Heavy Metals Bioaccumulation in *Celosia argentea* L. and *Corchorus olitorius* L. Grown on Refuse Disposal in Igabi Local Government Area, Kaduna State, Nigeria

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Abstract

Leafy vegetable farmers nowadays in part of the country gathered manure from dumped sites for growing vegetables due to the nation's high cost for both organic and artificial fertilizers. However, because of this, this study was carried out to evaluate bioaccumulation of heavy metals in Celosia argentea L. and Corchorus olitorius L. grown on heavy metal-contaminated manure from refuse disposal, employing Igabi local Government Area of Kaduna State as a case study. Two (2) species of leafy vegetables Cockscomb (Celosia argentea L.) and Jews mallow (Corchorus olitorius L.) were grown on three different pots I, II and III replicated three (3) times respectively. (control soil, contaminated soil that was gathered from disposal locations, and a mix of control and contaminated soil). After being digested using the wet acid method, the collected vegetables were subjected to atomic absorption spectroscopy (AAS) for heavy metal. The mean ± standard deviation was used to express the results, and Duncan Multiple Range Test (DMRT) is used to separate the mean values. The findings were contrasted with recommendations from the Food and Agricultural Organization (FAO) and the World Health Organization (WHO). Results demonstrated that the leafy vegetables' accreted levels of (Cr) chromium (Cockscomb-1.36 ± 0.062 mg/kg; Jews mallow - 1.10 ± 0.050 mg/kg) and (Cd) cadmium (Cockscomb- 1.65 ± 0.076 mg/kg; Jews mallow - 0.98 ± 0.045 mg/kg) are beyond the WHO/FAO-permissible limits(Cr -1.3 mg/kg; Cd - 0.2 mg/kg).However, Jews Mallow surpasses the allowable limit of 0.2 mg/kg in Cadmium (Cd) only, whereas Cockscomb has levels of Cadmium (Cd) and Chromium (Cr) that are higher than the permissible limits of 0.2 mg/kg and 1.3 mg/kg, respectively Accumulation order varies according to the species and soil's supply. Inconclusion, the two (2) Leafy vegetables (Corchorus olitorius L and Celosia argentea L) absorbs and accrues heavy metals above WHO/FAO permissible limit standard. In the two vegetables, the levels of cadmium (Cd) and chromium (Cr) is above the allowable limits respectively. When the two vegetables are compared, Celosia argentea L.(6.66mg/kg) absorbs and accumulates greater heavy metals as opposed to Corchorus olitorius L.(4.18mg/kg) Therefore, it is recommended that farmers should be sensitized of the dangers of using soil from dumping sites or any other polluted soil for crop and vegetable cultivation, as well as the needs for appropriate pollution management.

Keywords: Heavy Metals, Leafy Vegetables, Dumpsite Soil, Absorption and Bioaccumulation

Introduction

Chemical fertilizer for vegetable cultivation is expensive, particularly in Kaduna Northern Guinea Savannah ecoregion of Nigeria. Vegetables production has been impacted by Indigenous farmers who ended up employing a lot of mixed manure to increase output, using soil from landfills to grow vegetables, particularly in cities (Musa *et al.,* 2019: Shagamu *et al.,*2022). In general, the group of metals or metalloids having an atomic density higher than 5g/cm^3 in their elemental form are referred to as "heavy metals". (Ademoroti,1996, Sodimu, 2016). According to the USDA (2000), the manufacture of agro-allied items like fertilizers, insecticides, and herbicides as well as synthetic goods like paints and batteries is heavily dependent on heavy metals in many regions of the world, especially those with large agricultural operations; farming operations are crucial non-point sources of metals that greatly increase its overall soil concentration (Alloway, 1995; Bako, 2000). At extremely high concentrations, all heavy metals are poisonous to living things (Alloway, 1996; Bako, 2000).

People require trace levels of metals like copper (Cu), which can be dangerous if found in large concentrations in soil and leafy vegetables. According to Chen *et al.,* (2014), even trace levels of heavy metals like lead (Pb), cadmium (Cd), and chromium (Cr) can be harmful to people, because there is no efficient excretory mechanism available. They also explained that vertebrates' livers and kidneys store cadmium (Cd) resulting in challenging illnesses for these organs, but chromium (Cr) can be hazardous to both plants and animals and causes ulcers. However, rise in heavy metal concentrations above background and recommended values has been associated with the deposition of heavy metals in the soil from a variety of anthropogenic causes (Maine *et al.,* 2004; Bako *et al.,* 2008; Tanimu *et al.,* 2013 and Bako *et al.,* 2014).

Dumping sites is one of the major sources of heavy metals, but most researchers have not taken this into account. Instead, they are looking into how heavy metals (Pb, Cd, Cr, and Cu) build up in leafy crops as a result of irrigation water use (Musa *et al.,* 2019).Thus, this study was to appraise the risks of cultivating leafy vegetables with manure from disposal site, employing Igabi local government area of Kaduna State as case study. Nonetheless, the results of this study will be crucial for farmers and consumers alike.

Materials and Methods

The Study Area

This investigation was carried out in Nigeria's Northern Guinea Savannah Ecological Zone, specifically in Igabi Local Government.Latitude10047'55''and 10 o46'41''N / longitude 7 o31'29'' and 7o30'26''E (Figure:1). Apart from the Gbagyi's, who were initially non - Muslims or traditionalists before converting to Christianity, the majority of the indigenous population of Igabi is Muslim. Its area is 3,222 km2, and its density is 180.5 km². With projected estimated population of 581,500 residents, the region receives 1000–1500 mm of rainfall annually (KDBS, 2016)

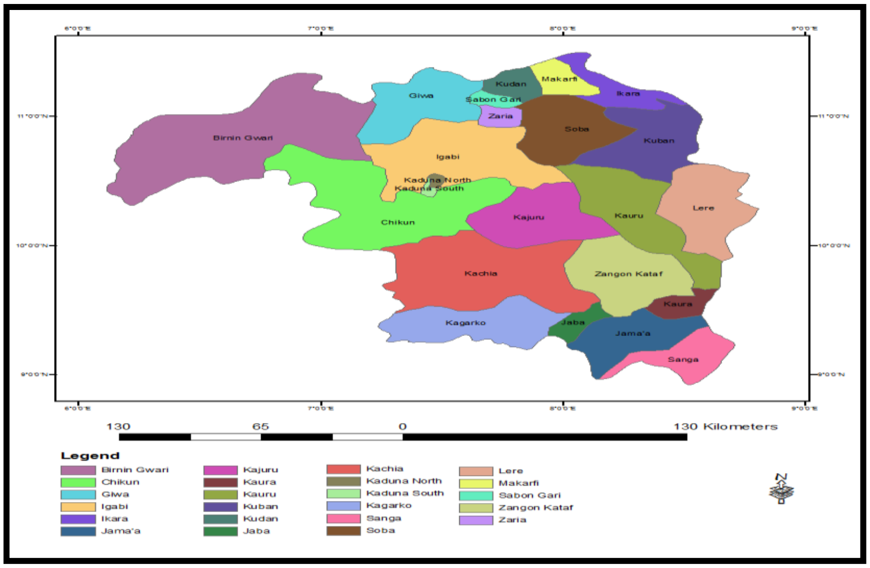

Figure 1: Position of the study area, Igabi Local Government, on a map of Kaduna State
Source: Sodimu et.al, 2021

Sampling Procedure

Seed of Jews mallow and Cockscomb were procured from the local farmers in Mando, for ease of identification, the seeds of the two vegetables was purchased, packaged (50g each), labeled in sterilized cotton sacks. The polluted soil sample from the landfill was gathered from where those native farmers typically gather their metal-contaminated manure with a sterile shovel and spade. The green vegetables were packed in sacks and delivered to the Horticultural and Landscape Technology Department of Federal College of Forestry Mechanization leafy vegetables Field Laboratory where the work was carried out. The experimental procedure and layout were adopted from the work of Shagamu *et al.,*2022. Eighteen (18) plastic pots were prepared (Nine (9) pots for Jew's Mallow and other Nine (9) for Cockscomb). The initial nine (9) pots for Jew's mallow were designated I, II, and III. The first pot had contaminated soil, the second had a mixture of contaminated and uncontaminated soil, and the third had normal/control soil that was free of contamination, and each were replicated 3 times. All nine (9) pots for Cockscomb were prepared in the same way, and seeds were evenly distributed on the pots (designated I, II, and III). To stop water from percolating and to let extra water drain out, the bottoms of each pot were perforated (Rai *et al.,* 2019).

Seed Identification/Cultural

Operation Following identification at the College of Forestry Mechanization's Department of Horticulture and Landscape Technology in Afaka Kaduna, the collected seeds were dispersed in pots with a suitable proportion of soil to manure. The pots were then lightly covered with soil to keep the seeds from being picked by birds or carried away by the wind (Rachel, 2021). Watering was carried out after the seeds were planted in order to supply the necessary moisture for the best possible germination and growth. After germination, the plant was regularly watered to maintain its ideal moisture requirements (Rachel, 2021).

Harvesting

25 - 30 days been the minimum maturation period for both Jew's Mallow (Corchorus olitorius L.) and Cockscomb (Celosia argentea L.), they were harvested after 30 days of sowing (Nwafor,2019; Mikail and Mustapha, 2022). Samples from the field laboratory were chopped into small pieces and allowed to air dry for two days at 20°C to 35°C before being oven-dried at 65°C to 70°C to remove the remaining moisture content without thermal degradation to guarantee even distribution of the metals in the samples, (Sodimu, 2016; Joshi and Verma 2020; Edogbo *et al.,* 2020; Shagamu *et al.,* 2022).

Analysis of heavy metals

Methodology adopted was from Shagamu *et al.,*2022 which involves grounding the vegetables leaves using pestle and mortar, then, passed the grounded leaves through 1.18 mm sieve and kept the smooth powdered leaves in a labeled clean plastic bottle until needed. Leblebici and Kar (2018) Each vegetable weighed one gram (1g), digested on a wet acid hot plate using 15 ml of concentrated nitric acid (HNO_3), sulfuric acid (H_2SO_4) and per chloric acid (3:1:1) at 75°C - 80°C until a clean solution was obtained. The clear solution was then sieved and transferred into a volumetric flask (100 ml), which was then filled to the brim with distilled water (Gupta *et al.,* 2010; Sodimu, 2016). The atomic absorption spectrophotometer (Model Buck 210 VGP) was used to analyze the heavy metal concentration (Sodimu, 2016).

Statistics Analysis

Data obtained was analyzed using SAS version 9.0 and subjected to Duncan Multiple Range Test (DMRT) at 5% level of probability (P=0.05) and the results were compared with WHO/FAO standard in Mg/K (Steel and Torrie, 1980; Sodimu,2016)

Results and Discussions

Results

Metal absorptions in Jews Mallow were greater in the soil mixture from the dumping site and control site alone. Cockscomb leafy vegetables grown in dumping site soil and a blend of dumping site soil and control site soil had greater quantities of heavy metals in three (3) different types of soil (P=0.05). However, lead (Pb) had the lowest absorption and zinc (Zn) the highest in all three categories (Table 1)

Table 1: Concentration of Heavy Metals in Cockscomb and Jews Mallow Grown on Various Site Soils

Treatment	Dumping Site Soil	Mixture of Dumping and Control Site Soil	Control Site Soil
Cock comb	6.66^{a}	5.16^{a}	3.34^{b}
Jews mallow	4.18^{b}	4.86^{a}	4.65^{a}
SE$\pm$	0.125	0.114	0.088
Metals			
Cadmium (Cd)	1.32^{b}	1.41^{bc}	0.83^{d}
Chromium (Cr)	1.23^{b}	1.93^{b}	1.28^{c}
Copper (Cu)	1.78^{b}	0.99^{c}	2.00b
Lead (Pb)	ND	ND	ND
Nickel (Ni)	0.37^{c}	0.15^{d}	0.34^{e}

Zinc (Zn)	27.80[a]	25.61[a]	19.52[a]
SE±	**0.217**	**0.197**	**0.152**
Interaction			
V*M	*	*	*

*Means followed by same letter(s) within the same treatment column are not different statistically at 5% level of probability (P=0.05) using Duncan Multiple Range Test (DMRT). * (Significant). (ND in Pb means not detected)*

Figure 2 revealed the measured concentrations of the heavy metal in the two vegetables (Cockscomb and Jews mallow) cultivated in the soil from the waste site. Table 1 order of accumulation differed from figure 2 and table 3. In this case, Jews Mallow has the following order: Zn > Cr > Ni > Pb > Cu > Cd. While order in Cockscomb include Zn> Cu>Cd>Ni >Cr> Pb. Additionally, as shown in figure 2, Jews Mallow surpasses the allowable limit of 0.2 mg/kg in Cadmium (Cd) only, whereas Cockscomb has levels of Cadmium (Cd) and Chromium (Cr) that are higher than the permissible limits of 0.2 mg/kg and 1.3 mg/kg, respectively (FAO/WHO,1984). However, the findings in figure 2, revealed that Cockscomb absorbs and accumulates more heavy metals at (P=0.05) than Jews Mallow.

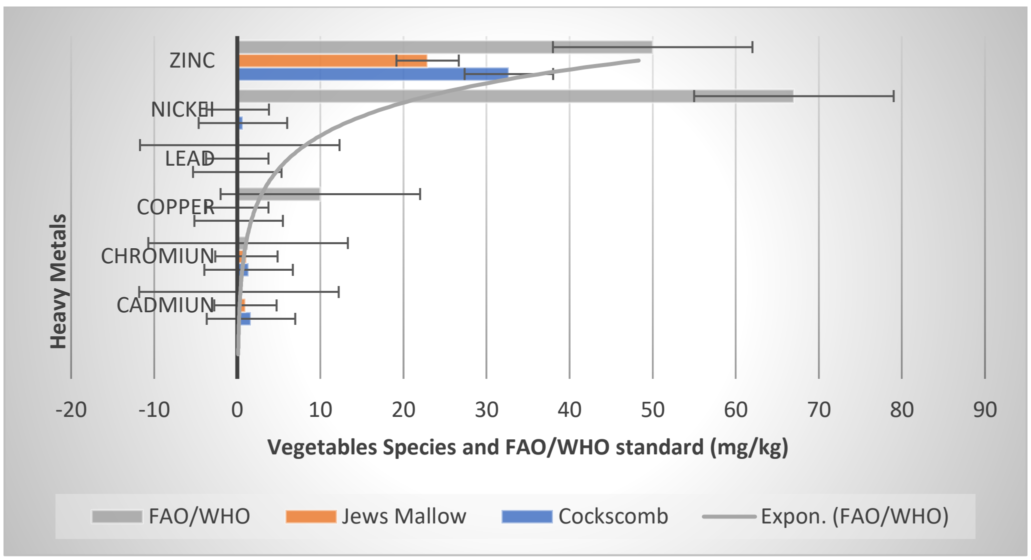

Figure 2: Mean concentration (mg/kg) of Leafy vegetables and heavy metals interaction With dumping site soil

Table 2 displayed the concentrations of the heavy metals in the two vegetables (Cockscomb and Jews mallow) that were cultivated using a combination of soil from the control and disposal sites. Metals found in the vegetables and order of accumulation differed. According to Table2, Zn > Cr > Cd > Ni > Cu > Pb is the order of accumulation for Jews Mallow. Zn > Cd > Cu > Cr > Ni > Pb is the situation for Cockscomb. Additionally, Table 3 furthered shows that the vegetables levels of cadmium (Cd) and chromium (Cr) are beyond the acceptable limits of 0.2 mg/kg and 1.3 mg/kg (P=0.05), respectively (FAO/WHO,1984)

Table 2: Mean Concentration of Heavy Metals (Mg/kg) and Leafy Vegetables Grown with a Control and Dump Site Soil Mixture

	Leafy Vegetable		
Metals	Cokgckscomb	Jews mallow	WHO/FAO (Mg/kg)
Cadmium	2.00 ± 0.092[c]	0.81 ± 0.037[d]	0.2
Chromium	1.87 ± 0.086[c]	1.98 ± 0.091[c]	1.3
Copper	1.98 ± 0.091[c]	0.00 ± 0.000[d]	10.0
Lead	ND	ND	0.3
Nickel	2.00 ± 0.000[d]	0.30 ±0.014[d]	67.0
Zinc	25.13 ± 1.152[b]	26.08 ± 1.195[a]	50.0

Means followed by same letter(s) within the same treatment column are not different statistically at 5% level of probability (P=0.05) using Duncan Multiple Range Test (DMRT). FAO/WHO: Food and Agricultural Organization/World Health Organization Permissible limits of Heavy Metals in Leafy vegetables (ND in Pb means not detected)

Table 3 displays heavy metals that were analyzed for the two crops (Cockscomb and Jews mallow) that were cultivated in control soil. There was notable variation in the content of metals in the two green crops. Zn > Cu > Cr > Cd > Ni > Pb is the sequence of accumulation for both the Jews Mallow and Cockscomb, as shown in Table 4 In both leafy vegetables, cadmium (Cd) surpasses the allowable limit of 0.2 mg/kg, whereas chromium (Cr) surpasses the allowable limit of 1.3 mg/kg just in cockscomb at (P=0.05). However, Cockscomb absorbs and accumulates more heavy metals than Jews Mallow (P=0.05).

Table 3: Mean Absorption of Heavy Metal Interaction with Leafy Vegetables in Control Site Soil (Mg/kg)

	Leafy Vegetable		
Metals (mg/kg)	Cockscomb	Jews mallow	WHO/FAO (mg/kg)
Cadmium (Cd)	0.47 ± 0.022[fg]	1.18 ± 0.054[de]	0.2
Chromium (Cr)	0.88 ± 0.040[ef]	1.68 ± 0.077[d]	1.3
Copper (Cu)	1.47 ± 0.067[de]	2.53 ± 0.116[c]	10.0
Lead (Pb)	ND	ND	0.3
Nickel (Ni)	0.33 ± 0.015[fg]	0.35 ±0.016[fg]	67.0
Zinc (Zn)	16.88 ± 0.774[b]	22.15 ± 1.015[a]	50.0

Means followed by same letter(s) within the same treatment column are not different statistically at 5% level of probability (P=0.05) using Duncan Multiple Range Test (DMRT). FAO/WHO: Food and Agricultural Organization/World Health Organization Permissible limits of Heavy Metals in Leafy vegetables. (ND in Pb means not detected)

Discussion

According to the study, the leafy vegetables cockscomb (*Celosia argentea*) and Jew's mallow (*Corchorus olitorius*) both absorb and accumulate heavy metals over allowable levels, particularly cadmium (Cd) and chromium (Cr) (P=0.05). This result is consistent with research by Anwar *et al.,* (2016); Shagamu *et al*., (2022), which discovered vegetables irrigated with sewage water had higher concentrations of heavy metals than allowed. Additionally, Adedokun *et al*., (2016) found that the amount of lead (Pb) in leafy greens was higher than the allowable limit when they conducted research on heavy metal intake through leafy vegetable consumption. In their study on lettuce, Jimoh and Mohammed (2016) likewise discovered comparable outcomes, with cadmium (Cd) levels beyond the allowable limit.

The accrual of heavy metals in the comestible portion of vegetables irrigated with wastewater, as reported by Mustapha and Adeboye (2014), has a negative impact on health because the allowable limit of heavy metals detected are above FAO/WHO heavy metals standard. Vegetables also store metals particularly heavy metals in their roots and move them to the plant's epigeal regions, according to Napoli *et al.* (2019). Yadav *et al.* (2017) came to the conclusion that vegetables cultivated in tainted water absorb more heavy metals than is allowed.

Conclusion and Recommendation

Leafy vegetables (Cockscomb and Jews mallow) grown on dump soil absorb and accumulate heavy metals above the WHO legal limit standard. Vegetables contained more cadmium (Cd) than the FAO/WHO allowable level. Additionally, both vegetables' chromium (Cr) contents were higher than the FAO/WHO permitted limit. According to data above, cockscomb absorbs and accumulates more metals than Jews mallow out of the two green vegetables. Therefore, it is recommended that farmers should be sensitized of the dangers of using soil from dumping sites or any other polluted soil for producing crops and vegetables, as well as the needs for appropriate pollution management.

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