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POLLUTION LEVEL OF SOME HEAVY METALS IN VEGETABLES PRODUCED THROUGH IRRIGATION FARMING IN GUDINCIN, JIGAWA STATE, NIGERIA

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ABSTRACT

The pollution level of Chromium (Cr), Cadmium (Cd), Copper (Cu), Lead (Pb) and Zinc (Zn) in Okra, Spinach and Tomato grown in irrigation system of farming in Gudincin Town, Hadejia LGA of Jigawa State was investigated using Atomic Absorption Spectroscopy. The level of metals in the different parts of the vegetables for Okra, Spinach and Tomato are in the order Zn>Cu>Cr>Cd>Pb, Zn>Cr>Cu>Cd> Pb andZn>Cr>Cu>Cd>Pb respectively. The data obtained showed the translocation of the metals from the agricultural soil into the vegetables. The concentrations of heavy metals in the irrigated soil are in the order Cr>Zn>Cu>Pb>Cd. All the heavy metals in the vegetable samples were found to be within the permissible limit set by Food and Agricultural Organization (FAO) and World Health Organization (WHO).The bioconcentration factor (BCF) of the metals for all the samples were greater than unity (>1)with the exception of Cr (0.946), for spinach and Cr (0.883) for tomato. The translocation factor (TF) value of the metals were all >1 for all the samples with the exception of Pb (0.140) in spinach, indicating translocateton of metals to the aerial parts after absorption. According to the data obtained, tomato, spinach and okra may serve as hyperaccumulators for Zn, Cr, Cd and Cu, whereas spinach can serve as excluder for Pd. Based on the data gathered from the research, the pollution levels of the studied metals in the vegetables was low. Therefore, there is no health concern consuming the vegetables from this farm.

Keywords: Heavy Metals, irrigation Soil, Tomato, Spinach, Okra, Translocation, Hyperaccumulator

INTRODUCTION

Heavy metals are natural constituents of the earth's crust, as such all soils naturally contain trace levels of these metals. The presence of metals in soils is, therefore, not indicative of pollution. However, excessive levels of many of these metals could result in destruction of ecological balance leading to soil quality degradation, thereby contaminating the food chain, posing a significant health hazard to humans, plants and animals (Sardar et al., 2013). Heavy metals, especially the non-essentials cause low biomass production, low growth and photosynthetic inhibition, altered water balance and nutrient assimilation in plants (Sardar *et al*., 2013, Balkhair and Ashraf, 2016). These metals are non-biodegradable and persist in the environment, and are not easily removed by normal cropping practices. It is believed that even the essential metals such as Chromium, Zinc and Copper (Cu) become threats to human health at elevated concentrations (Khan et al., 2010). In addition to heavy metal presence in the soil, the water used for irrigation can also contain heavy metals from various sources such as industrial runoff, mining activities and atmospheric deposition (Khan et al., 2010|). When such contaminated irrigation water is used for farming, metal accumulation can occur in the soil and are taken up by edible plants, including vegetables. These metals are taken up by the roots from the soil and translocated to the edible parts, which pose serious negative health risk to humans, plants and animals. For example, Cadmium is implicated in the causing of diarrhea, stomach pains and severe vomiting, as well as bone fracture, reproductive failure and perhaps even infertility. It also causes damage to the central nervous system, the immune system or even cancer development (Noler *et al*., 2006). Lead which has no biological importance in plants is also one of the most common heavy metal contaminants in soil and can cause morphological, physiological and biological problems (Zeng *et al.*, 2007, Kumar *et al*., 2017).

It is an established fact that plant cultivated using waste water has elevated levels of heavy metals than those grown on fresh water irrigated soil (Khan *et al.*, 2008, Singh et al., 2010). As such, it is essential to routinely assess the pollution levels of heavy metals in vegetables grown through irrigation farming.

MATERIALS AND METHODS

Study Area

Gudincin Town is situated in Hadejia Local Government Area of Jigawa State, Northern Nigeria. Hadejia is located between the latitudes 12.450N and 10.0404E, and longitudes 12º 27'0N and 10º 2'26Earming activities are carried out throughout the year with vegetables being one of the major crops cultivated through irrigation using river water during dry season. Various domestic activities are carried out in the river by the inhabitants. Road construction activities are ongoing in the study site.

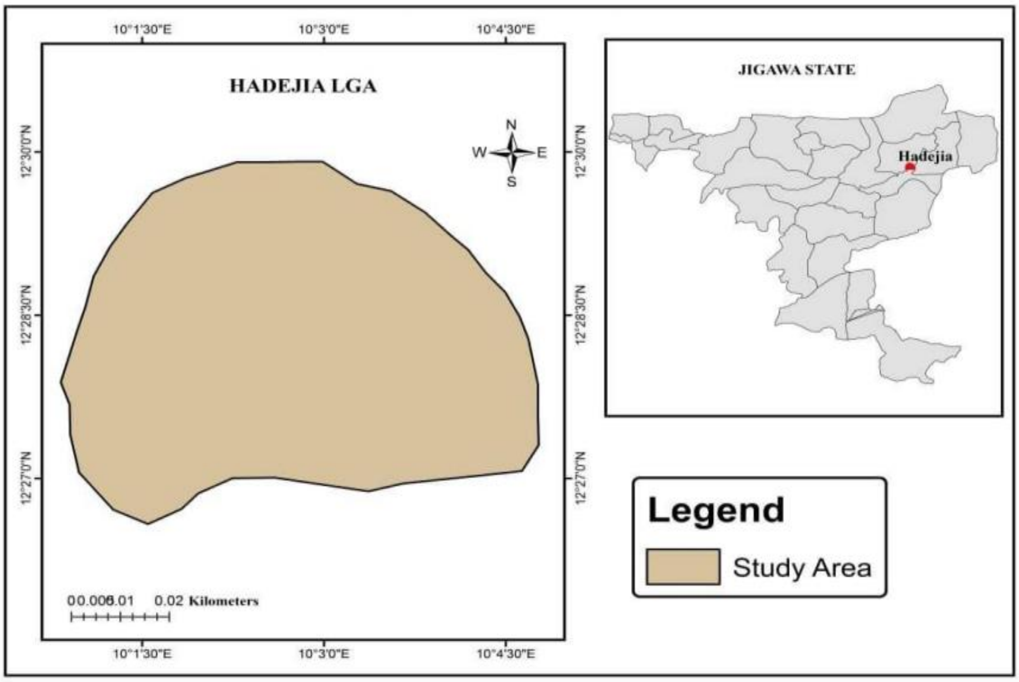

Plate 1: Map of Study Area

Sample Collection

A total number of three vegetable crops (Okra, spinach, and tomato) which are seasonally grown in the agricultural field by local farmers were collected in February/March 2022 in white plastic bags and brought to the laboratory. Three farms were randomly selected and each farm was divided into four sections. Three samples of each crop were pulled from the four sections for analysis. The samples were wiped first and then washed with clean tap water followed by rinsing with deionized water. The plants were then separated into leaf/fruit, stem and roots after which they were air dried for 72 hours, then ground using a pestle and mortar, and then kept in plastic containers for further analysis.

Water Sampling

About 100 cm^3 of the stagnant irrigated water samples were collected from different locations and transferred into 250 mL plastic bottles. About 1.0 mL concentrated HNO_3 was added to the bottles to prevent microbial activity.

Soil Sampling

The farmland was separated into four sampling area. Separate soil samples were collected from each of the four locations using a stainless steel hand trowel at 6 inches depth in an area of 5 m. All the soil samples were then mixed thoroughly to obtain a composite sample. The soil sample was air and oven dried, crushed and sieved, stored at 4^{o}C before analysis (Manuel *et al.,* 2021)

Digestion of water, Plant and Soil Samples

Approximately 50 mL of irrigated water sample was digested using 5 mL HNO3 and1mL HCl on a hot plate until the solution appeared light colored and clear, allowed to cool, filtered and made up to 50 mL with deionized water (Kisku *et al.*, 2000).

Exactly 3.0g of each part of the vegetable samples and soil samples were digested separately using aqua regia method (HCl + HNO_3, 3:1 v/v) on a hot plate in a fume cupboard, until a clear solution was obtained. To the solution, 30 cm^3 deionized water was then added and filtered using a Whatman No.42 filter paper into a 50 cm^3 standard volumetric flask and then made up to the mark. The filtrates were used for metal analysis by AAS (PerkinElmer PinAAcle 900H) as described by Kisku *et al.*, (2000).

Data Handling

Bioconcentration factor (BCF) was calculated using the equation given by Liu et al., (2009)

$$BCF = \frac{Cplant}{Csoil}$$

Where:

C_{plant} is concentration of metal in plant tissue.

C_{soil} is the concentration of the metal in the soil

Translocation factor (TF) was calculated by the formula given by Tiwari *et al.*, 2011.

$$TF = \frac{Caerial}{Croot}$$

Where:

C_{aerial} is the concentration in plants aerial part

C_{root} is the concentration in plant root

All analyses were performed in replicate to ensure reliability of the results. Data are presented as Mean ± SD (n=3).

RESULTS AND DISCUSSION

Physicochemical properties of the Soil

The values of the selected physicochemical parameters of the soil are as presented in Table 1.0

Table 1: Soil properties

Parameters/Test Performed	Result
pH	7.8 ± 0.10
Silt (%)	14± 0.47
Clay(%)	12± 0.26
Sand(%)	74± 0.01
Soil Textural Class	Loamy Sand
CEC(Cmol(+)/100kgSoil)	10.56±0.03
Organic matter Content(%)	0.57±0.01
EC (µS/cm)	1.36±0.01
Iron(g/kg)	2.37±0.01
Potassium (g/kg)	0.12±0.02
Manganese(g/kg)	0.067±0.01
Magnesium(g/kg)	0.35±0.01
Phosphorus(g/kg)	0.16±0.02
Nitrogen (g/kg)	0.07±0.01
Cadmium(mg/kg)	0.033±0.0004
Chromium (mg/kg)	4.007±0.0151
Copper(mg/kg)	0.340±0.0009
Lead(mg/kg)	0.233±0.0180
Zinc(mg/kg)	1.740±0.0038

It is evident from the Table that, the experimental soil is predominantly loamy sand in texture and slightly alkaline (pH 7.8) in nature. According to Atafar *et al.*,(2010) &, Sydney and Joan,(2020), this pH range is good for proper growth and efficient uptake of nutrients from the soil since it controls the solubility and hydrolysis of metal hydroxide, carbonate as well as phosphate. The soil is of low electrical conductivity (1.36µS/cm) but comparable with that reported in literature (Alghobar and Sureba (2017). Soil organic matter usually indicates the mineral character of a soil. From Table 1.0, the studied soil had low organic matter content (0.57%) which could be attributed to excessive cultivation and soil loss. This result is comparable with that of Sharma *et al.*,2018) but in contrast with what was reported by Adugna and Abegaz (2016). According to Botta *et al.*(2006) the ideal soil for growing plants should have at least 3- 6% of organic matter to enhance the nutrient supply and buffer the soil against pH. Again, from the same Table, the soil sample analyzed showed low Cationic exchange capacity of 10.56 Cmol/100 Kg . According to literature, soil with high CEC have a much lower percentage of cations in the soil water, and are far less susceptible to nutrient loss by leaching. From Table 1.0, the mean metal concentration in the soil is in ascending order of Cd < Pb < Cu < Zn < Cr. From Table 2.0, the mean metal concentration in the irrigation water ranged between 0.246 mg/L (Zn) and 0.034 mg/L (Cu),

Table 2: Mean metal Concentration in irrigation water

Metals	Metal concentration
Cadmium	0.042±0.0003
Chromium	0.181±0.0179
Zinc	0.246±0.0026
Copper	0.034±0.0008
Lead	0.236±0.0066

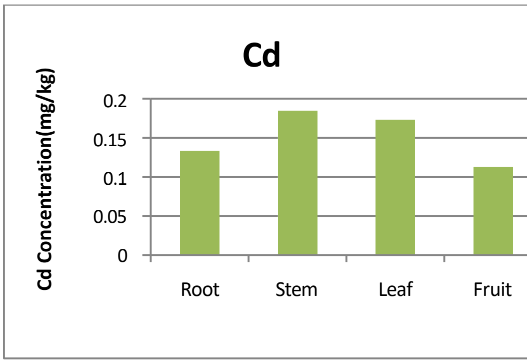

Figure 1: Concentration of Cadmium in okra

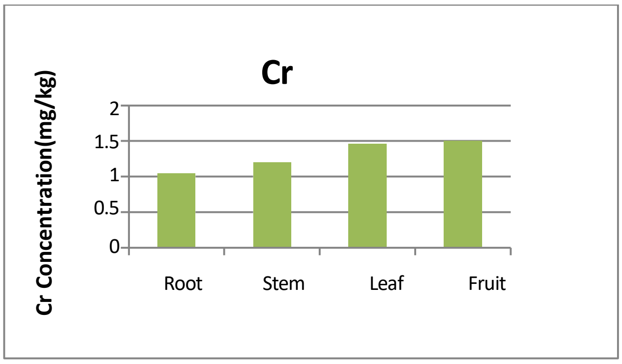

Figure 2: Concentration of Chromium in okra

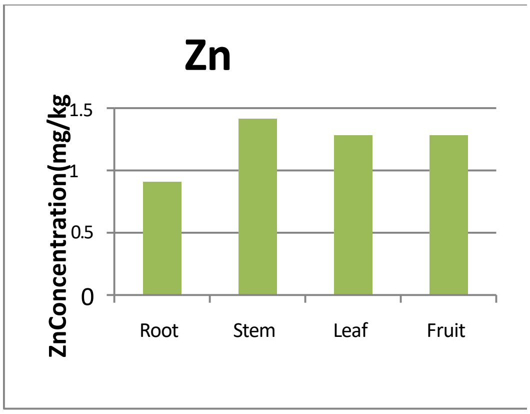

Figure 3: Concentration of Zinc in okra

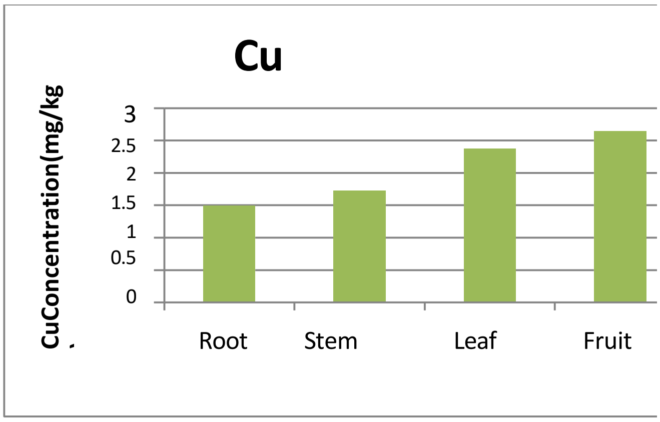

Figure 4: Concentration of Copper in Okra

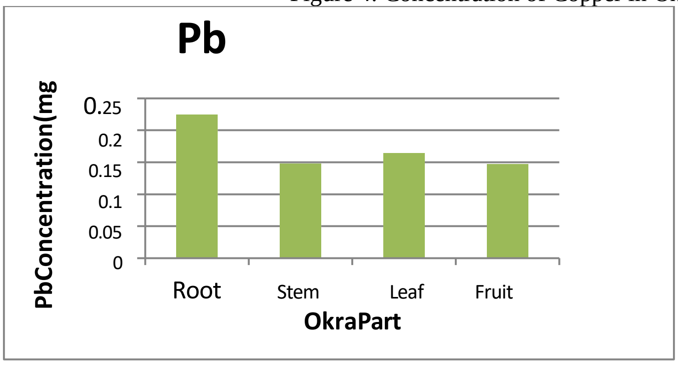

Figure 5: Concentration of Lead in Okra

The distribution pattern differed considerably among the metals studied in the various parts of the Okra as can be seen in Figures 1 -5. While Cd and Zn had highest accumulations in the stem of okra, Cr and Cu were more in the fruit and Pb accumulated more in the root of the plant. The distribution of Cd in okra plant in this study agrees well with that reported by Wang *et al*, (2016), for wheat plant. The authors observed more of the Cd was concentrated in the shoot. The Cr distribution was however in contrast to what was reported by Gomes *et al*, (2017), which showed more of the metal being retained in the root.

Cu was also found to be more concentrated in the root of *E. indica* as reported by Garba *et al*, (2011), which is in contrast with what was obtained in this study. However the result agrees with report of Wang *et al*, (2016) which had highest Cu concentration in the shoots. The pattern of Zn in this study also agrees with that of Wang *et al*, (2016), who reported the highest Zn in the shoots of *X-Strumarium* and *B- repens*.

For the okra plant studied, almost all the metals under consideration accumulated more in the above ground tissues. According to Al-Kateeb and Leilah (2005) and Keane *et al*, (2001), these trends could be as a result of atmospheric deposition or perhaps okra is just a good translocator of these metals from root to shoot.

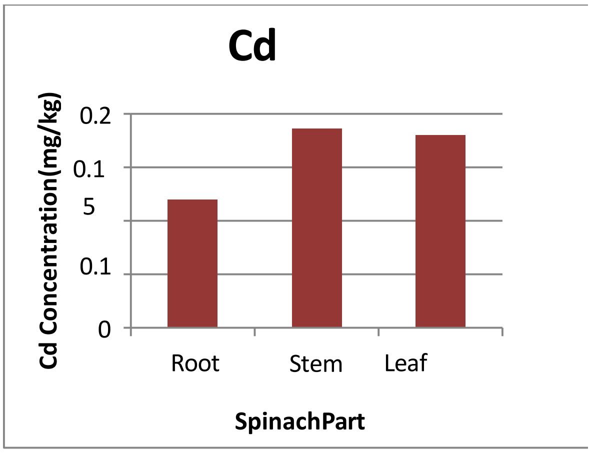

Figure 6: Concentration of Cd in spinach

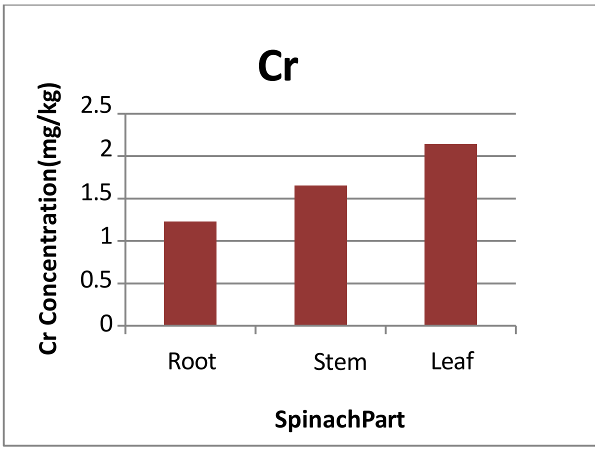

Figure 7: Concentration of Cr in spinach

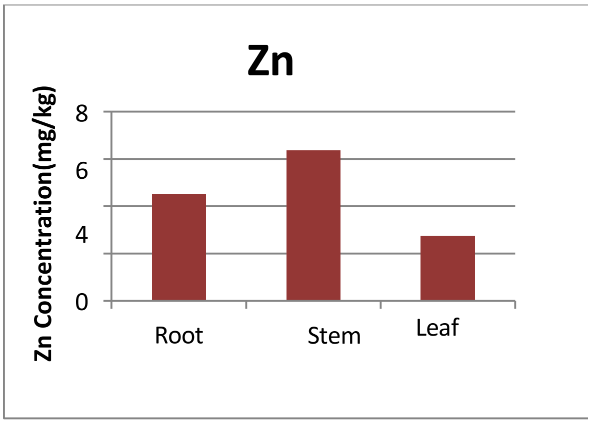

Figure 8: Concentration of Zn in Spinach

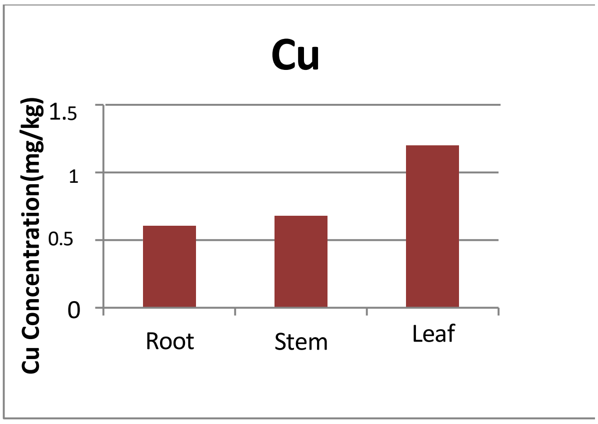

Figure 9: Concentration of Cu in spinach

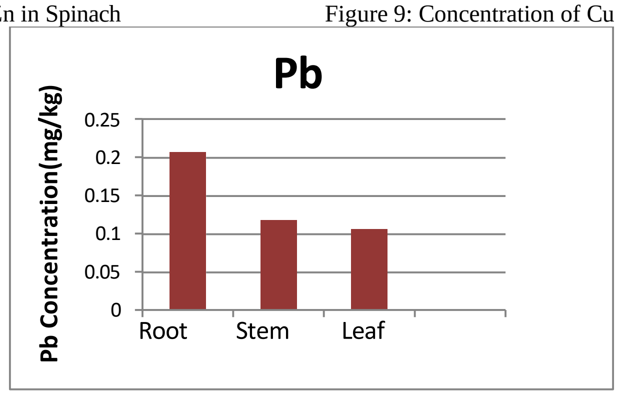

Figure 10: Concentration of Pb in spinach

The results of the metal distribution in spinach plant are as presented in Figures 6-10. From the Figures, it is also clear that the distribution varied from metal to metal. The highest concentration of the metals were all found in the above ground tissues except lead which was more in the bellow ground (root) tissue. This could be as a result of the mobility of these metals. The result agrees with that reported by Baker and Brook, (1989); Keane (2001) and Wang *et al*, (2016). Furthermore, according to Patra *et al*, (2004), lead is usually taken up by the plants from the soil and accumulated in the root with only portion being translocated into above ground tissues.

Figures 11-15 are the results of metal distribution in tomato plant. From these Figures, with the exception of lead ion, all the metals studied accumulated more in the root of the tomato plant. This result agrees with that obtained by Garba *et al*, (2011), while lead was more in the edible part of the plant (fruit) which also agrees with the report of Piechalak *et al*, (2002) and Sajida *et al*, (2012) who reported that only few species of plants accumulate high concentration of Pb in above ground tissues. These findings are also in line with report by Humberto *et al*, (2020), who reported tomato to be the least likely plant to absorb large amounts of heavy metals from soil. This result indicates that, tomato could be described as an excluder of these metals except Pb

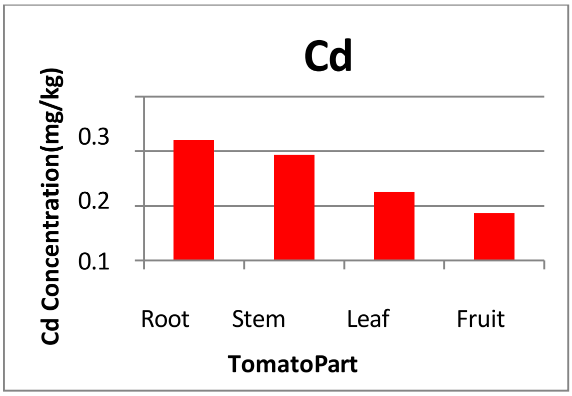

Figure 11: Concentration of Cd in Tomato

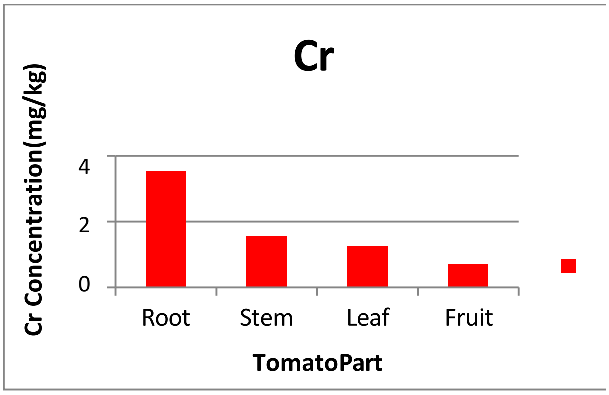

Figure 12: Concentration of Cr in Tomato

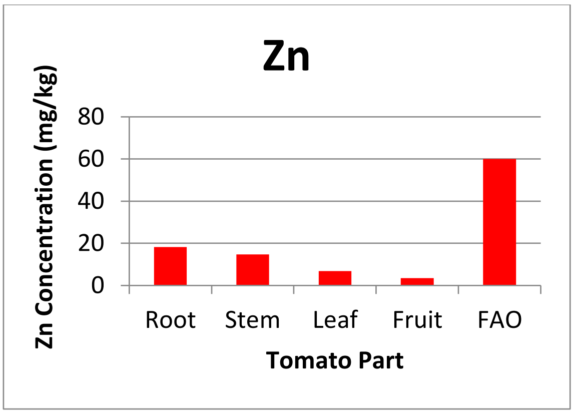

Figure 13: Concentration of Zn in Tomato

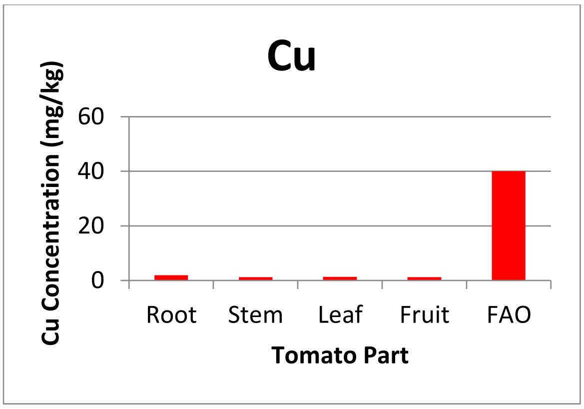

Figure 14: Concentration of Cu in Tomato

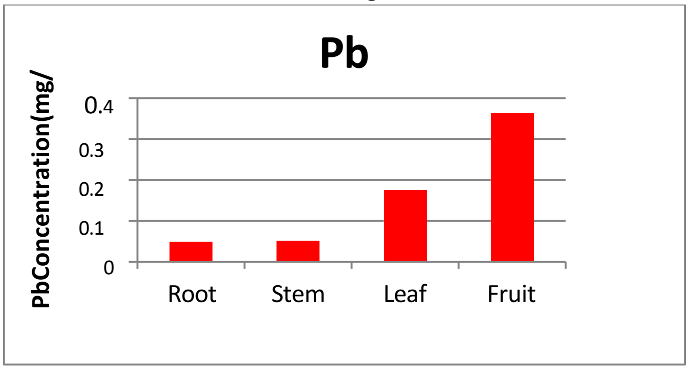

Figure 15: Concentration of Pb in Tomato

The bioconcentration factor (BCF) and translocation factor (TF) of the studied metals are Cd(1.43, 3.55), Cr(1.04, 4.00); Cu(19.85, 4.52), Pb(1.89, 1.62), Zn(22.88, 4.37) respectively for Okra; Cd (11.09, 3.05), Cr(0.95, 3.08), Cu(5.53, 3.10), Pb(1.91, 0.14), Zn(5.77, 2.02) respectively for Spinach and Cd(12.27, 1.84), Cr(0.88, 1.00), Cu(11.32, 2.06), Pb(1.59, 2.35) and Zn(14.47, 4.31) respectively for Tomato. According to Nas and Ali, (2018), plants with TF >1 or < 1 are considered as accumulators or excluders of the metals respectively. Based on this, Okra, Spinach and Tomato in the current study could be considered as accumulators of the studied metals. Again, according to Eissa *et al* (2016), BCF indicates the plant's ability to absorb the metal from the soil. It can be inferred from the BCF values above that the plants studied have the ability to absorb the metals from the soil.

CONCLUSION

This study aimed at investigating the pollution level of some heavy metals in some vegetables grown through irrigation farming. the research findings revealed that the concentrations of Cd, Cr, Cu, Zn and Pb in the vegetables were all below the permissible limits established by regulatory standards (WHO/ FAO). This indicates that the vegetables in the studied area cannot pose immediate health risk to the consumers. However, BCF and TF values show that the plants can absorb and transfer the metals into various parts of the plant therefore continued use of vegetables from the study area could pose threat to human health.

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