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Concentration of Heavy Metals in Vegetables Cultivated around Dumpsites in Jimeta and Ngurore Areas, Adamawa State, Nigeria

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ABSTRACT: The study analyses the health risk assessment of the concentration of Iron, Lead, Copper, Chromium, and Cadmium heavy metals in vegetables grown near dumpsites of Jimeta and Ngurore areas of Adamawa State, Nigeria. Vegetables mainly Spinach (*Spinacia oleracea*) and lettuce (*Lactuca sativa*) were collected in triplicates and analyzed using Atomic Absorption Spectrophotometer Buck 210VGP (AAS). The result revealed that heavy metals detected in spinach at Jimeta dumpsite decreased in the following order: Fe (3.7 mg/kg) > Pb (0.18 mg/kg) > Cu (0.12 mg/kg) > Cr (0.07 mg/kg) > Cd (below limit of detection), compared to the metal concentration in spinach at Ngorure dumpsite with lower concentration of heavy metal which decreased in the order of: Fe (2.5 mg/kg) > Pb (0.16 mg/kg) > Cu (0.14 mg/kg) > Cr (0.02 mg/kg) > Cd (below limit of detection). Other result for Spinach in Jimeta decreased in the order Fe (3.31mg/kg) > Pb (0.2mg/kg) > Cu (0.11mg/kg) > Cr (0.05mg/kg) > Cd (ND) beyond the limit of detection while Lettuce decreased in the order Fe (22.54mg/kg) > Cu (0.31mg/kg) > Pb (0.12mg/kg) > Cr (0.07mg/kg) > Cd (ND) beyond the limit of detection. Fe is the most abundant element in the vegetables with a mean value of 21 mg/kg followed by Pb (0.177 mg/kg). The analyses of paired T-test for vegetables in Ngurore and Jimeta at 0.05 level of significant confirmed that Cu and Cr showed no statistically significant difference in their concentration level while Fe and Pb confirmed that there was statistically significant difference in their concentration level. However, the detection of heavy metals in these vegetables calls for close environmental monitoring and adequate public awareness. This is necessary to discourage further pollution which could lead to high metal concentration and metal poisoning in vegetables and invariably humans that consume them.

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INTRODUCTION

Heavy metal is any relatively dense metal or metalloid that is noted for its potential toxicity, especially in environmental contexts. The term has a particular application to cadmium, mercury, lead and arsenic, all of which appear in the World Health Organization's list of 10 chemicals of major public concern. (WHO, 2016). Other examples of heavy metals include Manganese, Chromium, Cobalt, Nickel, Copper, Zinc, Selenium, Silver, Antimony and Thallium. Heavy metals are found naturally on earth. The use of dumpsite soils as organic manure is widespread in Adamawa State, Nigeria. This practice has been known to improve soil properties such as organic matter, nutrients, porosity, aggregate stability, bulk density and water retention, and as a result, increase plant productivity (Oluyemi *et al.,* 2008; Olarinoye *et al.,* 2010). However, it is a known fact that some of the waste products contain hazardous metals such as Cr, Pb, Cd, Fe, and Cu, 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 (Abdallah *et al.,* 2011; Adelekan and Alawode, 2011). Heavy metals become concentrated as a result of human activities and can enter plant, animal, and human tissues via in halation, diet, and manual handling. Based on their persistence and cumulative behavior as well as the probability of potential toxicity effects, the absorption of heavy metals in human diets as a result of the consumption of vegetables and fruits means that there is a requirement for the analysis of food items to ensure that the levels of trace heavy metals meet the agreed international standards. This is particularly important for farm products from parts of the world where only limited data on the heavy metal content are available. Knowledge of the contamination of fruit and vegetables with heavy metals is important. (Khan *et al.*, 2008). Heavy metal contamination of vegetables cannot be underestimated as these foodstuffs are important components of human diet. Vegetables are rich sources of vitamins, minerals, and

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fibers, and also have beneficial anti-oxidative effects. However, intake of heavy metal-contaminated vegetables may pose a risk to human health. Heavy metal contamination of the food items is one of the most important aspects of food quality assurance (Marshall, 2004; Radwan and Salama, 2006). Emissions of heavy metals from industries and vehicles may be deposited on the vegetable surfaces during their production, transport and marketing. Al Jassir *et al.* (2005), reported elevated levels of heavy metals in vegetables sold in markets at Riyadh, Saudi Arabia due to atmospheric deposition. Recently, Sharma *et al*., 2008a ; Sharma *et al*., 2008b also opined that atmospheric deposition can significantly elevate the levels of heavy metals contamination in vegetables commonly sold in the markets of Varanasi, India. Regulations have been set up in many countries and for different industrial set up to control the emission of heavy metals. The uptake of heavy metals in vegetables are influenced by some factors such as: climate, atmospheric depositions, the concentrations of heavy metals in soil, the nature of soil on which the vegetables are grown and the degree of maturity of the plants at the time of harvest. Air pollution may pose a threat to post-harvest vegetables during transportation and marketing, causing elevated levels of heavy metals in vegetables (Agrawal, 2003). Al-Rehaili (2009) monitored air quality in Riyadh city. He discussed 10 air pollutants, together with relevant meteorological parameters; his obtained results revealed that most sites had on the average exceeded the recommended standards for Sulphur dioxide (SO_2) and ammonia (NH_3) at concentrations of PM_{10} and O_3, respectively. The bio-toxic effects of heavy metals refer to the harmful effect of the metals when consumed above the bio-recommended limits (Duruibe *et al.,* 2007). Although individual metals exhibit specific signs of toxicity, the following have been reported as general fumes are signs associated with cadmium, lead, arsenic, mercury, zinc and aluminum poisoning: gastrointestinal (GI) disorders, diarrhea, stomatitis, tremor, hemoglobinuria causing a rust-red color stool, ataxia, paralysis, vomiting and convulsion, depression and pneumonia when volatile vapors and inhaled (McCluggage, 1991). The prolonged consumption of unsafe concentrations of heavy metals through foodstuffs and in particular vegetables may lead to the chronic accumulation of heavy metals in the kidney and liver of humans causing disruption of numerous biochemical processes, thus leading to cardiovascular, nervous, kidney and bone diseases (Jarup, 2003). Some heavy metals such as Copper (Cu), Zinc (Zn), Manganese (Mn), Cobalt (Co) and Molybdenum (Mo) act as micronutrients for the growth of animals and human beings when present in trace quantities, whereas others such as Cadmium (Cd), Arsenic (As), and Chromium (Cr) act as carcinogens. The contamination of vegetables with heavy metals due to soil and atmospheric contamination poses a threat to its quality and safety. Dietary intake of heavy metals also poses risk to animals and human health. Heavy metals such as Cadmium and lead have been shown to have carcinogenic effects. High concentrations of heavy metals (Cu, Cd and Pb) in fruits and vegetables were related to high prevalence of upper gastrointestinal cancer (Turkdogan *et al.,* 2002). This study analyses the concentration of heavy metals such as Iron (Fe), Lead (Pb), Copper (Cu), Chromium (Cr), and Cadmium (Cd) in vegetables grown near dumpsite of Jimeta and Ngurore areas of Adamawa State, Nigeria and their associated health risk.

MATERIALS AND METHODS

Study Area: The research was conducted in Jimeta Yola-North Local Government Area (LGA) and Ngurore Yola-South LGA, respectively, being the central part of Adamawa State, North-Eastern Nigeria. The area lies between latitude 9^o 15′ N 12^o 25′ E and longitude 9^o 20′ N 12^o 30′E, covering a total land mass of 1,213.30 sq.km^2 (Figure 1). Table 1 shows the coordinates of the dumpsites. The area has a tropical climate, marked by dry and rainy seasons. The rainy season commences around May and ends in the middle or late October. The rainfall is characterized by a single maximum with a mean total annual rainfall of 1,113.3mm. The dry season starts in late October and ends in late April (Adebayo and Tukur, 1999). Maximum temperature in Yola can reach 40^oC, around April, while minimum temperature could be as low as 18.30^0C between December and early January. Relative humidity in the area is about 26% in the months of January, while February is the lowest; with high relative humidity values of 58%, 69%, 79%, 79%, 77% and 66% respectively which could be recorded during the months of May to October, particularly during the months of July and August as the peak, with about 80% relative humidity (Adebayo and Tukur, 1999). Most inhabitants are civil servants, traders, fishermen, farmers and cattle rearing.

Collection of samples: Vegetables samples were collected from six (6) sites each within the dumpsite vicinity of Jimeta and Ngurore. The following vegetables were considered for heavy metals investigation: Spinach (*Spinacia oleracea*), and Lettuce (*Lactuca sativa*), which were mostly grown in the study area. Three vegetable samples were collected from six (6) sites, making a total of eighteen (18) vegetable samples for each study area mentioned. To serve as future surveillance points, coordinates of these points were recorded using global positioning system (Garmin, GPS72H).

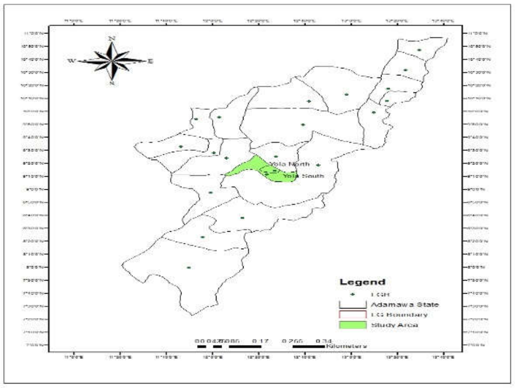

Fig. 1: Map of Adamawa showing study area. (Source: GIS Laboratory Department, MAUTECH-Yola 2018)

Plate 1: Vegetables sampling locations near Jimeta city solid waste dumpsites

Sample Treatment and Analysis: Two hundred grams (200g) of the vegetable samples collected were thoroughly washed with fresh water in order to remove the adhering dirt and finally with distilled water. The vegetable samples were cut into pieces and air-dried, then placed in an electric oven at 65°C to remove all the moisture. The dried vegetables samples were homogenized by grinding using an electric blender to obtain a homogenous mass for subsequent analysis. (Chailapakul *et al.,* 2007 and Wuana *et al.,* 2011). To determine the concentration of heavy metals in vegetable samples, aliquot (about 0.3 g) amount of the ground dried samples was taken in a vessel of the microwave oven and 4 ml of concentrated nitric acid (HNO_3) was poured. After the digestion, the samples were filtered and leveled up to the mark with distilled water in a 10 ml volumetric flask. Finally, the samples were analyzed for heavy metals using Atomic Absorption Spectrophotometer (Air Acetylene flame intergraded mode, Buck 210VGP) (Gupta *et al.,* 2008; Khan *et al.*, 2008).

Statistical analysis: SPSS Version 23.0 was used for the analysis. Descriptive statistics mainly mean and standard deviation was used to describe the concentration levels of heavy metals in vegetable. Paired T-Test to assess the differences in heavy metals concentration in vegetables was also used P 0.05.

Table1: Showing sampling coordinates in the Study Area

S/N	LGA	Dumpsite	Ward	Latitude (N)	Longitude(E)
1	Yola-North	Jimeta	Dubeli	9.287804^{0}N	12.458260^{0}E
				9.287644^{0}N	12.458201^{0}E
				9.288050^{0}N	12.457797^{0}E
				9.287317^{0}N	12.457571^{0}E
				9.287517^{0}N	12.456770^{0}E
				9.287451^{0}N	12.455511^{0}E
2	Yola-South	Ngurore	Ngurore	9.287485^{0}N	12.233566^{0}E
				9.287175^{0}N	12.233432^{0}E
				9.287721^{0}N	12.233568^{0}E
				9.287335^{0}N	12.233653^{0}E
				9.287359^{0}N	12.233500^{0}E
				9.286963^{0}N	12.233211^{0}E

RESULTS AND DISCUSSION

Cadmium (Cd) was omitted because Cd concentration was below the instrumentation detection limit in all the vegetable samples. The maximum permissible concentrations (MPC) of Fe, Cu, Cr, Pb and Cd in dry vegetables vary in comparison to standard values set by (FAO/WHO, 2007). Heavy metals uptake by spinach (*Spinacia oleracea*) near Jimeta dumpsite indicated that in Site 1: Fe (3.31 mg/kg) recorded the highest metal concentration, followed by Pb (0.2), Cu (0.11), Cr (0.05 mg/kg) and Cd (None Detected) was beyond the limit of detection. Site 2: Fe (4.7mg/kg) recorded highest metal concentration, Followed by Pb (0.2), Cu (0.06 mg/kg). Cr (0.06 mg/kg), Cd (ND). Site 3: Fe (2.75 mg/kg) indicated the highest metal concentration, followed by Pb (0.19 mg/kg), Cu (0.13 mg/kg), Cr (0.07 mg/kg) and Cd was beyond the limit of detection. Site 4: Fe (4.21 mg/kg) recorded the highest metal concentration, followed by Pb (0.18 mg/kg), Cu (0.13 mg/kg), Cr (0.07mg/kg), and Cd (ND). Site 5: Fe (4.61 mg/kg) showed highest metal concentration, followed by Pb (0.17 mg/kg), Cu (0.1

mg/kg), Cr (0.09 mg/kg) and the least was Cd (ND). Site 6: Indicated Fe (2.93mg/kg) stilled recorded the highest concentration of metals, followed by Cu (0.18 mg/kg), Pb (0.12 mg/kg), Cr (0.09 mg/kg) and the least was Cd which was beyond the limit of detection (Table 2). The results obtained for heavy metals uptake by spinach (*Spinacia oleracea*) near Ngurore dumpsite showed that in site 1: Fe recorded the highest metal concentration with 2.43 mg/kg, followed by Cu with 0.16 mg/kg, Cr and Pb recorded the same concentration of 0.01 mg/kg, while the least was Cd (ND) which was beyond the limit of detection. Site 2: Fe (2.16 mg/kg) recorded highest concentration, Followed by Pb (0.3 mg/kg), Cu (0.12 mg/kg). Cr (0.02 mg/kg), Cd (ND). Site 3: Fe (0.04 mg/kg) indicated the highest metal concentration, followed by Pb (0.17 mg/kg), Cu (0.04 mg/kg) and Cr (0.04 mg/kg) recorded the same concentration and Cd was beyond the limit of detection. Site 4: Fe (3.11 mg/kg) recorded the highest metal concentration, followed by Pb (0.14 mg/kg), Cu (0.12 mg/kg), Cr (0.03 mg/kg), and Cd (ND). Site 5: Fe (2.33 mg/kg) showed highest metal concentration, followed by Pb (0.22 mg/kg), Cu (0.16 mg/kg), Cr (0.03 mg/kg) and the least was Cd (ND). Site 6: indicated that Fe (3.12 mg/kg) was the highest concentration of metals, followed by Pb (0.13 mg/kg) and Cu (0.13 mg/kg Cr (0.02 mg/kg) and the least was Cd which was beyond the limit of detection (Table 3).

Table 2: Heavy metal Concentrations in Spinach (mg/kg) near Jimeta dumpsite

Sites	Cr	Fe	Cd	Pb	Cu
1	0.05	3.31	ND	0.2	0.11
2	0.06	4.7	ND	0.2	0.09
3	0.07	2.75	ND	0.19	0.13
4	0.07	4.21	ND	0.18	0.13
5	0.09	4.61	ND	0.17	0.1
6	0.09	2.93	ND	0.12	0.18
Total	**0.43**	**22.51**	**0**	**1.06**	**0.74**
Mean	**0.071667**	**3.751667**		**0.176667**	**0.123333**

Table 3: Heavy metal concentrations in Spinach (mg/kg) near Ngurore dumpsite

Sites	Cr	Fe	Cd	Pb	Cu
1	0.01	2.43	ND	0.01	0.16
2	0.02	2.16	ND	0.3	0.12
3	0.04	2.06	ND	0.17	0.14
4	0.03	3.11	ND	0.14	0.12
5	0.03	2.33	ND	0.22	0.16
6	0.02	3.12	ND	0.13	0.13
Total	**0.15**	**15.21**		**0.97**	**0.83**
Mean	**0.025**	**2.535**		**0.161667**	**0.138333**

Concentrations levels of Heavy metals by Lettuce (*Lactuca sativa*) near Jimeta dumpsite show that in site 1: Fe (22.54 mg/kg) recorded the highest metal concentration, followed by Cu (0.31 mg/kg), Pb (0.12mg/kg), Cr (0.07 mg/kg) and Cd (ND) was beyond the limit of detection. Site 2: Fe (15.51 mg/kg) recorded highest metal concentration, Followed by Cu (0.18 mg/kg), Pb (0.12 mg/kg). Cr (0.07 mg/kg), Cd (ND). Site 3: Fe (23.73 mg/kg) indicated the highest metal concentration, followed by Cu (0.29 mg/kg), Pb (0.2 mg/kg), Cr (0.05 mg/kg) and Cd was beyond the limit of detection. Site 4: Fe (21.5 mg/kg) recorded the highest metal concentration, followed by Cu (0.29 mg/kg), Pb (0.14 mg/kg), Cr (0.08 mg/kg), and Cd was not detected (ND). Site 5: Fe with (16.54 mg/kg) showed highest metal concentration, followed by Cu (0.16 mg/kg), Pb (0.07 mg/kg), Cr (0.07 mg/kg) and the least was Cd (ND). Site 6: Indicated that Fe with (26.23 mg/kg) recorded the highest concentration of metals, followed by Cu (0.36 mg/kg), Cr (0.7 mg/kg), Pb (0.19 mg/kg), and the least was Cd which was beyond the limit of detection (Table 4). Heavy metals Concentrations by Lettuce (*Lactuca sativa*) near Ngurore dumpsite showed that in Site 1: Fe with (18.64 mg/kg) recorded the highest metal concentration, followed by Cu (0.14 mg/kg), Pb (0.13 mg/kg), Cr (0.02mg/kg) and Cd (ND) was beyond the limit of detection. Site 2: Fe (16.04 mg/kg) recorded highest metal concentration, Followed by Cu (0.11 mg/kg), Pb (0.1 mg/kg). Cr (0.05 mg/kg) and Cd was not detected (ND). Site 3: Fe (20.01 mg/kg) indicated the highest metal concentration, followed by Pb (0.19 mg/kg), Cu (0.15 mg/kg), Cr (0.05 mg/kg) and Cd was beyond the limit of detection.

Table 4: Heavy metal concentrations in Lettuce (mg/kg) near Jimeta dumpsite

Site	Cr	Fe	Cd	Pb	Cu
1	0.07	22.54	ND	0.12	0.31
2	0.07	15.51	ND	0.12	0.18
3	0.05	23.73	ND	0.2	0.29
4	0.08	21.5	ND	0.14	0.29
5	0.07	16.51	ND	0.13	0.16
6	0.7	26.23	ND	0.19	0.36
Total	**1.04**	**126.02**		**0.9**	**1.59**
Mean	**0.173333**	**21.00333**		**0.15**	**0.265**

Table 5: Heavy metal concentrations in Lettuce (mg/kg) near Ngurore dumpsite

Site	Cr	Fe	Cd	Pb	Cu
1	0.02	18.64	ND	0.13	0.14
2	0.05	16.04	ND	0.1	0.11
3	0.05	20.01	ND	0.19	0.15
4	0.02	12.64	ND	0.19	0.1
5	0.06	17.1	ND	0.09	0.13
6	0.04	11.05	ND	0.16	0.13
Total	**0.24**	**95.48**		**0.86**	**0.76**
Mean	**0.04**	**15.91333**		**0.143333**	**0.126667**

Site 4: Fe (12.64mg/kg) recorded the highest metal concentration, followed by Pb (0.19 mg/kg), Cu (0.1 mg/kg), Cr (0.02 mg/kg), and Cd was not detected (ND). Site 5: Fe with (17.1 mg/kg) showed highest metal concentration, followed by Cu (0.13 mg/kg), Pb (0.09 mg/kg), Cr (0.06 mg/kg) and the least was Cd (ND). Site 6: Indicated that Fe with (11.05 mg/kg)

recorded the highest concentration of metals, followed by Pb (0.16 mg/kg), Cu (0.13 mg/kg), Cr (0.04 mg/kg), and the least was Cd which was beyond the limit of detection (Table 5). The mean concentrations of heavy metals in spinach at Jimeta dumpsite decreased in the following order: Fe (3.7 mg/kg) > Pb (0.18 mg/kg) > Cu (0.12 mg/kg) > Cr (0.07 mg/kg) > Cd (below limit of detection), compared to the metal mean concentration in spinach at Ngurore dumpsite with lower concentration of heavy metal which decreased in the order: Fe (2.5 mg/kg) > Pb (0.16 mg/kg) > Cu (0.14 mg/kg) > Cr (0.02 mg/kg) > Cd (below limit of detection). This result differs from the report of Nanven *et al.* (2015), who reported that spinach, bio-accumulated the metals Fe, Mn, Zn, Cd, Ni and Pb in the order Fe > Mn > Zn > Cd > Ni > Pb. This could be a reflection of the concentrations of the metals in the soil. Nanven *et al* (2015) also reported that the concentration of iron was highest in almost all the vegetables similar to this study. The higher concentration of Fe noted in this study could be as a result of its oxygen carrying ability for chlorophyll production and also for protein synthesis (Kashif *et al.,* 2009). Studies conducted by Adu *et al*., (2012) revealed that levels of Cu, Pb and Zn in spinach that was irrigated with wastewater were below the maximum permissible limits of the National Agency for Food and Drug Administration and Control (NAFDA) of Nigeria. Kudirat and Funmilayo, (2011), also found that levels of Cr and Zn in a leafy vegetable sold in 10 markets in Lagos, Nigeria were below the maximum permissible limits according to Nigerian standards. The mean concentrations of heavy metals in Lettuce from Jimeta dumpsite decreased in the order of; Fe (21.0 mg/kg) > Cu (0.27 mg/kg) > Cr (0.17 mg/kg) > Pb (0.15) > Cd (below limit of detection), compared to the metal mean concentration in lettuce at Ngorure dumpsite with lower concentration of heavy metal which decreased in the order of: Fe (15.91 mg/kg) > Pb (0.14 mg/kg) > Cu (0.13 mg/kg) > Cr (0.04 mg/kg) > Cd (below limit of detection). This is similar to the report of Achakza (2011), who recorded the value of heavy metals detected for various metals were in the order: Fe > Zn > Mn > Cu > Pb > Cd > Ni. This result is similar to the present study which obtained a low accumulation of Cd and Pb and a high accumulation of Fe and Cu. The study show that all the heavy metal contents are within the permissible limit. Thus, its concentrations on the leafy parts of the vegetables examined seem not to be alarming except in the case of excessive prolong consumption. Various sources of environmental contamination have been reported for presence of Pb in food and various values have also been reported for leafy vegetables which include 0.090 mg/kg for fluted pumpkin by Sobukola *et al* (2010), 0.049 mg/kg for lettuce by Muhammad *et al* (2008).

Conclusion: The results reported here confirm that the vegetables obtained from both Jimeta and Ngurore dumpsites contained substantial amounts of metals with exception of Cd which was found to be below the limit of detection by the machine. However, the concentrations of Fe, Cu, Pb, Cr, and Cd in vegetables were found to be within the safe limits prescribed by FAO/WHO. Furthermore, analyses regarding the monitoring of heavy metals in vegetable need to be continued, in order to ascertain consumption of safe, healthy vegetables.

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