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Heavy Metals Concentration Levels in Vegetables Irrigated From Lake Geriyo Area of Adamawa State, Nigeria

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ABTRACT: *The persistence and generation of toxic metals in our environment and its subsequent transfer from sources into soil, farm lands, water and food crops have remain a great challenge in most developing countries of the world. Heavy metal concentration levels in irrigated vegetables from Geriyo farm sites were examined using Buck Scientific atomic absorption Spectrophotometer (AAS) VGP 210 Model. The mean concentration levels of Fe 335.0 mg/kg, Zn 335.2mg/kg, Mn 44.2mg/kg and Cu 74.1mg/kg were on the higher side, but below the safe limit of FAO/WHO standard except for Cu. The mean concentration levels of the most toxic metals, Cd, Cr and Pb with values of 0.42, 0.34, 0.32, 9.80, 6.20, 5.80, 5.40mg/kg and 9.12, 6.20, 4.40 and 2.61mg/kg were alarmingly above the safe limit of 0.2, and 0.3mg/kg Standard in Cabbage, lettuce, amaranthus and tomatoes of this farm site. The studied vegetables have accumulated these toxic metals in their edible leaves to a higher level. The consumers of vegetables grown from this site in the long run may suffers the health risk of body organs like kidney, liver, lungs and spleen. Public enlightenment and education about the risk and the need to control environmental pollution, food chain transfer of toxic metal via vegetables consumption and the health risk index estimation is recommended.*

KEYWORD: *Heavy metals, pollution, farm site, accumulation, vegetables, health risk.*

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I. Introduction

Environmental pollution and contamination from industrial, domestic and agricultural activities has been known to constitute major public concern worldwide. The inadequate and improper disposal of wastes generated from the manufacturing industries, from domestic homes, and agricultural activities often leads to improper disposal of the wastes into open space, water ways, rivers and streams that have often been used as sourceof irrigation water in places like the Lake Geriyo Irrigation project in Yoladuring dry season which normally start from the month of October to April annually.

In Nigeria, the use of contaminated/polluted water in the immediate surroundings of many big towns and cities for the growing of vegetables in the dry season is a common practice through irrigation. The use of such water sometimes might be considered to be rich in organic matter and some plant nutrients, however, they arealso a good source of soluble salts and heavy metals like Pb, Cu, Cd, Cr, Mn, Ni and others which can be stored in the soil and subsequently transferred to the irrigated vegetables and finally into the food chain [1],[14] [15].Research results have indicated that heavy metals are potentially toxic to crops, animals and humans when contaminated soils and water are used for crop production [2][3][4]. According to [5], the main sources of heavy metal exposure to humans' adult in Nigeria are: food, accounting for over 60% of blood levels, air inhalation, accounting for approximately 30% and water 10%.

The production of vegetables through irrigation during dry season is a good means of sustaining and supplementing the deficit in food production from the rainfed agriculture, better quality, and dark green big leaves as characteristics of good quality leafy vegetables are produced. However, the external morphology of vegetables cannot guarantee safety from contamination especially with heavy metals. Information on the concentration levels of heavy metals in crops in this area that will lead to the assessment of the risks involved in their consumption is scarce. Therefore there is the need to examine the concentration levels of Fe, Zn, Mn, Cu, Cd, Cr, Pb and Ni in locally irrigated Cabbage (*Brassica Oleracea*), Lettuce (*Lactuca sativa*), Amaranthus (*Amaranthus caudatus*) and Tomatoes (*Lycopercecum esculentum*)grown on the Lake Geriyo Irrigation site in Yola, Adamawa State, Nigeria in other to sensitize people against long time exposure effects of heavy metals via consumption of these vegetables.

II. Materials And Methods

1. The Study Area

Adamawa State with a population of 3,737,223 people and land mass of 36,917km^2 is located in the northeastern part of Nigeria. Yola (Jimeta) the Adamawa State capital is located between Longitudes 12° 26' E and Latitude 9° 16' N (http://www.en.wikipedia.org/wiki/jimeta) along the banks of River Benue [6]. Lake Geriyo lies between Longitude 12° 00' and 12° 28' East of Greenwich and Latitude 9° 16' and 9° 19' north of the equator. Geriyo catchment has devoted land area of 1200 hectares under dry season irrigation. The state is in the Sahel region of Nigeria which is generally Semi-arid with low rainfall, low humidity and high temperature. The area experiences wet and dry seasons, the wet season starts from April to October while the dry season starts from November to April. Recorded mean daily temperature normally changes with season and ranges from 25°C to 45°C. The mean annual rainfall received is in the range of (250 – 1000mm). The climate is characterized by high evapotranspiration especially during dry season (Adebayo, 1999). Jimeta/Yola the State capital city is a commercial nerve center of the state and has an estimated population of 600,000 people [7]. Dry season farming is normally practiced along the River bank using municipal effluent wastewater and River water to grow Cabbage (*Brassica Oleracea*), Lettuce (*Lactuca sativa*), Amaranthus (*Amaranthus caudatus*) and Tomatoes (*Lycopercecum esculentum*) by local farmers.

2. Vegetable Sample Collection, Preparation and Analysis

Samples of *Lactuca sativa, Amaranthus caudatus, Lycopercecum esculentum and Brassica Oleracea* that was irrigated with municipal effluent river water were collected from farms in the months of February and March of 2017. Each of the samples was thoroughly washed with water to remove extraneous mater and rapped into a polyethylene bags at room temperature. The samples were immediately transported to Soil and Water Engineering Laboratory of Modibbo Adama University of Technology, Yola. The samples were air- dried at room temperature and were grounded into powder by using pestle and mortar after which the resulting powder was sieved with < 2µmm aperture size to obtain uniform powder. 10g of fine powder of each vegetables were ashed in muffle furnace for 3 hours at a temperature of 650^{o}C. 1g each of the ashed powder was digested with concentrated nitric acidand per chloric acidsand the digest were

Figure 1: Field sampling and Laboratory processing of Vegetables

Made up to 50ml by adding nitric acid. The digested solutions of vegetable extracts were then analyzed for the concentrations of Fe, Zn, Mn, Cu, Cd, Cr, Pb and Ni using Buck Scientific atomic absorption Spectrophotometer (AAS) VGP 210 Model. Allowable limit of the concentration of metals in vegetables from FAO/WHO was adopted for the purposes of comparism and interpretation of concentration status of these tested vegetables. The results generated is presented in Tables.

III. Results And Discussion

The heavy metals concentration levels in each of the four tested vegetables grown from Lake Geriyo farm sites are presented in Table 1. Among the four different vegetables examined, the concentration level of Fe are below the safe limit set out by FAO/WHO Standard, however, concentration of Fe in lettuce is much higher than in cabbage, amaranthus and tomatoes with a mean concentration of 335mg/kg. The concentration level of Fe in the tested vegetables conforms to the order: Lettuce > amaranthus > tomatoes > cabbage. Fe is very much essential for the activation of respiratory enzymes and synthesis of chlorophyll in plants. The concentration values of Fe recorded in our study is far greater than the mean value of 12.873mg/kg reported by [8]. The higher values of Fe recorded in lettuce could be a good supplement of Fe. Tomatoes recorded the highest concentration level of Zn among the vegetables with a mean value of 336mg/kg, while cabbage recorded the least mean concentration value of 38.5mg/kg of Zn. All the tested vegetables contents Zn higher than the safe limit of

20mg/kg standard.The relative abundance of Zn in all the vegetables are: Tomatoes > amaranthus > lettuce > cabbage.

Table 1:Concentration Level of Heavy Metals in mg/kg in Irrigated Vegetables in Geriyo Sites

Elements	Cabbage (n=10)	Lettuce (n=10)	Amaranthus (n=10)	Tomatoes (n=10)	Safe Limits as per (FAO & WHO, 2011)
Fe	76.10-76.3 (76.20)	334-336 (335.0)	118-119.8 (119.0)	116-166.7 (117.0)	425.0
Zn	38.1-38.6 (38.32)	39-39.8 (39.4)	50 -50.4 (50.21)	335.2-336.8 (336.0)	20.0
Mn	33.1-33.3 (33.20)	44-44.4 (44.2)	31.3-31.7 (32.0)	19.3-19.7 (20.0)	500.0
Cu	4.70-4.90 (4.80)	73-75.0 (74.1)	6.1-6.7 (6.40)	21- 21.8 (21.4)	40.0
Cd	0.30-0.38 (0.34)	0.30-0.34 (0.32)	0.41-0.43 (0.42)	0.11-0.13 (0.12)	0.2
Cr	6.10-6.30 (6.20)	5.1-5.8 (5.40)	5.7-5.9 (5.80)	9.7-9.9 (9.80)	0.3
Pb	6.20-6.30 (6.20)	2.6-2.63 (2.61)	4.1 -4.8 (4.40)	9.13-9.18 (9.12)	0.3

The mean concentration level of Mn in all the vegetables are generally lower than the safe limit of 500mg/kg, while the concentration mean value of 44.2mg/kg recorded in lettuce was the highest among the four studied vegetables. The mean concentration level of metals examined in tomatoes, lettuce, cabbage and amaranthus samples were found to be in the order: Zn > Fe > Mn. These trends suggest that tomatoes and lettuce samples have a high retention capacity for Zn and then Fe followed by Mn (Table 1).

The mean concentration levels of Cu indicated values of 4.80, 74.1, 6.40 and 21.4mg/kg in cabbage, lettuce, amaranthus and tomatoes. Concentration of Cu in lettuce was the highest in the four vegetables which is greater than 40.0mg/kg safe limit set out by FAO/WHO. The implication of this is that consumption of lettuce irrigated from Geriyo farms containing high concentration of Cu might in the long runbe a health risk to consumers.[9],[10] reported Cu higher meanconcentration values 36.4and 21.31mg/kg in vegetables produced in sewage irrigated areas in different region ofVaranasi and Agra Districts in India (Table 2).[2] reported lower mean concentration range values of 0.458 – 0.632 mg/kg in Foetid Cassia, Kenaf, Tossa jute and Wild jute in Katchina State in Nigeria. The results obtained in this present study concurs with [11], [3]. Mean concentration level of Cu in all the vegetables are in order: Lettuce > tomatoes > amaranthus > cabbage.However despite the lowest limit of 0.2mg/kg, the mean concentration levels of Cd in cabbage, lettuce and amaranthus with values of 0.34, 0.32 and 0.42mg/kg are all found to be higher than the allowable safe limit of 0.2mg/kg. Amaranthus accumulatedhigher mean concentration of Cd (0.42mg/kg) than all the other tested vegetables. Comparatively, lower Cd concentration value Cd (0.42 mg/kg)was obtained in this study than the value of (1.09 mg/kg) reported by [10].The order of abundance of Cd in all vegetables are: Amaranthus > cabbage > lettuce > tomatoes.It could be observed generally that all the vegetables studied have higher retention capacity for essential elements (Zn, Fe, Mn, and Cu) than the toxic ones (Cd, Cr and Pb).

The mean concentration levels of Cr assessed in Cabbage, Lettuce, Amaranthus and tomatoes with values of 6.20, 5.40, 5.80 and 9.80mg/kg were recorded respectively. All the Cr mean concentrationvalues given for each of the vegetables are far above the FAO/WHO Standard of 0.3mk/kg Table1. The higher concentration values of Cr recorded could be attributed to poor disposal of liquid and solid wastes from homes and industries containing Crpigments, cosmetics and batteries that are disposed into waterways and farm lands that are used for agricultural production. Cr availability in all the vegetable tested are: Tomatoes > cabbage > amaranthus > lettuce.

Pb is among the harmful and toxic element to plants, although, under irrigation condition, plants usually may show ability to accumulate high amount of Pb without showing a visible changes in their morphological appearancence or yield and therefore Pb accumulation may exceeds the maximum level permissible for human consumption [1]. The mean concentration levels of Pb recorded in cabbage, Lettuce, amaranthus and tomatoes are 6.20, 2.61, 4.40 and 9.12 mg/kg, all the recorded concentration values of Pb in all the four vegetables are above the maximum permissible limit of (0.3mg/kg) for safe consumption. The order of Pb accumulation in the studied vegetables are: Tomatoes > Cabbage > Amaranthus > Lettuce.

The accumulation of Pb in vegetables from Geriyo farm sites is a serious concern to consumers. The uptake and accumulation of Pb and other toxic elements in the edible parts of crops may in the long run enter the food chain and finally transmit the absorbed metals to consumers. In addition, the harmful effect of Pb accumulation in human being has been associated with effect on body organs like kidney, lungs, spleen and liver[4],[1].

Generally, the mean concentrations of the toxic heavy metals (Cu, Cd, Cr and Pb) in cabbage, lettuce, amaranthus and tomatoes as examined and revealed by this work is a potential health risk to vegetable consumers despite the nutrition benefit derivable from the consumption of vegetables in our daily dietary requirements as often advocated by our Medical and health Practitioners. Thisfindings therefore calls for public enlightenment and public education about the risk and the need to control environmental pollution.

Table 2: Comparison with other reports of heavy metals concentrations (mg/kg) in irrigated vegetables and Present study in Nigeria.

Countries	Sites	Fe	Zn	Mn	Cu	References
Geriyo (Nigeria)	Urban area	76 - 335 (161.8)	38 – 337 (115.9)	19- 44.4 (32.35)	4.9 - 75.0 (26.68)	This study
Katsina State (Nigeria)	Central market	0.214-0.334 (0.252)	0.221-0.375 (0.260)	NA	0.33-0.63 (0.458)	Shuaib and Abdullahi, 2013
India (Varanasi)	Urban area	NA	NA	NA	20.5-71.2 (36.4)	Sharma *et al.*, 2007
Dabaoshan (China)	Mine area	NA	2.34-40.2 (10.53)	NA	0.23-3.61 (1.18)	Zhuang *et al.*, 2009
Noakhali (Bangladesh)	Arsenic Contaminated area	NA	NA	NA	2.1-86.3 (20.6)	Rahman *et al.*, 2013
Dhaka City (Bangladesh)	Industrial area	NA	16.29-103.74 (41.54)	NA	8.3-29.39 (16.27)	Islam and Hogue, 2014

IV. Conclusion

Heavy metals concentration and accumulation levels in irrigated cabbage, lettuce, amaranthus and tomatoes grown on Geriyo farm sites were examined. The results obtained revealed that vegetables accumulated all the metals in their edible leaves.The mean concentration levels of Fe, Zn, Mn and Cu were on the higher side, but all were below FAO/WHO Standard except for Cu in lettuce. The concentration levels of the most toxic heavy metals Cd, Cr and Pb in all the vegetables are exceptionally higher than the permissible safe limit of FAO/WHO Standard. The implication of this development means that consumers of cabbage, lettuce, amaranthus and tomatoes from this farm sites in the long run will be at health risk of body organs like kidney, lungs, spleen and liver.Public enlightenment and education about the risk and the need to control environmental pollution, and the food chain transfer of toxic metal via vegetables consumption is here by recommended.

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