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Assessment of Heavy Metal Concentration in Vegetables Grown Around Jakara Reservoir, Kano State Nigeria

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Abstract

Heavy metal concentrations in vegetables (onion, pepper, and tomatoes) were used to evaluate the pollution state of Jakara Reservoir in Kano State between February and May of 2024. Analysis of the heavy metals was done according to established procedure. Every month, vegetables were gathered from six sampling locations designated A, B, C, D, E, and F according to the different human activity surrounding the reservoir. The findings showed that onion samples had mean values for Copper (Cu), Cadmium (Cd), Chromium (Cr), Manganese (Mn), Nickel (Ni), Lead (Pb), and Cobalt (Co) of 0.93, 0.37, 1.01, 0.79, 0.81, 0.69, and 0.56 mg/kg, respectively. Onions had the lowest levels of Cd while the highest level was Cr. The heavy metal accumulation in onions was as follows: Cr > Cu > Ni > Mn > Pb > Co > Cd. The following elements were found in pepper: Pb, Co, Mn, Ni, Cu, (Cr), (Cd), and 0.76, 0.66, 1.61, 0.58, 0.54, 0.53, and 0.48 mg/kg, respectively. Pepper accumulated in the following decreasing order: Cr > Pb > Cd > Mn > Cu > Ni > Co with the exception of Ni and Mn. The concentrations of all the heavy metals in pepper were higher than the FAO's recommended limit (2020). Tomatoes had correspondingly values of 0.63, 0.61, 0.49, 0.44, 0.29, 0.28, and 0.25 mg/kg of Cu, Cr, Cd, Mn, Ni, Co, and Pb. Cu > Cr > Cd > Ni > Mn > Co > Pb was the decreasing order for metals in tomatoes. With the exception of Cr, Mn, and Ni, the concentrations of all heavy metals in tomatoes were higher than the FAO's recommended level (2020). Based on the current study's findings, it can be said that eating vegetables grown in the study area poses a serious risk to the consumer's health. As a result, it is advised that the appropriate authorities enforce the safety regulations pertaining to vegetables originating from the research region and suggest alternate irrigation areas where the vegetables can be produced using uncontaminated soil.

Key words: Pollution, Heavy metals, Irrigation, Vegetables, Jakara Reservoir

INTRODUCTION

Heavy metal poisoning of the environment and related food safety problems have grown to be serious global environmental concerns (FAO, 2020). If these metals build up in greater amounts than are necessary, they can have detrimental effects on human and plant health (Jibrin *et al.*, 2021). Given that vegetables play a key role in human diet and nutrition and that people are becoming more aware of its nutritional value due to adequate education, it is

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reasonable that demand for and consumption of vegetables is rising dramatically worldwide (Aminu *et al.*, 2024). They are rich in fiber, vitamins, minerals, and carbohydrates all of which are vital for overall health (Eruteya *et al.*, 2024). However, the residual content of heavy metals in vegetables and soils has increased due to the use of agrochemicals, industrial effluent, and electronic waste (Badamasi *et al.*, 2023). Both human health and plant productivity are negatively impacted by heavy metals (Sadi *et al.*, 2023).

Heavy metal pollution is a worldwide issue that has drawn the attention of researchers, and one of the main challenges in cleaning up heavy metal-polluted soil is that these metals are not biodegradable (Chiromawa *et al.*, 2023). Heavy metals are now the most prevalent environmental contaminants in Kano State as a result of its fast industrialization (Sani *et al.*, 2020). Long-term ingestion of foods tainted with heavy metals causes the body to continuously accumulate poisons, especially in sensitive organs, which disrupts biochemical pathways (FAO, 2020). According to Zhang *et al.* (2023), phytotoxicity, or the toxicity of heavy metals in vegetables, impacts their growth and development and results in oxidative stress, cytotoxicity, and genotoxicity. Additionally, since contaminated plants can enter the human body, soil contamination is another method that heavy metals can be exposed to people (Adamu *et al.*, 2023). Considering the aforementioned, the purpose of this study was to determine the levels of heavy metal buildup in the edible portions of vegetables (tomatoes, pepper, and onion) cultivated along irrigation channels in Jakara Reservoir.

MATERIALS AND METHODS

Study Area

Sampling Site A: Getsi River: The Kwana Hudu Bridge is situated 100 meters from the Getrsi River. From the Bompai Industrial Estate, wastewater is dumped into the river. At the estate, there are textile mills and tanneries operating as factories. PVC pipes are utilized underground to supply residential potable water in the communities near Bompai, which spans the river, according to field observations.

Sampling Site B: Magami (The Confluence)
This location is five meters from where the Jakara and Getsi rivers converge. Here, household wastewater from the Jakara and industrial effluents from the River Getsi combine.

Sampling Site C: Bela (The Entry Point into Wasai reservoir).This is the point of entrance (inlet) where tributary wastewater enters the reservoir. The banks are used for unofficial irrigation, and it is a significant fishing station. The location is roughly 25 meters from the Wasai reservoir's Jakara River drainage point. The water, which the farmers referred to as "black water," or "Bakin Ruwa," is dark grayish when it first reaches reservoirs and loses its color when it mixes with the reservoir's water.

Sampling Site D: Barwa (The Spillway) This Barwa is located at 120 07.742N, 0080 41.235E, 5 meters from the dam's spillway. In addition to being a significant fishing location, the banks are also used for unofficial irrigation.

Sampling Site E: Wasai (The Outlet): This location, which is five meters from the dam's controlled discharge, doubles as a fishing station and has unofficial irrigation farming on its banks.
Sampling point F:This location is in Danmadanpho, where the reservoir receives non-point source outflows from neighboring farms and informal settlements. Fishing and livestock grazing are examples of human activity.

Samples Collection and Analysis for Heavy Metals

For four months, sampling was done every two weeks in duplicate from 7:00 am to 7:30 am at each of the six sampling locations. The method used by Babatunde *et al.* (2012) was used to dissect the sediment samples. To achieve a consistent weight, precisely 5g of the sediment was oven-dried at 105°C. Before being digested, the sediments were ground into a powder and stored in the desiccator. In accordance with Samson (2015), the powder was homogenized and digested using hydrogen peroxide (1:1) v/v and concentrated nitric acid. After adding 10 mL of each of HNO_3 and H_2O_2 to a 250 mLround-bottom flask containing precisely 2 g of the powder samples, the flask's contents were left to digest. To reduce the volume to 4 milliliters, the flask's contents were heated to 130 degrees Celsius on a heating mantle until they dissolved inside a fume hood. After allowing the digested samples to cool, they were filtered into a conical flask. The filtered sample was then moved to a 50 ml volumetric flask, where it was further diluted with de-ionized water to reach 50 ml. The Atomic Absorption Spectrophotometer (Perkin Elmer PinAAcle 900H Model) at Central Laboratory, Bayero University, Kano, was used to measure the amounts of heavy metals.

Analysis of Heavy Metals in Vegetables (Onion, Pepper and Tomato) Samples

After collecting samples of onion, pepper and tomato, they were carefully rinsed with deionized water to get rid of any dirt particles or debris that might have been adhered to them. After being air dried, vegetable samples were ground up and sieved using a 2 mm mesh screen. Before analysis, Jibrin *et al.* (2021) used a well-labeled plastic container to store the powdered samples at room temperature. Samson (2015) recommended that the powder be homogenized and digested using hydrogen peroxide (1:1) v/v and concentrated nitric acid. Ten milliliters (10 mL) of HNO_3 and H_2O_2 were introduced to a 250 milliliter round-bottom flask containing precisely two grams of the powder samples, and the flask's contents were left to digest. To bring the flask's capacity down to 4 milliliters, the contents were heated on a heating mantle to 120-130°C until they dissolved inside a fume hood. Following a period of cooling, the digested samples were filtered into a conical flask. The filtered sample was then moved to a 50 ml volumetric flask, where it was further diluted with de-ionized water to reach 50 ml. The Central Laboratory of Bayero University in Kano used an Atomic Absorption Spectrophotometer (Perkin Elmer PinAAcle 900H Model) to measure the concentrations of Cu, Cr, Cd, Mn, Ni, Co, and Pb.

Bio-Accumulation Factor Determination

Bioaccumulation factor (BAF) was calculated using the protocol described by (Vaseem and Banerjee, 2013):
BAF = M vegetables/M soil. Where; M vegetable is the metal concentration in vegetable (mg/kg) and M soil, metal concentration in soil (mg/kg).

Statistical Analyses

Analysis of variance (ANOVA) was used to determine whether there is significant difference in Heavy metals concentration between sites and vegetables. Least Significant Difference test was use to separate the mean difference between sites and vegetables. Pearson correlation was used to determine the association between the heavy metals parameters. Data were analyzed using IBM SPSS 20.0. Statistical software.

RESULTS AND DISCUSSION

The mean heavy metals concentrations of Cu, Cd, Cr, Mn, Ni, Pb, and Co in onion are 0.93, 0.37, 1.01, 0.79, 0.81, 0.69 and 0.56 mg/kg respectively. Cr had its the highest concentration in onion, and Cd was the lowest. The heavy metals in onion accumulated in decreasing order of Cr > Cu > Ni > Mn > Pb > Co > Cd (Table 1).

Table 1: Heavy Metals Concentration (mg/kg) in Onion Grown from Jakara Reservoir, Kano

Site	Cu	Cr	Cd	Mn	Ni	Co	Pb
A	0.85 ± 0.10^{a}	1.21 ± 0.21^{ab}	0.34 ± 0.01^{a}	0.72 ± 0.10^{a}	0.79 ± 0.01^{a}	0.56 ± 0.01^{a}	0.15 ± 0.01^{ab}
B	1.07 ± 0.11^{b}	0.81 ± 0.10^{ab}	0.13 ± 0.10^{a}	0.76 ± 0.01^{b}	0.64 ± 0.01^{b}	0.42 ± 0.10^{b}	0.31 ± 0.02^{a}
C	1.62 ± 0.10^{a}	1.46 ± 0.21^{b}	0.66 ± 0.02^{b}	1.80 ± 0.12^{b}	1.97 ± 0.11^{b}	0.84 ± 0.01^{b}	1.88 ± 0.02^{a}
D	0.88 ± 0.31^{a}	0.67 ± 0.10^{ab}	0.31 ± 0.14^{b}	0.40 ± 0.10^{b}	0.53 ± 0.20^{a}	0.73 ± 0.10^{a}	0.59 ± 0.10^{ab}
E	0.41 ± 0.06^{ab}	0.84 ± 0.00^{a}	0.42 ± 0.10^{a}	0.63 ± 0.01^{a}	0.57 ± 0.01^{ab}	0.46 ± 0.01^{b}	0.62 ± 0.01^{ab}
F	0.78 ± 0.12^{b}	1.02 ± 0.01^{ab}	0.40 ± 0.16^{a}	0.44 ± 0.11^{b}	0.37 ± 0.10^{ab}	0.36 ± 0.01^{ab}	0.64 ± 0.10^{ab}
Mean	**0.93±0.01**	**1.01±0.05**	**0.37±0.01**	**0.79±0.10**	**0.81±0.11**	**0.56±0.02**	**0.69±0.23**
WHO (2021)	0.01	0.05	0.01	1.00	3.00	0.01	0.01

Note: means followed with different superscript letters across the column are considered significant at ($p<0.05$)

The concentrations of Cu, Cr, Cd, Mn, Ni, Co and Pb in pepper are 0.76, 0.66, 1.61, 0.58, 0.54, 0.53, and 0.48 mg/kg respectively. Metals concentration decreased in order of Cr > Pb > Cd > Mn > Cu > Ni> Co. The values of all the metals in pepper were above the recommended limit set by FAO (2020), except for Ni and Mn (Table 2).

Table 2: Heavy Metals Concentration (mg/kg) in Pepper Obtained from Jakara Reservoir, Kano

Site	Cu	Cr	Cd	Mn	Ni	Co	Pb
A	0.32 ± 0.01^{ab}	1.05 ± 0.10^{b}	0.49 ± 0.01^{b}	0.44 ± 0.00^{a}	0.45 ± 0.10^{a}	0.42 ± 0.01^{a}	0.35 ± 0.01^{ab}
B	0.37 ± 0.00^{a}	0.17 ± 0.00^{a}	0.55 ± 0.10^{a}	0.83 ± 0.11^{b}	0.57 ± 0.01^{b}	0.51 ± 0.10^{a}	0.48 ± 0.02^{a}
C	1.42 ± 0.10^{ab}	1.30 ± 0.11^{b}	0.94 ± 0.01^{b}	1.10 ± 0.12^{b}	0.92 ± 0.16^{b}	0.88 ± 0.20^{b}	1.85 ± 0.03^{a}
D	0.23 ± 0.01^{a}	0.62 ± 0.10^{ab}	0.63 ± 0.10^{b}	0.43 ± 0.10^{b}	0.41 ± 0.10^{a}	0.43 ± 0.10^{a}	0.42 ± 0.10^{ab}
E	0.45 ± 0.01^{b}	0.80 ± 0.00^{a}	0.62 ± 0.01^{a}	0.32 ± 0.01^{a}	0.51 ± 0.10^{ab}	0.35 ± 0.12^{b}	0.34 ± 0.10^{ab}
F	0.47 ± 0.10^{b}	0.63 ± 0.01^{ab}	0.45 ± 0.11^{a}	0.39 ± 0.11^{b}	0.38 ± 0.41^{a}	0.28 ± 0.00^{a}	0.52 ± 0.01^{ab}
Mean	**0.54±0.01**	**0.76±0.05**	**0.61±0.01**	**0.58±0.12**	**0.53±0.34**	**0.48±0.01**	**0.66±0.26**
FAO/WHO (2018)	0.05	1.00	0.01	1.0	1.5	0.01	0.01

Note: means with different superscript letters across the column are considered significant at ($p<0.05$)

The concentrations of Cu, Cr, Cd, Mn, Ni, Co and Pb in tomatoes were 0.63, 0.61, 0.49, 0.44, 0.29, 0.28, and 0.25 mg/kg respectively. The heavy metals concentrations in onion decreases in the order of Cu > Cr > Cd > Ni > Mn >Co > Pb. The concentration of all the heavy metals in tomatoes were above the recommended limit set by FAO (2020), except for Cr, Mn and Ni (Table 3).

Table 3: Heavy Metals Concentration (mg/kg) in Tomatoes from Jakara Reservoir, Kano

Site	Cu	Cr	Cd	Mn	Ni	Co	Pb
A	0.41 ± 0.10^{ab}	0.82 ± 0.01^{b}	0.23 ± 0.01^{b}	0.03 ± 0.01^{a}	0.45 ± 0.10^{a}	0.07 ± 0.01^{a}	0.31 ± 0.01^{a}
B	0.57 ± 0.01^{a}	0.65 ± 0.01^{a}	0.20 ± 0.10^{a}	0.31 ± 0.10^{b}	0.57 ± 0.01^{a}	0.21 ± 0.10^{a}	0.48 ± 0.02^{b}
C	1.31 ± 0.10^{ab}	0.83 ± 0.10^{b}	0.87 ± 0.10^{b}	0.54 ± 0.12^{b}	0.72 ± 0.26^{b}	0.56 ± 0.00^{a}	1.47 ± 0.03^{a}
D	0.33 ± 0.10^{b}	0.34 ± 0.10^{a}	0.53 ± 0.01^{b}	0.41 ± 0.00^{b}	0.36 ± 0.10^{a}	0.23 ± 0.01^{b}	0.06 ± 0.00^{a}
E	0.52 ± 0.01^{a}	0.54 ± 0.10^{ab}	0.74 ± 0.01^{a}	0.39 ± 0.00^{a}	0.47 ± 0.10^{b}	0.35 ± 0.10^{b}	0.01 ± 0.10^{a}
F	0.65 ± 0.01^{b}	0.51 ± 0.01^{ab}	0.40 ± 0.16^{a}	0.11 ± 0.11^{b}	0.08 ± 0.00^{b}	0.31 ± 0.01^{a}	0.02 ± 0.01^{b}
Mean	**0.63±0.16**	**0.61±0.81**	**0.49±0.50**	**0.29±0.11**	**0.44±0.30**	**0.28±0.01**	**0.25±0.06**
FAO/WHO (2018)	0.05	1.00	0.01	1.0	1.5	0.01	0.01

Note: means with different superscript letters across the column are significant at ($p<0.05$)

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Table 4.Metals Concentrations (mg/kg) in Vegetables Grown along Jakara River Channel

Heavy metals	Onion	Pepper	Tomatoes	FAO (2020)
Cu	0.93±0.31[a]	0.54±0.31[a]	0.63±0.20[a]	2.0
Cr	1.01±0.11[a]	0.76±0.01[a]	0.69±0.12[a]	0.05
Cd	0.37±0.56[a]	0.61±0.10[a]	0.49±0.01[a]	0.01
Mn	0.79±0.04[a]	0.58±0.10[a]	0.29±0.00[a]	0.01
Ni	0.81±0.01[a]	0.54±0.17[a]	0.44±0.11[a]	0.5
Co	0.56±0.32[a]	0.47±0.11[a]	0.28±0.00[a]	0.01
Pb	0.69±0.01[a]	0.66±0.00[a]	0.22±0.01[a]	1.0

Discussion

Table 1 shows the levels of copper (Cu), cadmium (Cd), chromium (Cr), manganese (Mn), nickel (Ni), lead (Pb), and cobalt (Co) in vegetables grown near the Jakara Reservoir. Onion samples have the following concentrations: 0.93, 0.37, 1.01, 0.79, 0.81, 0.69, and 0.56 mg/kg of Cu, Cd, Cr, Mn, Ni, Pb, and Co. Onions had the largest accumulation of Cr and the lowest of Cd. The heavy metal accumulation in onions was as follows: Cr > Cu > Ni > Mn > Pb > Co > Cd. All heavy metal concentrations in onions, with the exception of Ni and Mn, are higher than the FAO (2020) threshold levels. This suggests that heavy metal contamination of onions grown in the research area is caused by pesticide inputs, industrial wastewater, and other human activities. The comparable amounts of heavy metals in the sediments are responsible for the high levels of these metals in onions, particularly Cr and Ni. The results of Jibrin *et al.* (2021), who evaluated the distribution of heavy metal concentrations in Kano-grown carrot, lettuce, pepper, onion, and cabbage, were consistent with this. The use of agrochemicals from adjacent irrigation sites along the reservoir channels may be the cause of the heavy metals found in the edible portion of the plants. Yuguda *et al.* (2015) observed a similar observation. In plant tissue, heavy metals are primarily carried apoplastically (Guo *et al.*, 2020). Metals must pass through the endodermis and the casparian strips in order to enter the roots' xylem vessels which, in younger plant parts are not yet fully developed. Guo *et al.* (2020) also showed how water transpiring via leaves changes the metals' translocation to the shoot, which takes place in the xylem. This may explain why onion have higher levels of heavy metals than peppers and tomatoes.

Pepper contains 0.76, 0.66, 1.61, 0.58, 0.54, 0.53, and 0.48 mg/kg of copper (Cu), chromium (Cr), cadmium (Cd), manganese (Mn), nickel (Ni), cobalt (Co), and lead (Pb), in that order. Onions accumulated heavy metals in the following decreasing order: Cr > Pb > Cd > Mn > Cu > Ni > Co. With the exception of Ni and Mn, the concentrations of all the heavy metals in pepper were higher than the FAO's recommended limit (2020). Similar findings on the concentration of heavy metals in plants were published by Gebeyehu and Bayissa (2020). As a tuber, onion bulbs grow more quickly and transpire at a lower rate than leafy vegetables like tomatoes and peppers. They therefore have a high propensity for plant roots to absorb heavy metals. This aligns with the findings of Ohaeri *et al.* (2020), who found elevated levels of Pb, Ni and Zn in the Challawa water body. Additionally, Nuhu (2000) found that mango leaves from industrial zones in Kano city's Bompai, Challawa, and Sharada had elevated levels of cadmium, manganese, and lead. According to the research by Guo *et al.* (2020), the high concentration of Cu found may be caused by the discharge of sewage and the use of electrical appliances. Clays can readily absorb chromium ions due to their mobility (Zhang *et al.*, 2023). Adsorption and reduction in the sediments facilitate the nature of chromium in soil and its movement from soil to vegetables (Jibrin *et al.*, 2021). According to the current findings, the sources of Cr contamination in the sediment and water of Jakara Reservoir, such as the manufacture of organic fertilizers or other anthropogenic sources, are responsible for the high concentration of Cr observed. Furthermore, a considerable amount of Cr is present in the tannery effluents from the Sharada and Bompai Industrial areas that flow into the Jakara River. Ohaeri *et al.* (2020) observed a similar observation in the Challawa River. Plant physiology, including root surface area, plant type, transpiration, and root secretion type, as well as soil characteristics, including pH, CEC, and texture, all influence the transfer of Cr from soil to vegetables. Animals, microbes, and plants are all poisoned by lead (Guo *et al.*, 2021). Lead is known to prevent seeds from germinating, and its toxicity depends on a number of soil characteristics, including pH, plant species, carbon exchange capacity, and soil organic matter (Chiromawa *et al.*, 2023). Mean Pb amounts of 0.69, 0.66, and 0.25 mg/kg found in tomatoes, peppers, and onions throughout the study period were greater than the WHO (2020) recommendation of 0.01 mg/kg. Plant species, salt type, Pb content, and soil characteristics all affect Pb toxicity. Plant enzyme activity, photosynthesis, and mineral feeding are all impacted by elevated Pb concentrations. Major processes like seed germination, dry shoots and roots, and seedling growth are all impacted by toxic levels (Sani *et al.*, 2020). According to Shawai *et al.* (2018), lead is a phytotoxic metal that inhibits the synthesis of ATP, changes the permeability of cell membranes, reacts with the phosphate groups of ADP and ATP, and replaces necessary ions to produce reactive oxygen species (ROS), which are the cause of DNA damage and lipid peroxidation.

Due to its capacity to transform Cr (VI) into Cr (III), soil organic matter controls the bioavailability, mobility, and sorption of Cr (Alzaharani *et al.*, 2023). Although plants require manganese, excessive amounts of the element can be harmful to them and hinder a variety of activities (Abii, 2012; Musa *et al.*, 2020). The mean manganese concentrations in tomatoes, peppers, and onions over the study period were 0.79, 0.58, and 0.29 mg/kg, respectively. Values were below WHO (2020) threshold of 1.0 mg/kg. According to Ezike *et al.* (2019), Mn phytotoxicity is caused by the suppression of glutathione reductase and peroxidase, two essential antioxidant enzymes that help cells fight off free radicals. Plants with high Mn levels experience oxidative stress due to the antagonistic interaction of metals with similar patterns, which results in a shortage of the enzyme cofactors needed for oxidative activities (Habu *et al.*, 2021). High Mn concentrations have caused changes in the cell's metabolic processes, chromosomes, and cell homeostasis (Rayhan and Ara, 2021). Excess Mn in plants results in chlorosis, a reduction in photosynthetic rate, a reduction in chloroplast size, and necrosis of the leaves, according to Anjum *et al.* (2014). High limed soil (pH of up to 8), acidic soils (pH of 5.5 or below) and poorly aerated sediments from waterlogging or compacted sediments are some of the causes of excessive Mn concentrations in vegetables. Because Mn does not bind to ligands, root tissues, or xylem fluid, it is known to be rapidly absorbed and translocated in plants. The phloem exudate has a lower concentration of Mn than leaf tissues, and Mn is carried as Mn^{2+} ions. This lower concentration in the phloem vessel is what causes the lower concentration of Mn in the vegetables under investigation (Kim *et al.*, 2015).

Tomatoes had correspondingly values of 0.63, 0.61, 0.49, 0.44, 0.29, 0.28, and 0.25 mg/kg of copper (Cu), chromium (Cr), cadmium (Cd), manganese (Mn), nickel (Ni), cobalt (Co), and lead (Pb). With the exception of Cr, Mn, and Ni, the concentrations of all heavy metals in tomatoes were higher than the FAO's recommended level (2020). Vegetables differed greatly in their heavy metal concentrations. This is explained by variations in their propensity to accumulate due to genetic and physiological variations as well as variations in soil conditions (Gebeyehu and Basiyya, 2020). Large quantities of heavy metals are accumulated in vegetables produced in industrial locations, leading to significant developmental modification and long-term detrimental impacts on public health (Gebeyehu and Bayissa, 2020; Guo *et al.*, 2020). Long-term use of foods polluted with heavy metals may result in the accumulation of toxins linked to heavy metals in human key organs, which could alter critical biochemical pathways. The content of some heavy metals in the vegetables were discovered to be out of proportion to the samples. Plants can readily absorb cadmium due to its high mobility in tissues.

Conclusion

In the samples of pepper and onion, the heavy metal concentrations dropped in the following order: Cr > Pb > Cd > Mn > Cu > Ni > Co and Cr > Pb > Cd > Mn > Cu > Ni > Co, respectively. All heavy metal concentrations in onions, with the exception of Ni and Mn, are higher than the FAO (2020) threshold levels. The heavy metals in tomatoes decreased in the following order: Cr > Cd > Ni > Mn >Co > Pb, except for Cr, Mn, and Ni. Given the current study's findings, it can be said that eating vegetables grown in the study area poses a serious risk to the consumer's health. As a result, it is advised that the appropriate authorities enforce the safety regulations governing vegetables originating from the research region and suggest alternate irrigation areas where uncontaminated soil can be used to grow vegetables.

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