Journal of Capital Development in Behavioural Sciences Vol. 12 Issue 1 (March, 2024)
Faculty of Arts & Education, Lead City University, Ibadan, Nigeria
***ISSN Online:** 2449-0679* ***ISSN Print:** 2354-3981*

Assessment of Heavy Metal Accumulation in Vegetables Irrigated with Water from Different Sources in Lead City University Farms, Ibadan, Nigeria

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Abstract
Rapid and unorganised industrialisation and urbanisation has contributed to the elevated levels of metals in the urban environment in developing countries, with attendant effect on the health and wellbeing of final consumers of such agro-products. This study was conducted to assess the amount of heavy metal accumulated by selected tropical leafy vegetables irrigated with waste-water from different sources; poultry waste water, Kitchen waste water and borehole water as control. The sampled vegetables used were Amaranthus hybridus, Telfaria occidentalis and Corchorus olitorus. The vegetables were grown for a period of six weeks in the screen-house of the LCU farms, Lead City University, Ibadan Oyo State, Nigeria. The vegetables were irrigated with the different water sources, after which the vegetable leaves were harvested and taken to the Microbiology laboratory.

Elemental analysis of the vegetables was determined using the Atomic Absorption Spectro-photometer (AAS) and pH level of the soil and irrigation water was assessed. The results indicated the elemental composition of the Bore-Hole Water (BHW) as (Cu=0mg/kg), (Pb=0mg/kg), (Fe=0.018 mg/kg), (Zn=0.038mg/kg) and (Mn=0.0026mg/kg); Kitchen-Waste water (KWW) was (Cu=0178mg/kg), (Pb=0.035mg/kg), (Fe=0.023mg/kg), (Zn=0.025mg/kg) and(Mn=0.0031mg/kg) Poultry-Sewage water (PSW) is (Cu=0.029mg/kg), (Pb=0.048mg/kg), (Fe=0.0547mg/kg), (Zn=0.147mg/kg) and (Mn=0.0033mg/kg). PSW had the highest composition of heavy metals; comparing the vegetables, C. olitorius accumulated more Iron(Fe), Lead(Pb) and Copper(Cu), while T. occidentalis accumulated more Zinc (Zn) and Manganese (Mn) than A. hybridus. PSW contained substantial amount of heavy metals varying according to source while Corchorus olitorus and Telfaria occidentalis showed a high affinity for accumulation of heavy metals.

Keywords: Leafy vegetables, Phyto-remediation, Metals, Toxicity, and Waste water.
Word Count: 249

Introduction

Vegetables are freely consumed across the tropics due to the fact that they are abundantly grown, with most of the ethnic groups consuming them in significant quantity. The consumption of vegetables as food provides adequate vitamins, supply minerals and fibers; occupying a very important place in the diet (Okunlola, 2010; Okunlola & Odunola, 2017). They can be root, leaf, fruit or seeds. Vegetables contribute between 33 and 37% of family income among semi-urban vegetable farmers. Their production is predominantly subsistence and is characterized by cyclic deficits sometimes prompted by unreliable rainfall patterns constituting one of the many challenges to their increased production (Okunlola & Akinrinola, 2014). It is therefore expected that in periods and regions of water scarcity, farmers would turn to domestic or urban waste water as a source to irrigate their vegetable crops, this waste water often contains large amount of organic materials, some inorganic elements and/or substantial amount of toxic heavy metals such as Zn, Cu, Pb, Ni, Cd and Cr (Khillare, Balachandran & Meena, 2004). The term "heavy metal" applies to a group of elements that exhibit metallic properties with similar chemical properties; inhuman health, heavy metals are metallic elements which may be toxic, potentially harmful and/or harm-less to the body system. They occur naturally in the ecosystem with large variations in concentration, (Mohsen and Salisu, 2008; Raskin and Ensley, 2014).

These elements at concentration exceeding the physiological demand, have toxic effects because they are non-biodegradable and could enter the food chain when they are deposited on the surfaces of soils/water and then absorbed into the tissues of the plants from where they get biomagnified; posing a threat to human health (Zhang, Yang, et al. 2010).

Several studies in Africa suggest that agriculture based on waste water irrigation accounts for 50% of the vegetable supply to urban areas (Bigdeli & Seilsepour, 2008; Okunlola & Akinrinnola, 2014). Farmers generally are not bothered about environmental benefits or hazards and are primarily interested in maximizing their yields and profits. Although the metal concentrations in waste water effluents are usually relatively low, long-term irrigation of land with such can eventually result in heavy metal accumulation in the soil which may cause acute or chronic toxicity (poisoning).

Wastewater typically contains a variety of toxins and pollutants. Among them are:

- Pathogens (such as bacteria, viruses, helminths, and protozoa)
- Heavy metals (such as copper, cadmium, nickel, chromium, zinc, and lead).
- Nutrients for plants, such as phosphorus, potassium, and nitrogen.
- Micro-pollutants, such as medications, cleaning supplies, and cosmetics;

- Organic pollutants, such as pesticides, polychlorinated biphenyls, biodegradable organics, and polyromantic.

In event of their excessive presence, these metals enter into the body and may disturb the normal functions of central nervous system, liver, lungs, heart, kidney and brain, resulting in hypertension, abdominal pain, skin eruptions, intestinal ulcer and different types of cancer (Laura & Susan,2009).

Hence, heavy metal contamination in agricultural soils from waste water irrigation (particularly in areas where vegetables are irrigated with waste water) is of serious concern due to its implications on human health.

Statement of the Problem

The UN has released a report on wastewater treatment that claims wastewater is being wasted worldwide. This is particularly true in developing and impoverished nations, where less than 8% of wastewater is treated (FAO, 2010). The largest issue at hand is how to start thinking about wastewater as a solution rather than a problem. Untreated sewage and poorly treated industrial wastewater continue to deteriorate water quality throughout the world. Although wastewater might be seen as a substitute source of liquid fertilizer to farms, water, the process of collection from the sources must come first. The aforementioned quality issues have the potential to lead to environmental and health complications, which in turn may have an economic impact on the society.

Objective of the Study

The main objective for the study was to evaluate heavy metals accumulation in selected vegetables, irrigated with waste-water from different sources.

The specific objectives are to:

1. Evaluate the capacity of the selected vegetables for heavy metal absorption.
2. Determine the waste-water source with the highest levels of heavy metals concentration.
3. Determine how much of heavy metal concentration was found in the selected vegetables irrigated with waste-water from different sources.

Research Questions

The following questions were unraveled during the course of the study:

4. Which of the selected vegetables absorbed the heavy metal the most?
5. Which of the waste-water sources has the highest levels of heavy metals?
6. How much of heavy metal concentration was found in the selected vegetables irrigated with waste-water from different sources?

Materials and Method

Study Area

This study was conducted at the screen-house of the LCU farms, Lead City University, Ibadan Oyo State, Nigeria (Longitude 50^{o}.20'N and latitude7^{o}.25'E) in South-western, Nigeria from November 2021, to January 2022.

Selected Species of Vegetables for the Study

Amaranthus hybridus

Depending on the colour of the foliage, this plant is also known as red amaranth, green amaranth, or *tete* in the area. It belongs to a species of flowering annual plant. It is a weedy species that has been brought to Europe and Eurasia and is currently present over much of Nigeria. A large number of tribes in Nigeria, particularly in the Southwest, used the plant for food and medicinal. It is one of the species found in most grocery stores. Although, it contains promising anti-cancer phytochemicals, it has limited antibacterial activity.

Corchorus olitorius

This kind of shrub belongs to the Malvaceae family and, is often referred to as "bush okra" and "West African sorrel". It is known as Ewedu among Nigerian Yoruba people. When combined with C. capsularis, it serves as the main vegetable source. The seeds are edible, the dried leaves are used to make tea and thicken soup, and the immature fruits and leaves are used as vegetables. Jute's edible parts are its leaves. Due to its abundance in potassium, vitamin B6, iron, vitamin A, and vitamin C, this crop is especially significant in areas where people rely heavily on staple crops low in micronutrients to meet their energy needs. Most people who eat this vegetable come from west Africa, especially from Nigeria's southwest and Asia.

Telfairia occidentalis

This tropical vine is cultivated for its delicious seeds and, as a leaf vegetable in West Africa. The plant is also known by the common names fluted gourd, fluted pumpkin, *Ikong-Ubong* (in the Efik and Ibibio languages), *Okwukwo-Wiri* (in the Ikwerre language), and *Ugwu* (in the Igbo language). T. occidentalis is a native of Southern, Nigeria and a member of the Cucurbitaceae family. The fluted gourd is a vegetable that grows throughout West Africa, although it is most often grown in southeast Nigeria, where it is used in soups and herbal remedies. The edible seeds can be fermented and added to *Ogili*, or they can be boiled and eaten whole. Because of its high protein content, fluted gourd has been utilised traditionally by indigenous cultures as a blood tonic. You can use the seed flour to make high-protein loaves. Moreover, the leaves and shoots can be eaten like vegetables. T. occidentalis is used to treat anaemia, malaria, and convulsions that occur suddenly. When produced for herbal medicine, it also serves as a crucial and preventive measure against cardiovascular illnesses.

Sample Collection

Water samples were collected from three different sources; viz:

Water samples were collected from three different sources; viz:

1. Bore-Hole Water (BHW)
2. Kitchen-Waste Water (KWW)
3. Poultry-Sewage Water (PSW)

PSW was obtained from the Trench outlet-point dug for disposing poultry wastes at LCU south gate area. KWW was obtained from the main waste-water outlets of Royal Cafeteria and other adjoining canteens on the campus; while BHW was collected from the tap in the screen house. Soil samples were obtained from the said Lead City University, (LCU) Farm. The vegetables were cultivated in plastic pots, harvested and taken to the Microbiology lab for digestion and elemental analysis.

The samples digested were sampled vegetable leaves, water and soil samples. The acidity and alkalinity of the soil and water samples were also tested.

The vegetable leaves were thoroughly washed in distilled water to get rid of superficial dust. The sampled vegetables were air-dried after which they were dried in the oven at a temperature of 50°C for 24 hours. The leafy part of the vegetables was collected and then crushed into fine particles and sieved using 0.5mm diameter sieve. The sieved vegetable samples were stocked in small plastic bottles prior to digestion.

The sampled were digested using 0.5g of dried samples adding10ml of HNO_3 and 3ml of Perchloric acid $HClO_4$. The mixture was heated up to 150°C for 2 hours and scaled up to10ml by adding de-ionized water. This process was repeated for other plant samples and replicated. Soil samples were digested by using 5g of air dried samples 12ml of HNO_3 65% and 5ml of $HClO_4$ were added. Soil pH was assessed by adding 0.01M of $CaCl_2$ to soil solution in ratio1:2 and in distilled water using a pH meter fitted with glass electrode.

Statistical Analysis

Data were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS version 20) and means (X) separated using Duncan Multiple Range Test.

Result

Plate 1: *Amaranthus hybridus* grown on the farm.
Source: Field Survey, 2021.

Plates 1-3 are actual pictures of the selected vegetables used for the experiment. These are:
Amaranthus hybridus
Corchorus olitorus
Telfaria occidentalis

Plate 2: *Telfaria occidentalis* grown on the farm.
Source: Field Survey, 2021.

Plate 3: *Corchorus olitorus* grown on the farm.
Source: Field Survey, 2021.

Table1 showed the heavy metal (Cu, Pb, Fe, Zn and Mn) in the water used for irrigation of the vegetables. The elemental values showed that sewage water had the highest followed by fishpond water and tap water had the least.

Table1: Elemental values of heavy metals in water used to irrigate the vegetables (mg/kg)

Treatments	Cu	Pb	Fe	Zn	Mn
BHW	33.60a	25.57a	28.86b	33.60a	25.57a
PWW	43.84b	28.86b	59.57b	43.84b	28.86b
KWW	69.82c	55.17c	32.50c	69.82c	55.17c

* Values followed by the same letter within a column are not significantly different ($P<0.05$) Bore-Hole Water (BHW), Kitchen-Waste Water (KWW), Poultry-Sewage Water (PSW)

Source: Field Survey, 2021.

The result from Table 2 showed the heavy metal composition of the soil. Pb had the highest value followed by Fe and Mn, while Zn and Cu had the least.

Table 2: Heavy metal composition of the soil medium used to grow the vegetables in (mg/kg)

Cu	Pb	Fe	Zn	Mn
0.30a	10.79a	9.65a	0.49a	8.28a

* Values followed by the same letter within a column are not significantly different ($P<0.05$)

Source: Field survey, 2021.

The results in Table 2 revealed the effect of the heavy metals on the morphology of the vegetables. The vegetables irrigated with sewage water had the least growth, while fish pond water had the highest.

Table 3: Leaf area of vegetables (cm^2)

Vegetables	BHW	PWW	KWW
Amaranthus hybridus	33.60a	25.57a	**4**
Telfaria occidentalis	43.84b	28.86b	59.57b
Corchorus olitorus	69.82c	55.17c	32.50c

* Values followed by the same letter within a column are not significantly different ($P<0.05$)

Source: Field Survey, 2021

Heavy Metal Accumulation by the selected Vegetables

It can be inferred from Table 5, that *Corchorus olitorus* accumulated more Fe, Pb and Cu than other vegetables, while *Telfaria occidentalis* accumulated more Zn and Mn.

Table 4: Heavy metal accumulation of the cultivated vegetables

Vegetables (mg/kg)	Cu	Pb	Fe	Zn	Mn
Amaranthus hybridus	4.59a	1.48a	4.85a	2.48a	2.81a
Telfaria occidentalis	6.74b	1.71a	8.90b	7.06c	3.30a
Corchorus olitorus	7.61c	2.82b	11.38c	5.69b	4.98b

* Values followed by the same letter within a column are not significantly different ($P<0.05$)

Source: Field Survey, 2021.

Table 5 showed that vegetables irrigated with sewage water had a higher amount of heavy metals, followed by fish pond water and tap water had the least.

Table 5: Heavy metal accumulation of vegetables (mg/kg)

Vegetables	BHW	PWW	KWW
Amaranthus hybridus	33.60a	25.57a	**4**
Telfaria occidentalis	43.84b	28.86b	59.57b
Corchorus olitorus	69.82c	55.17c	32.50c

Source: Field survey, 2021.

Discussion

Vegetables irrigated with sewage water confirmed the heavy metal content of poultry waste report by Okunola, (2017), that plants grown on heavy metal polluted water used for irrigation was very high affirming soils show a reduction in growth, performance, and the report by Khillare et al., 2004; Mustapha and yield (Amoah, 2008). Borehole water had the highest contaminations. Poultry waste-water least concentration of heavy metals as it also lacked consists of numerous elements including organic some essential trace metals; Copper, Lead Zinc materials, little amounts of inorganic elements and Manganese which may be essential for plant substantial amount of trace metals as well as non-growth Essentially, heavy metals which could be harmful to animal and humans are almost the constituents of the water samples. This makes it unsafe for use as *Telfaria occidentalis* and *Corchorus olitorus* irrigation water especially for vegetables because it accumulated more of the heavy metals compared to *A. hybridus;* which could contaminate human food chain and also pollute the environment. Plants used for phyto-extraction usually the environment. The soil values were relatively below possessing the following characteristics: rapid growth the maximum allowable limits of heavy metals in soils rate, high biomass, extensive root system, and ability according to the World Health Organization (WHO), to tolerate high amounts of heavy metals. This ability to tolerate high concentration of heavy metals by these plants may lead to metal accumulation in their soils used for agricultural activities have low harvestable part (Agrawal, 2011). Amount of heavy metals at the initial level but the continued use of fertilizers, irrigation with partially treated or untreated water; contaminates the soil and the use of Poultry waste water for irrigation increased the level of heavy metal content, especially for vegetables which can sometimes be eaten raw should be avoided because it can pose serious danger to human health with regards to metal accumulation.

Conclusion

In conclusion, it was observed that contamination was restricted to the depth and surface area that the roots occupy. This showed that it is not totally possible to stop pollutants from being absorbed by the crops. The toxicity of the contaminated land and the overall state of the soil have an impact on the plants' ability to survive. Pollutants, particularly heavy metals were observed to have bioaccumulate in crops and could have an impact on consumers. Heavy metals were suspected to have been absorbed by the crops, binded to the organic matter in the soil, hence making it impossible for the plants to extract them. Therefore, vegetables could serve as accumulators, and can be used in phyto-remediation of heavy metal contaminated soils.

Recommendation

Farmers and other vegetable growers should put precautionary measures in place when applying waste water to farmlands to prevent any form of adverse environmental impact. Farmers should ensure that waste water must not contain non-degradable materials, such as plastics, which would make farmland disposal unsightly. Vegetables from such farms should be thoroughly washed to avoid contamination and food poisoning. Irrigation discharge points for waste water from sources or irrigators should be as near to the ground as is practicable and the liquid waste water trajectory should be kept low so as to minimize spray drift and visual impact. Untreated waste water should be injected under the soil surface using special fittings with injection equipment.

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