also revealed that the waste dumpsite can transfer significant levels of these toxic and persistent metals into the soil environment [4,5]. Heavy metals are toxic pollutants that therefore, severely limit the beneficial use of dumpsite soil as organic manure. Heavy metals are very harmful because of their non- biodegradable nature, long biological half life and their potential to accumulate in different body parts [6]; even low concentrations of heavy metals are toxic because there is no good mechanism for their elimination from the body. The bioaccumulation of metals as a major route through which increased levels of the pollutants are transferred across food chain web has been reported [7]. The presence of heavy metals in the ecosystem therefore, has far reaching implication directly to the soil and indirectly to man. Metal uptake by plants can be affected by several factors including metal concentrations in soils, soil pH, cation exchange capacity, organic matter, types and varieties of plants and plant age. [8]. It is generally accepted that the metal concentration in soil is the dominant factor and the concentrations of heavy metals are higher in soils than vegetables grown on the same soils [9]. It has also been reported that vegetable crop plants have high ability to accumulate metals from the environment, which may pose risks to human health when they are grown on or near contaminated lands and consumed. Thus, accumulation of heavy metals in the edible parts of vegetables represents a direct pathway for their incorporation into the human

food chain [10, 11]. The health risk will depend upon the chemical composition of the 49 waste material, its physical characteristic, types of vegetables cultivated and the consumption rate 50 [12, 13]. 51 This study therefore assessed the uptake of metals by plant vegetables grown on a farm treated 52 with urban solid waste in Kuru Jantar, Jos-South. 53 Materials and Methods 54 Soil and Plant Sampling 55 The [soil and vegetable samples](#) for this analysis [were collected](#) randomly [from](#) a farm [located](#) 56 about 200m from Kuru Jantar dumpsite on longitude 080 53'E and latitude 090 42 N. The 57 vegetables were harvested at the same spots where the soil samples were collected. The vegetables harvested were spinach, cabbage, radish, and tomatoes and pepper and [were washed with distilled water to remove](#) soil particles. The [soil samples were air-dried, crushed and sieved to pass](#) through 60 a 2mm [sieve](#). Similarly, [the](#) vegetables were cut with plastic knives before drying in oven at 700C 61 until stable weights were obtained. [The dried samples were ground in mortar and sieved.](#) . 62 Analysis of [the Heavy Metal Content in Soil and Vegetable Samples](#) 63 Triplicate samples of 1.0g of the [sieved soil samples were digested with](#) 25mL of a 64 [mixture of hydrochloric acid \(HCl \) and](#) trioxonitrate (v) acid (HNO3) in the ratio of three to one 65 parts by volume respectively at 1200C on a [water bath in a fume cupboard. The solution was](#) 66 [heated to dryness](#) and [the residue was re-dissolved in 5mL of 2.0M HCl](#) [14 – 16]. Digested 67 samples were filtered [into a 100ml volumetric flask and made up to the mark with distilled water.](#) 68 Triplicate (1g) of the sieved vegetable samples were weighed into different conical flasks 69 and digested with conc. HNO3 to a clear solution. Digested samples were filtered into a 100mL 70 [volumetric flask and made up to the mark with](#) distilled [water](#) [17]. [The](#) concentrations of [the](#) 71 metals [in the digested soil](#) and vegetable [samples were determined using](#) Buck scientific VGP 210 72 [Atomic Absorption Spectrophotometer at wavelengths specific to each metal.](#) [The](#) metals analyzed 73 in both samples were: Pb, Cu Cr, Ni, Zn, Fe, Cd, Mn. 74 Calculation of Enrichment Factor (E/F) and Contamination Pollution Index (C/P) 75 The enrichment factors of the heavy metals in soil were calculated with the formula as 76 reported by other researchers [19] 77 $EF = [C_{metal}/C_{normalizer}]_{soil} / [C_{metal}/C_{normalizer}]_{control}$ 78 where C_{metal} and $C_{normalizer}$ are the [concentrations of heavy metal and](#) normalizer [in soil](#) and 79 in unpolluted control respectively. Iron(Fe) was used as the normalizer in this calculation. The [contamination/pollution index was calculated as the ratio between metals effectively](#) 82 [measured by chemical analysis to the reference value](#) [20]. The conversion formula [19] for the 83 C/P index was also used and the reference standard used in the calculation was the Federal 84 Environmental Protection Agency [22] target value. 85 86 87 Pollution index (PI) = Concentration of metal in soil Standard recommended maximum value in soil 88 pH Determination 89 Triplicate quantities (20g) of air-dried of the soil samples were [weighed into a 50mL beaker and](#) 90 [20mL of distilled water was added. The mixture was allowed to stand for 30 minutes with](#) 91 [occasional stirring](#) using a glass rod. [The electrode of the calibrated pH meter,](#) MI 806 92 pH/EC/Temperature Portable Meter [inserted into the partly settled suspension and the pH](#) value 93 read [14] 94 Organic Matter Determination 95 The soil [samples were ground to pass through 0.5mm sieve after which they were weighed in](#) 96 duplicate and transferred to 250mL Erlenmeyer flasks. Exactly 10mL of 1M potassium dichromate 97 [was](#) pipette [into each flask and swirled gently to disperse the soil followed by addition of](#) 20mL of 98 [concentrated, tetraoxosulphate \(IV\) acid. The flask was swirled gently until soil and reagents were](#) 99 [thoroughly mixed. The mixture was then allowed to stand for 30 minutes on a glass plate to allow](#) 100 [for the oxidation of potassium dichromate to chromic acid. Distilled water](#) (100mL) [was added](#) 101 then [3-4 drops of ferroin indicator, after which the mixture was titrated with 0.5M ferrous sulphate](#)

102 solution. A blank titration was similarly carried out. [14]. The % organic carbon is given by the 103 following equation: $M1e1 K_2Cr_2O_7 - M2e2 FeSO_4 \times 0.0031 \times 100 \times F$ Mass (g) of air-dried soil. 107 108 109 110 F= correction factor (1.33), M1 = mole of $K_2Cr_2O_7$, E1= volume of $K_2Cr_2O_7$ M2 = mole of $FeSO_4$, E2 = volume of $FeSO_4$, % = organic matter in soil = organic carbon $\times$ 1.729. 111 **Total Nitrogen: The total Nitrogen was determined using the kjeldahl digestion method. The** 112 ammonia in the digest was absorbed into boric acid mixed indicator solution and then titrated with 113 standard 0.01M H_2SO_4 . The soil samples (2g) were digested into 50ml solution, and then 20mL of 114 the digest were used for the determination of total nitrogen. 115 Available Phosphorous: This was extracted using bray P1 and P2 extractant and P in the extract 116 was measured with spectrometer (model spectronic 20D) using the molybdenum blue colour 117 method. 118 Exchangeable Bases: This were extracted with 1M NH_4OAC (pH 7) solution. The 119 concentrations of **K and Na in the extract were determined using** Flame analyser (Model FP640) 120 while Mg was obtained by versenate titration. 121 Cation Exchanged Capacity (CEC): **cation exchange capacity by the 0. 01M silver -thiourea** 122 **method** [23] 123 Statistical Analysis 124 The data obtained in the study were analyzed using Pearson correlation analysis. **Correlations were** 125 **calculated to measure the degree of linear relationship between plant metal concentrations and soil** 126 **properties/soil metal concentrations.** 127 128 129 130 RESULTS AND DISCUSSION The physicochemical properties **have been reported to have profound influence on the** 133 **mobility and bioavailability of heavy metals** and uptake by plants [18, 19]. Therefore, the 134 properties of the soils collected from the dumpsite and farm such as **pH, cation exchange capacity** 135 **(CEC), electrical conductivity (EC) and organic** matter (OM) were determined. The **results of the** 136 **physicochemical** properties **are presented in Table 1. The results showed that the pH** at the 137 dumpsite was slightly alkaline with a pH of 8.30. **This may be attributed to the buffering effect of** 138 **soil organic matter against pH changes in addition to the release of basic cations during the** 139 **organic matter decomposition** [5] 140 **The pH of the** soil collected from the farm was 6.71 which indicated that the soil was 141 slightly acidic. This could be attributed to the inorganic fertilizer and other chemicals used on the 142 farms. This was also **expected as most soils in the tropics have their range from acidic to slightly** 143 **neutral** pH [5]. **The pH levels that are acidic tend to have an increased micronutrient solubility and** 144 **mobility as well as increased heavy metal concentration in the soil** [20]. The **results of the** 145 **available phosphorus in the** dumpsite **soil** were very similar to that in the farm ranging from 0.03 – 146 0.12mg/kg. The concentration of phosphorus contributes to the growth of plants [22]. 147 The **cation exchange capacity is the amount of exchangeable cation per unit weight of dry soil that** 148 plays very important role in soil fertility. The concentrations of the exchangeable cations (CEC) in 149 cmol/Kg at the dumpsite were 1.86 (Na), 21.60 (K), 5.20 (Mg) and 11.12 (Ca) while at the farm 150 the values were 0.30, 0.76, 0.50 and 4.65 respectively. However, the concentration at the farm was 151 higher than the control, which indicated that the dumpsite could be implicated with the 152 amendment of soil properties of the farm. The **CEC is directly related to the capacity of adsorbing** 153 **heavy metals since the adsorption behaviour depends on combination of the soil properties and the** 154 **specific characteristics of the element** [24]. 156 157 158 159 160 161 162 163 164 165 166 167 **The organic matter (OM) content of the** dumpsite **soil** was 5.8% while the farm had 2.40% and the control had 1.12%. The **OM content of the control site was significantly lower compared to the** farm and dumpsite soils (see Table 1). This **might be attributed to the activities of the microorganisms involved in the organic matter decomposition** from the dumpsite **thereby, accumulating more organic matter in the soils** [18]. Thus, **the** results showed that the use of the urban solid waste as

manure influenced the organic matter in the farm. The [organic matter is one of the factors that may reduce the ability of metals to be phytotoxic in the soil due to metal-organic complexation](#) [18]. The [organic matter content of the soil plays an important role in](#) absorption [reaction in the soil](#) and total cation exchange site [21]. The [organic matter is also an important indicator of the soil as a rooting environment](#) [20]. Table 1: Some Selected Soil Physicochemical Properties of Kuru Dumpsite and Farm Treated with the Dumpsite 168 Dumpsite Farm [F1]

Control	169	170	171	172	173	174	175	176	177	178	179	pH	Organic Matter %	Total Nitrogen %	Exchangeable Na (cmol Kg-1)	Exchangeable K (cmol Kg-1)	Exchangeable Mg (cmol Kg-1)	Exchangeable Ca (cmol Kg-1)	Available P (mg /Kg)	CEC (cmol Kg-1)	Texture		
8.30	6.71	5.80	2.40	0.63	0.35	1.86	0.30	21.60	0.76	5.20	0.50	11.12	4.65	0.11	0.11	40.50	6.53	Sand	Sand	6.15	1.12	0.35	0.24
0.87	0.45	1.80	0.03	3.68	Sand	The concentration of the exchangeable cations (CEC) in the dumpsite soil was 40.50 181 cmolkg-1 which was much higher than 6.53cmolkg-1 from the farm. The concentrations of the 182 exchangeable cations were however, higher than the control which implicated the use of the 183 dumpsite soil to have affected the farm positively. This could be due to difference in the 184 heterogeneous nature of waste [5], which is expected to impact differently on soil properties . The 185 available phosphorous in the farm and dumpsite were the same 0.11mg/kg which was higher than 186 the value for the control farm (0.03mg/kg). The percentage of nitrogen was 0.35%. 187 The physicochemical parameters indicated that the organic matter, cation exchange capacity, nitrogen and phosphorus content of the farm were moderate with moderate values of C:N ratio implicating the urban solid waste to be fertile . Thus, the results of the physicochemical parameters revealed that the soils were fertile to support plant growth but this cannot be compared 191 to the adverse effect of using this solid waste as manure. This may serve as a source of metals into 192 the food chain. 193 The heavy metal concentrations in soil samples from the dumpsite, farm and controls were 194 determined and the results are presented in Table 2. The results showed that the mean 195 concentrations of copper (Cu) in the dumpsite and farm soil samples were 130.19 and 63.23mg/kg 196 respectively. Therefore, the value at the dumpsite was above the normal range 2-100 mg/kg [9] in 197 the mineral soil environment and is significantly above the data obtained for the control samples . 198 Copper is very toxic to most plants, and highly toxic to mammals [13]. Copper concentration 199 levels above normal range are highly dangerous and pose health risks to the environment . The 200 concentration of Cu in this study was lower than the values reported at Lagos metropolis, Nigeria 201 [13]. 202 The concentration of manganese (Mn) at the dumpsite (422.72mg/Kg) was much higher than the 204 farm treated with the waste from the dumpsite which had a value of 219.60mg/kg. However, the 205 concentration of Mn at the farm was much higher than the control. The higher levels of Mn found 206 in the farm could be closely related to the pollutants from the dumpsite. The values of Mn in this 207 study were much higher than the values reported by other researchers [25]. However, the values 208 were within WHO/FAO recommended maximum value (2000mg/kg) for agricultural soil as 209 reported by [17, 24]. The results obtained for the different soil samples from the dumpsite and the 210 farm show that they are highly contaminated with iron when compared with the control values . 211 The mean concentration value of 2436 mg/kg at the dumpsite and 408 mg/kg were within the 212 normal range of mineral soil environment of 300-500,000 mg/kg reported for naturally occurring 213 heavy metal concentrations for soil [22, 23] 214 The concentration of zinc found in the soil samples at the dumpsite (246.39mg/Kg) and farm 215 (66.23mg/Kg) were within the normal range 10-300 mg/kg for agricultural soil. The results of the 216 dumpsite and the farm showed that they were contaminated with Zn when compared with the 217 control values . Zinc																	

constitutes an essential element (micronutrient), but it is toxic to crop plants especially vegetables at the level of 400 mg/kg in the soil [14]. The concentrations of Cd in the dumpsite soil sample (28.06mg/Kg) was higher than the WHO/FAO maximum permissive limits while the concentration in the farm soil sample (2.30mg/Kg) was lower than the maximum permissive limit. Similarly, the concentrations of Ni in the dumpsite and farm samples were lower than the maximum permissive limit (Cd 3; Ni 23 75[14]. However, the concentrations of these metals at the dumpsite and farm were higher than the control values. Therefore, there are apparent indications of the adverse effects of the dumpsite on the values of metals as compared to their values in the control. Similar observations have been reported [20 and 21]. This result is also consistent with previously published data [14]. Table 2.

Average Concentrations of Metals in Soil Samples Collected from the Dumpsite and Farm

Element	Farm	Dumpsite	Control
Cu	130.19±2.30	2.45±0.05	63.23±25.36
Mn	422.72±28.67	28.99±9.11	219.60±57.88
Fe	2436±105.95	249.00±7.43	408.20±78.38
Cd	28.06±2.03	ND	2.30±0.14
Ni	26.32±2.85	ND	15.60±0.12
Zn	246.39±10.75	8.92±3.12	66.23±8.96
Pb	23.30±5.70	9.13±3.25	25.33±0.38

The metal concentration correlation analysis between the farm and the dumpsite was conducted using Pearson correlation coefficient (r) values to determine the level of association. The results showed perfect positive correlation values above 0.9 between the farms and the dumpsites, which indicated that there was a strong association or similarity between them. At both p<0.05 and p<0.01 level of significant, all the correlations were significant. This implies that the similarity in the concentrations between the farm and dumpsite was quite high. The concentrations of the metals in the farm (F1) decreased in the order Fe > Mn > Zn > Pb > Cu > Ni > Cd. Enrichment Factor (EF) of the heavy metals in soil from farm 1 showed that Cu (0.49), Mn (0.88), Fe (1), Ni (0.94), Zn (0.52) and Pb (0.88) had minimal enrichment while Cd (13.93) had significant enrichment (see Table 3). Table 3: Enrichment Factor (EF) and Contamination /Pollution (C/P) Index of Heavy Metals in Soil samples from the Farm (F1)

Element	EF	C/P Index
Cu	0.49	0.08
Mn	0.88	0.77
Fe	1.00	0.45
Ni	0.94	0.22
Zn	0.52	0.09
Pb	0.88	0.26
Cd	13.93	0.94

The use of urban solid waste as manure could be implicated with the high enrichment of Cd at the farms. The soil Cd could also be due to the application of phosphate fertilizers [26]. This therefore poses serious concern as crops grown on these farms could bioaccumulate the metal. The Pollution Index (P/I) of the metals at F1 ranged from 0.08 to 0.90 which showed that the farm had very slight contamination to very severe contamination with the metals. Metal Content in Vegetables grown on the Farm

The concentration of the metals obtained in the leafy vegetables (spinach and cabbage), root vegetable (radish) and fruit vegetables, (tomato and pepper) are presented in Table 5. The main sources of heavy metals to vegetable crops are their growth media from which these are taken up by the roots. A better understanding of heavy metals sources, their accumulation in the soil and subsequent uptake by plant species seem to be particularly important in present day research on risk assessment [27]. The uptake of metal ions has been shown to be influenced by the metal species and plant parts. [26]. The results of the metal content in vegetables grown on the

280 farm in this study showed that spinach, bio-accumulated the [metals Fe , Mn, Zn, Cd, Ni and Pb in](#) 281 the [order Fe > Mn > Zn > Cd > Ni > Pb](#) (Table 5). This could be a reflection of the concentrations of 282 the metals in the soil. Leafy vegetables have been shown to accumulate [relatively higher](#) 283 [concentrations of heavy metals than fruit vegetables](#) [24]. The observed concentrations of the 284 metals in the vegetables were compared with the recommended limit as established by the 285 FAO/WHO in 1999 to assess the levels of food contamination. The concentration of Cd 286 (3.21mg/kg) was much higher than the recommended maximum levels in vegetables (0.20mg/kg) 287 [28]. Cadmium [is relatively easily taken up by](#) the [food crops especially by vegetables](#) in the 288 addition to foliar absorption of Cd from atmospheric deposition on plant leaves [29]. Several 289 [studies have indicated that vegetables grown in heavy metals contaminated soils have higher](#) 290 [concentrations of heavy metals than those grown in uncontaminated](#) soils [29]. Cd is relatively 291 mobile in soil under range of pH, O.C and CEC conditions. This shows that some other soil 292 factors in addition to the total soil contents of the metals also influenced metal uptake. The other 293 metals were within the recommended maximum limits in vegetables with Mn and Fe 294 (500.30mg/Kg) and Zn (99.40mg/Kg) [30]. 295 296 297 298 299 300 301 302

Table 5. Mean Concentrations of [Metals in](#) Vegetable [Samples Collected from the](#) Farm [F1]. 306 Element Vegetables 307 308 309 310 311 312 313 314 315

Cu	Mn	Fe	Cd	Ni	Zn	Pb	Spinach	Cabbage	Raddish
25.26±5.87	31.33±4.01	51.10±4.12	220.65±33.24	191.75±15.14	92.10±22.36	103.00±88.44	85.00±30.11	93.55±33.56	3.25±0.12
0.71±0.02	5.70±0.55	13.00±0.15	ND	ND	53.77±22.11	33.54±4.02	0.89±0.05	3.21±0.05	ND
ND	ND	316	317	318	319	320	321	322	323
324	325	326	327	328	329	Tomatoes	Pepper	18.45±6.44	ND
77.63±35.22	ND	ND	ND	ND	53.25±12.50	29.85±8.35	80.69±38.77	ND	ND
21.22±5.98	ND	*RMLV	73.30	500.00	425.50	0.20	67.90	99.40	0.30

RMLV: Recommended Maximum Levels in Vegetables * Source: [17 and 29] Cabbage, bio-accumulated Cu, Mn, Fe, Cd and [Zn from the soil](#) and [the concentrations of the metals](#) were [in the](#) other [Mn > Fe > Zn > Cu > Cd](#). The concentration of Cd [in](#) cabbage was also higher than the recommended maximum levels in vegetables (0.20mg/kg) [30]. This could be attributed to the urban solid waste used as manure in this farm. The other metals bio-accumulated in cabbage were also below the recommended maximum limits. The results showed that radish in bio-accumulated only the metals Cu, Mn, Fe, Cr and Zn in its roots in the sequence Fe > Mn > Cu > Cr > Zn. The metals bio-accumulated were also below the recommended maximum limits for vegetables (see Tables 5). Tomatoes on the other hand bioaccumulated only Cu, Fe and Cd, in decreasing order of Fe > Cu > Cd. The concentration of Cd was also higher than the recommended maximum limit in vegetables. Pepper bio-accumulated Cu, Mn, Fe, Ni and Zn [in the order Fe > Cu > Mn > Zn > Ni](#). The metals in pepper were within the recommended limit. Generally, the concentration of iron was highest in almost all the vegetables. The higher 331 concentration of Fe could be as a result of its oxygen carrier ability for chlorophyll production and 332 also for protein synthesis [31]. The [concentrations of Mn and Cu](#) only [were higher in](#) cabbage [than](#) 333 spinach. The results also showed that spinach, cabbage and radish, bioaccumulated more metals 334 than pepper and tomato. This is in agreement with the reports of other researchers [24]. The higher 335 levels of heavy metal [contamination found in](#) some fruit [and vegetables](#) could [be closely related to](#) 336 [the pollutants in irrigation water, farm soil](#), and pesticides or alternatively could be due to 337 pollution from traffic on the highways [31]. 338 Based on the pattern of metal accumulation in the vegetables, it could be suggested that 339 radish and pepper could be safely grown on Cd contaminated soils. On the other hand, vegetables 340 like spinach, cabbage, radish, may not suitable for cultivation on Cu, Mn, Fe, Zn and Cd 341 contaminated soils.

However, some fruit type vegetables like tomato and pepper could be safely grown on Cr, Ni, and Pb contaminated soils. Root type vegetable like radish could be cultivated on Cd, Cr, Ni and Pb contaminated soils. Heterogeneous accumulation of heavy metals in different crop species has been reported [7, 32], which could be attributed to their diverse morphological characteristics. Conclusion From this study, it could be concluded that the dumpsite was polluted with the metals Cu, Mn, Fe, Cd, Cr, Ni, Zn and Pb. The used of the dumpsite soil as manure, contaminated the farm studied. The concentration of the metals in the farm were in the order Fe> Mn> Cu> Zn> Ni> Cd> Pb. The vegetable grown in these farm bioaccumulated some of the metals analyzed. The differences in respect of metal uptake could be emphasized for selection of vegetable crops for cultivation on metals contaminated soils depending on their metal uptake potential. The results of the Pearson correlation coefficient (r) showed perfect positive correlation values above 0.9 between the concentration of metals in the farm and the vegetables, which indicated that there was a strong association or similarity between them. At both $p<0.05$ and $p<0.01$ level of significant, all the correlations were significant. This implies that the similarity in the concentrations between the farm and vegetables were quite high.

References

1. Ogunyemi S., Awodoyin R.O., Opadeji T. (2003). Urban agricultural production: heavy metal contamination of *Amaranthus cruentus* L. grown on domestic refuse landfill soil in Ibadan, Nigeria. *Emirate Journal of Agricultural Science* 15(2), 87-94
2. Oluyemi E. A., Feuyit G., Oyekunle J. A. O. and Ogunfowokan A. O. (2008). Seasonal variations in heavy metal concentrations in soil and some selected crops at a landfill in Nigeria. *African Journal of Environmental Science and Technology* 2 (5), 089-096.
3. Olarinoye, I.O., Sharifat, I., and Kolo, M.T. (2011). Heavy Metal Content of Soil Samples from two Major Dumpsites in Minna. *Natural and Applied Sciences Journal*. 11 (1), 1-5.
4. Adelekan B.A. and Alawode A.O. (2011). Contributions of municipal refuse dumps to heavy metals concentrations in soil profile and groundwater in Ibadan Nigeria. *Journal of Applied Biosciences*. 40: 2727-2737.
5. Abdallah S.A., Uzairu A., Kagbu J.A., Okunola O. J. (2011). Mobility and Bioavailability of Pb, Cr, Zn, Cd, Mn and Cu from Waste Soils of Refuse Dumpsites in Kano Metropolitan City, Nigeria. *Australian Journal of Basic and Applied Sciences*, 5(8): 707-715.
6. Oti Wilberforce, J. O. and Nwabue, F. I. (2013). Heavy Metals Effect due to Contamination of Vegetables from Enyigba Lead Mine in Ebonyi State, Nigeria. *Environment and Pollution*, 2 (1) 19 -26.
7. Singh S., Zacharias M., Kalpana S. and Mishra S. (2012) Heavy metals accumulation and distribution pattern in different vegetable crops. *Journal of Environmental Chemistry and Ecotoxicology* 4 (10), 170-177
8. Olayinka K. O., Oyeyiola A. O., Odujibe F. O. and Oboh B. (2011). Uptake of potentially toxic metals by vegetable plants grown on contaminated soil and their potential bioavailability using sequential extraction. *Journal of Soil Science and Environmental Management*. 2 (8), 394 220-227
9. Nimyel D.N, Daniel V.N, and Daniang I.E (2009). Investigating the uptake of heavy metals by some vegetables grown around unclaimed mining sites in Zawan. *Journal of Research in Agriculture*, 6(2) 71-73.
10. Harmanescu M, Alda L. M, Bordean D. M, Gogoasa I and Gergen I (2011). Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study: Banat County, Romania. *Chemistry Central Journal*, 5(1) 64 - 70
11. Mohajer R., Salehi M. H. and Mohammadi J. (2012). Accumulation of Cadmium and Lead in Soils and Vegetables of Lenjanat Region in Isfahan Province, Iran. *International journal of Agronomy and Plant Production*. 3 (12), 576-578,
12. Adekunle, O. Bamgbose, M.T. Adetunji And Y.A. Lanre-

Iyanda(2010). Impact of un- 409 remediated solid waste dumpsite converted to farmland on plant cadmium 410 phytoaccumulation and toxicity. Journal of Applied Sciences in Environmental Sanitation, 411 5(3), 238-252. 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 13 Adewuyi G.O. and Opasina M.A. (2010).Physicochemical and Heavy Metals Assessments of Leachates from Aperin Abandoned Dumpsite in Ibadan City, Nigeria. European Journal of Chemistry. 7(4): 1278-1283. 14 Adewuyi G.O.; Dawodu F.A, and Jibiri N.N. (2010). Studies of the Concentration Levels of Heavy Metals in Vegetable (*Amaranthus caudatus*) Grown in Dumpsites within Lagos Metropolis, Nigeria. The Pacific Journal of Science and Technology , 11 (1) 616 - 621 15 Anake W. U, Adie G. U. and Osibanjo O (2009). Heavy metals pollution at municipal solid waste dumpsite in Kano and Kaduna state in Nigeria. Bulletin Chemical Society of Ethiopia. 23(1)281289. 16 Olarinoye, I.O., Sharifat, I.,and Kolo, M.T.(2011).Heavy Metal Content of Soil Samples from two Major Dumpsites in Minna. Natural and Applied Sciences Journal.11 (1),1-5. 17 Elbagermi M. A., Edwards H. G. M., and Alajta A. I. (2012) Monitoring of Heavy Metal Content in Fruits and Vegetables Collected from Production and Market Sites in the Misurata Area of Libya. SRN Analytical Chemistry, 2012 (2012) 18 Tukura,B.W.,Kagbu J. A.and Gimba C.E. (2007).Effect of pH and Total Organic Carbon (TOC) on the distribution of trace metals in Kubanni Dam Sediments, Zaria, Nigeria. Science World Journal, 2:1-6. 19 Adaikpoh E. O. and Kaizer A. N. (2012).Trace metal enrichment in Sediments from Otofure and Teboga waste Dump Sites in Benin City, Nigeria International Journal of Chemistry; 4, (4),14 – 27. 440 20 Obasi N.A., Akubugwo E.I., Ugbogu O.C. and Otuchristian G, (2012).Assessment of Physico- 443 chemical Properties and Heavy Metals Bioavailability in Dumpsites along Enugu-port Harcourt Expressways, South-east, Nigeria. Asian Journal of Applied Sciences, 5: 342- 356. 444 21 Uba, S., Uzairu, A. Harrison, G.F.S., Balarabe, M.L. and Okunola, O.J., (2008).Assessment of 445 heavy metals bioavailability in dumpsites of Zaria metropolis, Nigeria. African Journal 446 Biotechnology, 7 (2), 122-130 447 22 FEPA. Guidelines and standard for environmental impact assessment in Nigeria.1997;87–95. 448 449 450 451 452 453 454 455 23 United States Environmental Protection Agency (USEPA)., 2010. Quality Criteria for Water. United States 24 David N. O.; Benjamin L. K and Patrick O. Y.(2009). Some physico-chemical and Heavy metal levels in soils of waste dumpsites in Port Harcourt Municipality and Environs. Journal of Applied Science and Environmental Management. 13(4) 65 - 70 456 457 458 459 460 461 462 463 464 465 466 467 468 25 Jacob O. J and Kakulu S. E..(2012) Assessment of Heavy Metal Bioaccumulation in Spinach, Jute Mallow and Tomato in Farms Within Kaduna Metropolis, Nigeria. American Journal of Chemistry 2(1): 13-16. 26 Odoh Rapheal and Kolawole Sunday Adebayo (2011). Assessment of trace heavy metal contaminations of some selected vegetables irrigated with water from River Benue within Makurdi Metropolis, Benue State Nigeria. Advances in Applied Science Research, 2 (5):590-601 27 Mohajer R. , Salehi M. H. and Mohammad J.(2012). Accumulation of Cadmium and Lead in Soils and Vegetables of Lenjanat Region in Isfahan Province, Iran. International Journal of Agronomy and Plant Production., 3 (12), 576-578, 469 470 471 28 Myung C. J. (2008). Heavy metal uptake in soils and factors affecting metal uptake by plants in the vicinity of a korean Cu-W mine. Sensors, 8, 2413-2423. 472 473 474 475 29 Amusan, A. A., Ige, D. V. and Olawale, R. (2005). Characteristic of soil and crops uptake of metals in Municipal Waste Dumpsite in Nigeria. Journal of Human Ecology, 17(3):167-171. 476 477 478 30 WHO/FAO: Codex Alimentarius Commission, “Food Additives and Contaminants”, Joint FAO/WHO Food Standards Programme, 2001; ALINORM 01/12A: 1 – 289 479 31 Kashif S.R. , Akram M., Yaseen M. and Ali S. (2009)

Studies on heavy metals status and their uptake by vegetables in adjoining areas of Hudaira drain in Lahore. Soil & Environ. 28(1): 7-12. 32 Singh A., Sharma R. K, Agrawal M, Marshall F. M.(2010).Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, 484 India. Tropical Ecology, 51(2S): 375-387. 485 486 487 488 489 490 491 1 35 59 81 106 132 155 180 203 227 228 254 255 278 304 305 330 354 395 396 441 442 482 483 34 58 80 104 105 131 226 252 253 277 303 353 392 393 438 439 480 481