



**ACCUMULATION OF SELECTED HEAVY METALS IN CASSAVA (*Manihot esculenta*)
CULTIVATED AT VARIOUS SITES IRRIGATED WITH TEXTILE EFFLUENT**

¹Isah, B.I. and ²Ado, G.

¹Department of Biological Sciences, Nigerian Police Academy Wudil, Kano State, Nigeria.

²Department of Science Education, Faculty of Education, Federal University, Gashua, Yobe State ,
Nigeria

Corresponding Author: garbado05@gmail.com (08036350343)

Abstract

This study evaluates heavy metal accumulation in cassava (*Manihot esculenta*) grown on the soils irrigated with textile effluent. Root samples were collected from effluent-affected and control fields. Samples were digested and analyzed via AAS/ICP-OES to quantify lead (Pb), cadmium (Cd), chromium (Cr), zinc (Zn) and copper (Cu). The results revealed that effluent-irrigated sites accumulated significantly higher concentrations of lead (Pb, 9.1 µg/kg) compared to the control. Cadmium (Cd) levels were extremely elevated (29.4 µg/kg), exceeding those of the control by more than tenfold. Chromium (Cr) concentrations were slightly higher (66.9 µg/kg), while zinc (Zn, 50.3 µg/kg) and copper (Cu, 21.4 µg/kg) showed moderate increases relative to the control.

Keywords: Cassava, Control, Effluent, Heavy metals and Textile

Introduction

Cassava (*Manihot esculenta* Crantz) is a widely cultivated root crop and a major source of carbohydrates for millions of people in tropical and subtropical regions (Iyaka, 2011). Its adaptability to poor soils, drought tolerance, and high yield potential make it a vital food

security crop in many developing countries (Akinola et. al, 2008). However, the safety and nutritional quality of cassava are increasingly threatened by environmental pollution, particularly contamination with heavy metals (Okereke et.al, 2020). Cassava is a staple crop vital to food security in Nigeria and similar

climates. However, irrigating croplands with industrial effluents—particularly from textile factories—can introduce heavy metals into the food chain (Iwegbue et al, 2013). Textile effluents often contain toxic metals such as chromium (Cr), lead (Pb), and cadmium (Cd), attributed to dyes and additives in wastewater streams (Adjei-Mensah, 2020). Plants like cassava bioaccumulate heavy metals, which pose risks to consumers and ecosystems (Muhammad, 2002). Despite extensive research on cassava mill effluent, less is known about the impact of textile effluent-irrigated soils. This study assesses heavy metal levels in soil and cassava roots, evaluates transfer to edible parts, and estimates health risk using TF, EDI and THQ indices. Heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), zinc (Zn), and copper (Cu) are naturally occurring elements, but their concentrations in the environment have been significantly elevated due to anthropogenic activities (Osokwe and Okolie, 2015). Sources include industrial discharges, mining, smelting, application of agrochemicals, and the use of untreated wastewater for irrigation. Cassava cultivated in contaminated soils or irrigated with polluted water can accumulate heavy metals in its roots and leaves through uptake from the soil,

leading to bioaccumulation along the food chain (Fagbote and Olaripekun, 2010).

Excessive accumulation of heavy metals in cassava poses serious health risks to consumers. While some metals, such as Zn and Cu, are essential micronutrients in small quantities, elevated levels can cause toxicity, affecting vital organs and biological systems (Okoye and Ugwu, 2010). Non-essential metals like Pb and Cd are toxic even at low concentrations and are associated with neurotoxicity, kidney damage, carcinogenicity, and other chronic health problems

The detection of Pb and Cd above permissible limits set by the FAO/WHO Codex Alimentarius and national food safety guidelines suggests possible contamination from sources such as industrial effluents, agrochemicals, and vehicular emissions. Lead exposure is associated with

neurotoxicity, especially in children, while cadmium is linked to kidney dysfunction and skeletal damage upon chronic intake (Asante et. al, 2023). Elevated levels in cassava roots could therefore pose a significant public health risk in communities dependent on cassava as a staple food

Chromium, in its trivalent form (Cr^{3+}), is an essential trace element, but its hexavalent form (Cr^{6+}) is highly toxic and carcinogenic. The presence of elevated Cr in cassava from effluent-irrigated fields suggests leaching from industrial discharge, particularly from textile, tannery, or metal plating operations. Continuous consumption of such contaminated cassava could result in long-term health effects.

In contrast, Zn and Cu are essential micronutrients required for enzymatic and metabolic processes. However, excessive levels, especially above 50 mg/kg for Zn and 40 mg/kg for Cu in food crops, may cause gastrointestinal disturbances and interfere with the absorption of other essential minerals (Nwoko and Mgbeahuruke, 2011). The moderate Zn

and Cu concentrations found in some samples may indicate both natural soil contribution and supplementation from fertilizers or industrial waste. The study aims to evaluate heavy metal accumulation in cassava (*Manihot esculenta*) grown on the soils irrigated with textile effluent.

Materials and Methods

Study area and Sampling Effluent-affected fields near a textile processing plant were

identified in Challawa Industrial Estate in Kano State of Nigeria. Challawa lies between latitude $11^{\circ} 52' 29''$ N and longitude $8^{\circ} 31' 04''$ E.

Control sites with freshwater irrigation and similar soil types were established nearby. From each site, 5 composite soil samples (0–20 cm depth) and corresponding cassava roots were collected. Sample preparation and digestion

Soil and cassava root samples were air-dried, ground, and sieved. Approximately 0.5 g of each sample was digested using $\text{HNO}_3\text{--H}_2\text{O}_2$ microwave digestion. Digests were diluted to known volumes for analysis (Adelasoye and Ojo, 2015).

Analytical procedure

Metal concentrations (Pb, Cd, Cr, Zn, Cu) were measured using AAS or ICP-OES. Quality control included blanks, spikes (80–120% recovery), duplicates, and certified reference materials. Detection limits were determined for each metal.

Results

Effluent-irrigated soils exhibited significantly higher mean concentrations of all the tested heavy metals ($\mu\text{g}/\text{kg}$) relative to controls ($p < 0.05$)

Cassava root concentrations elevated levels of the heavy metals were found in cassava from effluent versus control. The findings align with previous studies (Eze et al., 2021); [Adebayo et al., 2019], which reported that cassava grown in areas impacted by industrial discharge tends to accumulate higher levels of non-essential metals than those from uncontaminated soils. This trend underscores cassava's ability to bioaccumulate metals due to its extensive root system and long growth period

The variability in heavy metal

levels among sampling sites may be attributed to differences in effluent composition, soil pH, cation exchange capacity, and irrigation practices. Acidic soils, for instance, increase metal solubility and hence uptake by plants. Seasonal variations in effluent discharge volumes may also influence contamination levels.

From a food safety perspective, the elevated levels of toxic metals in some cassava samples call for urgent mitigation strategies. These may include pre-treatment of industrial effluents before discharge, adoption of phytoremediation plants to reduce soil metal load, and regular monitoring of food crops from high-risk areas. Additionally, awareness campaigns are necessary to educate farmers and consumers on the risks of cultivating and consuming from contaminated sites.

Overall, while cassava remains a vital food security crop in many regions, its role as a potential pathway for heavy metal exposure cannot be overlooked. Effective environmental management and policy enforcement are essential to safeguard public health.

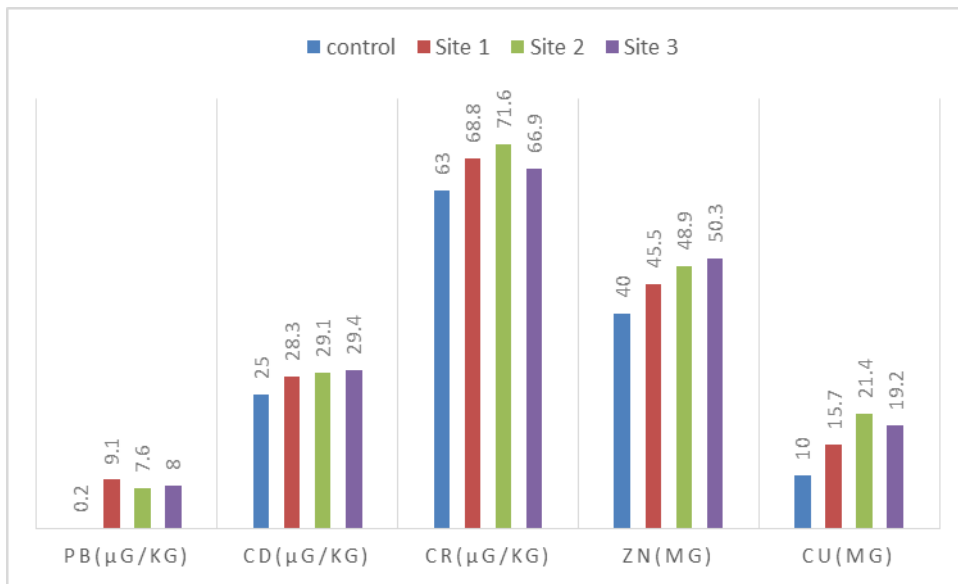


Figure1: Accumulation of Heavy metals by cassava roots treated with textile Effluents.

Discussion

The elevated heavy metals in effluent-irrigated soils reflect contributions from textile effluent, consistent with industry-effluent contamination literature. High TFs for Zn and Cu suggest cassava readily translocates these elements, aligning with other soil-plant uptake studies. Although EDI values suggest current consumption is within safe bounds, the high THQ for Pb warrants caution due to its neurotoxic effects. Long-term consumption could elevate risks, especially for children or pregnant women. Lead (Pb) Control is 0.2 µg/kg. Sites are much higher (7.6–9.1 µg/kg), which indicates contamination at all sites, especially Site 1. Cadmium (Cd): Control is 25

µg/kg. Sites: Elevated (28.3–29.4 µg/kg) Moderate increase, possibly from pollution sources. Chromium (Cr) Control is 63 µg/kg. Sites higher (66.9–71.6 µg/kg) slight increase with site 2 being the highest. Zinc (Zn) Control is 40 mg sites higher (45.5–50.3 mg) consistently elevated, with Site 3 the highest. Copper (Cu) Control is 10 mg sites: significantly higher (15.7–21.4 mg), with the highest at Site 2. Heavy metal contamination in food crops is a growing environmental and public health concern, particularly in developing regions where industrial and agricultural waste is poorly managed. Cassava (*Manihot esculenta*), a major staple in many tropical countries, is highly susceptible to

absorbing heavy metals from contaminated soils. Akinola et al. (2008) investigated levels of lead (Pb), cadmium (Cd), and chromium (Cr) in root crops from refuse dump sites in Lagos, Nigeria. Their findings revealed concentrations exceeding WHO/FAO limits, highlighting the risks associated with cultivation on waste-affected soils. Similarly, Fagbote and Olanipekun (2010) examined cassava grown near open dumps in Ekiti State and found significant contamination in both soil and tubers, attributing it to leachates from waste. Okoye and Ugwu (2010) explored the impact of vehicular emissions by analyzing cassava from farms near highways. Elevated levels of Pb and Cd were detected, pointing to atmospheric deposition as a key pathway. Nwoko and Mgbeahuruike (2011) extended this concern to ready-to-eat cassava products, confirming bioaccumulation from field to food. In a study of irrigation impact, Iyaka (2011) assessed cassava grown along the River Niger, where water is often used untreated. The study found heavy metals such as Cd and Zn at levels that may pose chronic health risks with long-term consumption. Overall Interpretation revealed that all sites show elevated levels of heavy metals compared to the control. Site 2 generally shows the highest contamination across most metals, which corresponds with the

work of Adelasoye and Ojo (2015). These elevations may suggest anthropogenic activities (industrial, agricultural or urban runoff).

Conclusion

Cassava grown on textile-effluent-irrigated soils accumulates higher levels of heavy metals, particularly Zn and Cu, with Pb levels close to risk thresholds. However, the current dietary risk remains moderate, the potential for chronic exposure and bioaccumulation calls for immediate interventions—such as treating effluent before use, monitoring metal levels in crop and soil, and exploring phytoremediation strategies—to ensure food safety. The findings underscore the need for wastewater treatment, prudent irrigation practices, and routine monitoring. Phytoremediation or effluent pre-treatment technologies may mitigate future contamination.

These studies consistently emphasize the need for regular monitoring of cassava cultivation areas, especially near industrial zones, highways, and waste disposal sites. The findings also underline the importance of setting and enforcing agricultural safety standards to protect public health.

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