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DETERMINATION OF SOME HEAVY METAL CONCENTRATIONS IN SOIL AND PLANT PARTS OF SOLANUM LYCOPERSICON IN OBOCHI EHE FARMLAND, OKENGWE, KOGI STATE

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ABSTRACT
Environmental pollution by heavy metals and associated food safety is a major global concern, these metals can pose a serious health implication to all living things in general and humans in particular if accumulated in elevated concentration above body requirements. One of the ways that poisonous heavy metals can enter human tissues and endanger human health is through food crops, especially fruits and vegetables. This study was conducted to determine the concentration of some heavy metals (Copper (Cu), Cadmium (Cd), Chromium (Cr) and Lead (Pb) in soil and plant parts (root and fruit) of tomatoes grown at Obochi ehe farm, which is a major farmland in Okengwe, Kogi state. The heavy metals present were analyzed using Atomic Absorption Spectrophotometer (AAS). The results showed that all the heavy metals were detected in soil, root and fruit from the various sites of the farm, there was significant difference in the concentrations of the metals between the soil, root and fruit, with the soil recording higher concentrations for Cu, Cd and Cr, while the concentration of Pb was significantly higher in the root. The study also revealed, Cu, Cr and Cd concentrations were below the World Health Organization (WHO) and Food and Agriculture Organization (FAO) safe limit of 73.3, 2.3mg/kg and 0.2 mg/kg respectively, while Pb was slightly above the safe limit of 0.3mg/kg. The findings from this study shows the importance of the development of measures to ensure food safety and protection of human health.

Keywords: Heavy metals, Tomatoes, Farmland, Okengwe

INTRODUCTION

The continuous and diverse expansion of agriculture, society and the economy, as well as the preservation of human health, depends on the quality and safety of the soil environment (Chen *et al*., 2016). Since poisonous metals are non-biodegradable and accumulate in living tissue throughout the food chain, their accumulation in agricultural soils is like-wise thought to be a significant problem for humanity.

Growing, urbanization and industrialization have contributed to poor air, water, and soil quality internationally, specifically emphasizing soil contamination (Oyebamiji *et al.,* 2024). One of the ways that poisonous heavy metals can enter human tissues and endanger human health is through food crops, especially fruits and vegetables. Food crops play a significant role in our diet and may include a range of both essential and dangerous metals, depending on the characteristics of the growth medium utilized (Waqas *et al.*, 2015). Heavy metals accumulate in both edible and non-edible parts of plants, causing a variety of problems for humans. The majority of a person's intake of heavy metals, or about 90% of it, comes from eating contaminated vegetables, with the remaining 10% coming from skin contact and breathing in polluted dust (Khan *et al*., 2014).

Because of their toxicity, persistence, and capacity to build up in the biota, trace metals in the environment continue to pose a hazard even if persistent organic contaminants and greenhouse gases have received more attention (Ali *et al*., 2019). Exposure to heavy metals in soil primarily occurs via inhalation, oral consumption, and skin touch, constituting the three main routes of human contact (Kolo *et al*., 2018). Numerous exposure pathways are considered for evaluating health hazards, such as skin contact with contaminated soil, consuming contaminated food or drink, and breathing polluted air. It is well-known that the elements Cr, Cu, Cd, Pb, and As are hazardous toxic metals in the environment (Zhang *et al*., 2023). Exposure to salts of heavy metals such as cadmium and lead causes immune system dysfunction, leading to dysregulation of inflammation and increasing the risk of adverse outcomes (Balabekova *et al.,* 2024).

These heavy metals are not biodegradable, they have long biological half-lives, toxic in nature and their accumulation with time produces reactive oxygen species that can cause oxidative stress, leading to the production of various diseases (Fu and Xi, 2020).
When used in moderation, heavy metals are beneficial to human health; nevertheless, when used in excess, they can cause serious diseases. Some fruits and vegetables include nutrients that are crucial for psychological and biochemical health, but they shouldn't be ingested in excess since they may result in a range of metabolic symptoms (Fawad *et al*., 2017).
The cultivated tomato, *Solanum lycopersicum,* is a member of the Solanaceae family. Due to its widespread use as a fundamental component in a variety of raw, cooked, and processed cuisines, it is the most planted vegetable in the world. Tomatoes rank among the most popular vegetables consumed worldwide, it has also been linked to a number of health advantages, including decreased risk of cancer and heart disease. Phylloquinone (vitamin K1), potassium, folate, and vitamin C are also abundant in them (FAO 2021).

Obadahun *et al.* (2021) conducted a comprehensive analysis of heavy metals concentration in tomato fruits and the surrounding soil in an industrial area of Kano State, Nigeria and the increased levels of heavy metals such as lead, cadmium, chromium, iron

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found in tomato fruits was primarily attributed to nearby industrial activities. Gebeyehu and Bayissa (2022), also investigated the heavy metal accumulation in tomato fruits and associated health risks and found that heavy metals such as lead (pb) and cadmium (cd) exceeded permissible limits in tomato samples, posing significant health risks to consumers. Presence of potential cancer risk to the population from As, Cd, Cr and Ni due to the consumption of both tomato and cabbage being cultivated was also reported by Gebeyehu and Bayissa, (2020)

A comprehensive assessment of heavy metal contamination and subsequent risks for ecosystems and humans is necessary to develop management measures, reduce soil insecurity, and handle climate change (Kumar *et al*. 2019). As a result, this study will ascertain the presence of toxic metals in the edible parts of tomatoes grown in the study area and also in the soils in which they are cultivated.

MATERIALS AND METHODS

Study Area

The study was carried out in Okengwe community, Okene, Kogi state Nigeria with Latitude: N7◦33'23.62212" and Longitude: E6◦11'21.246" (Google, n.d.).
This community has a population of over 470,000 and is located in the central part of Kogi State and the people are mainly involved in the cultivation of yam, vegetable, pepper, tomato, maize.

Sample Collection and Preparation

Samples of tomato fruit, soil and root were carefully collected in replicates from different points of the Obochi ehe farm, in Okengwe and placed in a polythene bag. The tomato fruit and root samples were washed carefully with distilled water to remove soil and dirt and then dried at 70◦C to constant weight in an oven. The dried tomato and root samples were grounded and homogenized into fine powder using a grinder. Each dried sample was stored in an airtight container to prevent surface contamination.
One gram of each grounded sample (both tomato, root) and soil was weighed for all the samples with the aid of an analytical weighing balance. Each weighed sample was placed in a digestion tube, 10 mL of Nitric acid was prepared and added to each digestion tube containing 1g of prepared samples. The digestion tube was placed in a hot plate and heated on a controlled temperature of 210 degree Celsius for approximately 150 minutes. The samples were removed from the hot plate after the digestion process has been completed and allowed to cool to prevent loss of volatile substance. The digested solution was diluted with deionized water to a volume of 100ml for analysis. All reagents used were of analytical grade and the Atomic Absorption Spectrophotometer (AAS) was used to determine the heavy metal (Cadmium, Chromium, Copper and Lead) concentrations in the digested solution.

Statistical Analysis

Data were reported as mean ± standard deviation (SD). One way analysis of variance (ANOVA) was used to determine significant difference ($p<0.05$) between groups using SAS version 9.1.

RESULTS AND DISCUSSION

The concentration of the heavy metals in the soil samples analyzed at various points of the farm is shown in table 1. The concentration of copper increased from sample point one to three, peaking at sample point three before stabilizing at point four and five, indicating possible localized contamination or variation in soil composition. The cadmium levels are relatively low but showed a significant difference, particularly between sample points two and four, indicating potential environmental factors affecting its concentration. The different sample points showed significant difference in the concentration of chromium with sample point three showing the highest concentration. Concentration of lead was significantly higher in sample point three compared to other sites

Table 1: Heavy metal concentrations (mg/kg) in soils of the sampled location

Sample points	Cu	Cd	Cr	Pb
1	0.20 ± 0.57^{d}	0.08 ± 0.00^{ab}	0.22 ± 0.33^{c}	0.35 ± 0.57^{c}
2	0.27 ± 0.66^{bc}	0.08 ± 0.33^{a}	0.25 ± 0.00^{b}	0.37 ± 0.57^{b}
3	0.30 ± 0.57^{a}	0.07 ± 0.00^{c}	0.26 ± 0.33^{a}	0.41 ± 0.66^{a}
4	0.25 ± 0.57^{c}	0.067 ± 0.33^{c}	0.22 ± 0.00^{c}	0.27 ± 0.66^{d}
5	0.25 ± 0.57^{b}	0.073 ± 0.33^{bc}	0.20 ± 0.33^{d}	0.27 ± 0.66^{d}
P value	**0.000****	**0.005****	**0.000****	**0.000****

The results showed that all the heavy metals were detected in soil, root and fruit from the various sites of the farm (figure 1). Copper is the third most used metal in the world, it is an essential micronutrient required in the growth of both plants and animals (Mohammed *et al.,* 2022). The concentration of copper in this study was significantly ($p<0.05$) higher in the soil compared to the root and fruit of the plant, this may be due to the soil being a higher bio-accumulator of the metal, there was no significant difference in the concentration of copper in the root and fruit, though the lowest concentration was found in the root. Copper concentrations in the soil and parts of the plant were found to be below the World Health Organization (WHO) and Food and Agriculture Organization (FAO) safe limit of 73.3mg/kg as shown in table 2. Cadmium is a non-essential element in foods and natural waters and primarily it accumulates in the kidneys and liver (Divrik, *et al.,*2006). Cadmium concentration in this study was significantly higher in the soil compared to the root and fruit, though the concentrations were below the WHO and FAO safe limit of 0.2mg/kg (Table 2). Chromium plays a vital role in the metabolism of cholesterol, fat, and glucose but at high concentration, it is toxic and carcinogenic (Chistri *et al*., 2011). The highest concentration of chromium in this study was recorded in the soil, this may be due to chromium being more available in the soils than the plant parts, though the concentrations fall within the WHO and FAO safe limit of 2.3mg/kg. The elevated concentrations of these metals in the soil samples compared to other parts could be attributed to various domestic activities around the farm. This is similar to the study of Ndinwa *et al*. (2014) where the high concentrations of heavy metal in the soil were attributed to urbanization and anthropogenic wastes normally found in urban towns. In contrast, copper, cadmium and chromium were found to be present in a higher concentration above the normal concentration range by Abdulkadir *et al*. (2023).

Lead is one out of four metals that have the most damaging effects on human health. It can enter the human body through uptake of food (65%), water (20%) and air (15%) (Mohammed *et al.,* 2022). The highest level of Pb (0.48 mg/kg) in this study was found in the

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root, and it was significantly different ($p<0.05$) from those of the soil and fruit. The concentration of lead was found to be slightly above the WHO/FAO safe limit of 0.3mg/kg, this could be as a result of illegal dumping of refuse, or improper use of agrochemicals, fertilizers and pesticides since there was no industry near the farmland studied.

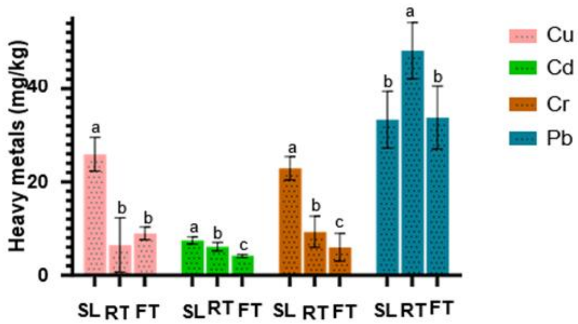

Figure 1: Heavy Metals concentration in the soil, root and fruit of *Solanum lycopersicum*
Key: SL- Soil, RT -Root, FT- Fruit

Table 2: Heavy Metal concentration (mg/kg) in soil, root and fruit of *Solanum lycopersicum*

		Cu	Cd	Cr	Pb
1.	Soil	0.26 ± 3.62a	0.08 ± 0.743a	0.23 ±2.52a	0.33 ± 6.09b
2.	Root	0.07 ± 5.80b	0.06 ± 0.915b	0.09 ± 3.35b	0.48 ± 6.02a
3.	Fruit	0.09 ± 1.36b	0.04 ± 0.352c	0.06 ± 2.97c	0.34 ± 26.14b
	WHO/FAO Standard	73.3mg/kg	0.3mg/kg	0.2mg/kg	0.1mg/kg

Conclusion

The soils recorded higher concentrations for most of the metals, which is an indication of sources of pollution around the farmland. Lead showed the highest concentration among the metals analyzed, and was found to be higher in the root of the plant, indicating anthropogenic contamination of the sites and also high take up and accumulation of the metals from the soil by the tomatoes thus the need for environmental monitoring of the area. Additionally, Cu, Cr and Cd were found to be lower than the threshold limit, while Pb exceeded the safe limit.

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