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Assessment of Heavy Metals Accumulation in *Lactuca sativa* and
Amaranthus caudatus Grown with Manure from Refuse Dumping
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ABSTRACT

Local farmers nowadays gathered manure from dumped sites to grow vegetables. Due to this fact, this research was conducted to assess the health risk of growing vegetables using manure contaminated with heavy metals, by using the Atomic Absorption Spectroscopy (AAS). In this research, vegetables (Lettuce and Amaranthus) were grown on three different pots (A, B and C) that comprises the control soil, contaminated soil from dumped sites and the mixed of control and contaminated soil. The harvested vegetables were digested using wet acid method and prepared for metal analysis using AAS and the data was analyzed using Minitab version 16.0 and the results was expressed as mean \pm standard deviation and the mean values were compared with World Health Organization (WHO) recommended dose. The findings revealed that Cadmium (Cd) and Chromium (Cr) exceed WHO permissible limits of 0.2mg/L and 1.3mg/L respectively. The order of accumulation varied from plant to plant. Lettuce has the following: Zn > Cr > Cd > Ni > Pb > Cu. While that of Amaranthus is: Zn > Cu > Cd > Cr > Ni > Pb. Also, in comparison with lettuce, amaranthus absorb and accumulates more heavy metals.

Keywords: absorption, accumulation, dumpsite soil, heavy metals and vegetables

1.0 INTRODUCTION

High cost of chemical fertilizer for growing vegetables especially in the North-western states of Nigeria has affected vegetables production. In order to improve productivity, local farmers resulted in using a large amount of manure mixed with soil from dump sites (contaminated with many chemicals including heavy metals) for growing vegetables especially in urban areas (Musa *et al.*, 2019).

Although some metals such as Copper (Cu) were among the essential elements required by humans in trace amount, a high concentration in vegetables and soil leads to toxicity in human (Yang *et al.*, 2018).

Chen *et al.*, (2014) believed that heavy metals such as Lead (Pb), Cadmium (Cd), Chromium (Cr) can be harmful to human even in trace amount as effective excretory mechanism is not available. They further narrated that Cadmium (Cd)

accumulates in the liver and kidney of vertebrates causing difficult diseases to these organs while Chromium (Cr) causes ulcers and can cause toxic to both plants and animals.

Dump site is one of the major sources of heavy metals but have not been considered by most of the researchers they rather consider investigating the accumulation of heavy metals (Pb, Cd, Cr, Cu) by vegetables from the water use for irrigation (Musa *et al.*, 2019).

In this study heavy metals accumulation by vegetables grown with manure mixed with dump soil in Gada Biyu area of Gusau, Zamfara State of North-Western Nigeria was investigated and the findings of this study will benefit both the farmers and consumers on the health risk of consuming vegetables grown with manure mixed with dump soil.

2.0 MATERIAL AND METHODS

2.1 Study Area

The study was conducted in Gada Biyu Area, Gusau, Zamfara State, Nigeria. The city of Gusau, is located in Northwestern Nigeria, and is the capital of Zamfara State. It has an area of 3,364 km² and an estimated population of 614,569. Gusau is along Sokoto – Zaria road (Latitude 12°09'N and Longitude 6°40'E), and the coordinates of the dumping site are: Latitude 12°11'44.4" N and Longitude 6°38'02.2" E. (Bala *et al.*, 2012). The mean temperature of Gusau according to Zamfara Agricultural Development Project [ZADP] (2021) is 37°C and the average humidity is 41% while the mean rainfall is 857 mm and the vegetation type is Northern guinea savannah.

2.2 Collection of Seeds

For the purpose of this study, seed of Spinach and Lettuce were collected from the local farmers in Gusau Local government, 1 tin (50g) of each seed was collected then packed and tagged in a sterile fabric sack for easy identification (Ashraf *et al.*, 2021).

2.3 Collection of Sample

Contaminated soils from dumped sites (where those local farmers usually collect their manure contaminated with metals) was collected using sterile shovel and packed in sacks and then transported to the site (Gada Biyu Area, Gusau) where the vegetables were planted (Musa *et al.*, 2019).

2.4 Preparation of Planting Site

Eighteen plastic pots were prepared (9 pots for Spinach and other 9 for Lettuce) and their size is 6 litres each which is equivalent to 6000 cubic centimetres. The first nine pots for growing Spinach were categorized as A, B and C, pot A contained contaminated soil, pot B contained a mix of contaminated and uncontaminated soil, while pot C contained normal/control soil with no contamination. Same procedure was adopted for the other nine pots for growing lettuce. After the preparation, seeds were distributed evenly on the pots (labelled A, B & C). All the pots were

perforated at the bottom to allow excess water to run out (Rai *et al.*, 2019).

2.5 Planting of Vegetable Seeds

The collected seeds after identification were dispersed in the pots containing mixture of soil and manure in appropriate proportion, then covered lightly with the soil to prevent carried away by wind or picked by birds (Rachel, 2021).

2.6 Watering

After seeds were planted, watering was followed to provide enough moisture required for germination and growing, and after germination the plant were frequently being watered morning and evening to maintain the moisture requirement by the plant (Rachel, 2021).

2.7 Harvesting of the Vegetables

Harvesting of both the Amaranthus (*Amaranthus caudatus*) and Lettuce (*Lactuca sativa*) was done after 40 days of planting, as that is the minimum maturation period of each of them (Joshi & Verma 2020).

2.8 Sample Preparation

The samples were cut into small pieces, air-dried (20°C – 35°C) for two days to reduce water content and finally oven-dried at 70°C to remove all moisture content without thermal decomposition (Edogbo *et al.*, 2020).

2.9 Sample Digestion and Analysis

To ensure uniform distribution of the metals in the samples, the leaves were grounded using pestle and mortar, passed through 1.18 mm sieve and kept in clean plastic bottles (Leblebici *et al.*, 2018). One gram (1g) of each vegetable was digested (wet acid) with 15 mL of concentrated nitric acid, sulfuric acid, and perchloric acid in the ratio 3:1:1 at 80°C until a clear solution was obtained. The clear solution was filtered and transferred into a 100 mL volumetric flask and filled to the mark using distilled water (Gupta *et al.*, 2010). Heavy metal concentration analysis was done using the atomic absorption spectrophotometer (AAS) MY19479002, Version 1.6.1.10384.

2.10 Statistical Analysis

Data obtained was analyzed using Minitab version 16.0 and the results was expressed as mean \pm standard deviation and the mean values were compared with accepted standard.

3.0 RESULT

Table 1: Heavy Metals Mean Concentration (In Mg/l) In Vegetables Grown with Control Soil

Metals (mg/L)	Vegetables		WHO/FAO
	Lettuce	Amaranthus	
Zn	14.88 \pm 2.36	21.13 \pm 3.92	50
Cd	0.44 \pm 0.04	1.16 \pm 0.06	0.2
Cu	1.44 \pm 4.38	2.51 \pm 1.93	10
Ni	0.31 \pm 0.05	0.30 \pm 0.55	67
Cr	0.87 \pm 0.25	1.61 \pm 0.37	1.3
Pb	-0.43 \pm 0.03	-0.32 \pm 0.02	0.3

FAO/WHO: Food and Agricultural Organization/World Health Organization Permissible limits of Heavy Metals in Leafy Vegetables. (Negative sign in Pb means not detected)

The analyzed heavy metals (Zn, Cd, Cu, Ni, Cr and Pb) concentrations of the two vegetables (Lettuce and Amaranthus) grown with control soil were listed in Table 1 above. The metals concentration in vegetables showed significant variability among the two vegetables.

The order of accumulation of the heavy metals according to mean concentrations measured in the vegetables varied from table to table. In Table 1 the order of accumulation for both the Lettuce and Amaranthus are: Zn > Cu > Cr > Cd > Ni > Pb. Also as observed in Table 1 above, Cadmium (Cd) exceed the permissible limit of 0.2mg/L in both lettuce and amaranthus, while Chromium (Cr) exceed the permissible limit of 1.3mg/L only in amaranthus.

In comparison with lettuce, amaranthus absorb and accumulates more heavy metals as observed from the data from table 1.

Table 2: Heavy Metals Mean Concentration (In Mg/l) In Vegetables Grown With Mix Of Control And Dump Site's Soil.

Metals (mg/L)	Vegetables		WHO/FAO
	Lettuce	Amaranthus	
Zn	24.06 \pm 3.06	21.12 \pm 2.08	50
Cd	0.72 \pm 0.21	1.33 \pm 0.12	0.2
Cu	-0.12 \pm 0.45	1.95 \pm 1.41	10
Ni	0.28 \pm 0.12	-0.40 \pm 1.10	67

Cr	1.88 \pm 1.54	1.77 \pm 0.92	1.3
Pb	-0.36 \pm 0.03	-0.36 \pm 0.09	0.3

FAO/WHO: Food and Agricultural Organization/World Health Organization Permissible limits of Heavy Metals in Leafy vegetables. (Negative sign means not detected)

Table 2 above, showed the analyzed heavy metals (Zn, Cd, Cu, Ni, Cr and Pb) concentrations of the two vegetables (Lettuce and Amaranthus) grown with mix of control and dump site's soil.

The order of accumulation of the heavy metals according to mean concentrations measured in the vegetables varied also. In Table 2 the order of accumulation for Lettuce is: Zn > Cr > Cd > Ni > Cu > Pb. While for Amaranthus is: Zn > Cr > Cu > Cd > Ni > Pb which was same in Table 1. Also as observed in Table 2, Cadmium (Cd) and Chromium (Cr) exceeds the permissible limit of 0.2mg/L and 1.3mg/L respectively in both the lettuce and the amaranthus.

Table 3: Heavy Metals Mean Concentration (In Mg/l) In Vegetables Grown With Dump Site's Soil

Metals (mg/L)	Vegetables		WHO/FAO
	Lettuce	Amaranthus	
Zn	20.87 \pm 5.03	29.64 \pm 6.97	50
Cd	0.95 \pm 0.10	1.61 \pm 0.23	0.2
Cu	-0.83 \pm 0.96	3.21 \pm 1.48	10
Ni	0.01 \pm 0.10	0.62 \pm 0.16	67
Cr	1.04 \pm 0.13	1.26 \pm 0.29	1.3
Pb	-0.44 \pm 0.06	-0.48 \pm 0.21	0.3

FAO/WHO: Food and Agricultural Organization/World Health Organization Permissible limits of Heavy Metals in Leafy vegetables. (Negative sign means not detected)

Table 3, showed the analyzed heavy metals (Zn, Cd, Cu, Ni, Cr and Pb) concentrations of the two vegetables (Lettuce and Amaranthus) grown with dump site's soil.

The order of accumulation in Table 3 varied from that of Table 1 and 2, here Lettuce has the following: Zn > Cr > Cd > Ni > Pb > Cu. While that of Amaranthus is: Zn > Cu > Cd > Cr > Ni > Pb. Also as observed in Table 3, Cadmium (Cd) and Chromium (Cr) exceeds the permissible limit of 0.2mg/L and 1.3mg/L respectively in both the lettuce and the amaranthus, but in comparison with lettuce, amaranthus absorb and accumulates more heavy metals as observed from the data in table 3.

4.0 DISCUSSION

The findings of the study revealed that Lettuce (*Lactuca sativa*) and Amaranthus (*Amaranthus caudatus*) absorb and accumulates heavy metals in them above permissible limits especially Cadmium (Cd) and Chromium (Cr). These findings are in accordance with the findings of Anwar *et al.*, (2016) where they found that concentration level of heavy metals in vegetables irrigated with sewage water is above permissible level. Also, Adedokun *et al.*, (2016) when conducting research on Metals Intake via Consumption of Leafy Vegetables in Lagos, Nigeria found out that Lead (Pb) in leafy vegetables was above permissible limit. Another research conducted by Jimoh and Mohammed (2016) found similar results in their research, where Cadmium (Cd) exceeded the permissible limit in lettuce.

Mustapha and Adeboye (2014) conducted a research on accumulation of heavy metals in edible part of vegetables irrigated with waste water and the results when compared with FAO/WHO heavy metals standard was very detrimental to health because the heavy metals found were above the recommended threshold limit. Napoli *et al.*, (2019) also revealed that vegetables accumulate heavy metals in their roots and translocate them to epigeal parts of the plant.

Babandi and his colleagues (2012) in their research on level of heavy metals in soil and vegetables irrigated with waste water around Sharada, Kano, Nigeria found out that the level of heavy metals in all the vegetables were above WHO permissible limit.

Another study conducted by Yadav *et al.*, (2017) concluded that vegetables grown with contaminated water absorbs the heavy metals above permissible limit.

5.0 CONCLUSION

In this study it was concluded that vegetables (Lettuce and Amaranthus) grown with dump soil absorbs and accumulates the heavy metals above WHO permissible limit as was observed from all the tables above, that Cadmium (Cd) exceeded the FAO/WHO permissible limit of 0.2mg/L in vegetables. Also, Chromium (Cr) in Table 1 and 2

exceeded the FAO/WHO permissible limit of 1.3mg/L in both the vegetables.

Among the two leafy vegetables, Amaranthus absorbs and accumulates more metals than Lettuce as observed from the tables above. Therefore, awareness should be given to the concerned farmers of the dangers of using dump site's soil or any other contaminated soil for growing vegetables and crops.

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