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Analysis for the Presence of Heavy Metals in the Tissues of *Saccharum officinarum* (SUGAR CANE), *Musa paradisiaca (*PLANTAIN) AND *Manihot esculenta* (CASSAVA) Harvested in Otuoke Community

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Abstract: *The study examines the levels of heavy metals (lead, cadmium, mercury, and arsenic) in the tissues of Saccharum officinarum (sugar cane), Musa parasidiaca (plantain), and Manihot esculenta (cassava) grown in Otuoke, Bayelsa State. Existing literature has shown that heavy metals can be absorbed by plants from contaminated soils. Samples of the crops were taken from three locations (Beach Road, Kakata Road and PA Road) in Otuoke community. The atomic absorption spectrophotometry (AAS) was used to quantified the concentrations of heavy metals in the plant samples. The results revealed that cassava accumulated the highest concentrations of lead (0.10-0.14 mg/kg) and cadmium (0.015-0.03 mg/kg), while plantain showed higher arsenic concentrations (0.02-0.04 mg/kg). Mercury levels were low and consistent in all the plant samples, ranging from 0.003 mg/kg to 0.008 mg/kg. Sugar cane tissues had lead concentrations between 0.03 mg/kg and 0.07 mg/kg, with the highest levels in leaf tissues, and arsenic concentrations from 0.015 mg/kg to 0.03 mg/kg. The study revealed significant variations in the uptake and accumulation of Lead, Cadmium, Mercury and Arsenic in plant tissues. These results highlight the need for monitoring and implementation of strategies that could mitigate heavy metal contamination in agricultural crops to protect biodiversity and human health.*

Keywords: *Heavy Metals in Plant Tissues, Sugar Cane, Plantain, Cassava and Soil Pollution*

Introduction: Heavy metals are naturally occurring elements that can be found in the environment, often as a result of human activities such as industrial processes, mining, and agricultural practices (Selin, 2013). These metals, including lead, cadmium, mercury, and arsenic, pose serious health risks to humans and the environment due to their toxicity and persistence in the ecosystem (Alloway, 2013). In recent years, there has been growing concern about the contamination of agricultural crops with heavy metals, as these metals can accumulate in plant tissues and eventually enter the human food chain, leading to adverse health effects. Otuoke, located in the Ogbia Local Government Area of Bayelsa state, Nigeria, is an area of particular interest due to its proximity to industrial activities and potential sources of heavy metal pollution. Crop plants play a crucial role in the transfer of heavy metals from soil to humans, as they absorb these metals from the soil through their roots and accumulate them in various plant tissues, including leaves, stems, and fruits (Kabata-Pendias & Mukherjee, 2007). Understanding the levels of heavy metal accumulation in different crop plants is essential for assessing the potential health risks associated with consuming these crops and implementing strategies to mitigate contamination. Sugar cane (*Saccharum officinarum*) is a widely cultivated crop in tropical regions, including Nigeria, and is used for sugar production and ethanol fuel. Studies have shown that sugar cane has the ability to accumulate heavy metals from contaminated soil, with concentrations varying depending on factors such as soil properties, cultivation practices, and environmental conditions (Arao *et al.*, 2009). Research conducted in similar agricultural settings has highlighted the potential for sugar cane to accumulate heavy metals such as cadmium and lead, posing risks to human health (Arao *et al.*, 2009). Plantain (*Musa paradisiaca*) is a staple food crop in Nigeria and other West African countries, known for its high nutritional value and versatility in culinary applications. Like other crop plants, plantain has been found to accumulate heavy metals from contaminated soil, although studies specific to heavy metal accumulation in plantain in the Otuoke community are limited. However, research conducted in neighboring regions has shown that plantain has the potential to accumulate heavy metals such as cadmium and mercury, particularly in regions with high levels of industrial activity and soil contamination (Jin *et al.*, 2018). Cassava (*Manihot esculenta*) is a drought-tolerant root crop widely grown in Nigeria for its starchy tubers, which are a staple food for millions of people. While cassava is known for its ability to grow in poor soils, it can still accumulate heavy metals from contaminated soil, posing risks to human health through consumption of cassava products (Ogunkunle *et al.*, 2015). Studies have shown that cassava has the potential to accumulate heavy metals such as cadmium and arsenic, with concentrations varying depending on factors such as soil pH, organic matter content, and the presence of other soil contaminants (Kachenko & Singh, 2006).

The presence of heavy metals in the tissues of crop plants such as sugar cane, plantain and cassava, in Otuoke, Ogbia Local Government Area, Bayelsa state, Nigeria, poses significant concerns for human health and environmental integrity. Despite the agricultural importance of these crops in the region, there is limited understanding of the extent of heavy metal contamination and its potential impacts on food safety and public health. There is a lack of comprehensive data on the levels of heavy metals, such as lead, cadmium, mercury, and arsenic, present in the tissues of sugar cane, plantain, and cassava grown in the Otuoke community. Without these data, it is challenging to assess the extent of heavy metal contamination and its implications to the environment, biodiversity and human health.

Materials and Methods: **Study Area**: The study on the analysis of the presence of heavy metals in the tissues of sugarcane (*Saccharum officinarum*), plantain (*Musa paradisiaca*) and cassava (*Manihot esculenta*) was carried out in Otuoke, Ogbia Local Government Area, Bayelsa State, located in the Niger Delta region of Nigeria, the area is characterized by a rich biodiversity of plant species, some of which are traditionally consumed as food. Otuoke is located at coordinates of 4°45' and 6°18'E. The southern and central parts of Bayelsa State fall within the Nigerian lowland rainforest zone. The temperature in this region is around 26ºC-32°C during the day and drops slightly to 24-26°C at night. The community typically experiences significant rainfall from April to July and September to October every year. This area is characterized by lush, dense forests, with a wide variety of tree species, including mahogany, iroko, obeche, and numerous other hardwoods. These forests are home to a rich diversity of plant and animal species. Agricultural and economic activities in Otuoke and its surroundings primarily revolve around trading, civil service, contracting, farming, fishing, and logging. The fertile soils and favorable climate conditions support the cultivation of various crops, including the studied sugarcane, plantain, and cassava, as well as other staples like yams and maize. Fishing is also a significant economic activity due to the proximity to rivers and creeks, providing a vital source of income and food for the local population. Additionally, the abundant forest resources contribute to the logging industry, with valuable hardwoods being harvested for timber. These activities are crucial for the livelihoods of the local communities, shaping both the economy and the cultural practices of the region.

Collection of samples: Three farms which were located at Kakata road, Beach road and PA road within Otuoke Community were selected randomly. Three crop plants were targeted: sugar cane (*Saccharum officinarum*), Plantain (*Musa paradisiaca*), and cassava (*Manihot esculenta*). Healthy, mature plants were selected to avoid variability due to disease or developmental stage. Samples were taken from different parts of the plants to account for potential variations in heavy metal accumulation. Collected samples were placed in clean, labeled polyethylene bags to prevent contamination. Each sample was labeled with information including the plant type, part of the plant, location, and date of collection. Samples were transported to the laboratory in a cooler to minimize degradation.

Sample preparation: The collected samples were cleaned with deionized water to remove surface contaminants. After the cleaning, they were dried in an oven at 60-70°C until a constant weight was achieved. The samples were grinded into a fine powder using an electric blender.

Digestion of Samples : 0.5grams of the powdered sample was weighed and transfer into a digestion vessel. A Mixture of 10 mL nitric acid and 5mL of hydrochloric acid was added to the sample. The mixture was heated using microwave digestion system until complete digestion is achieved. The digested solution was cooled and filtered to remove particulates. The digested solution was transferred into a volumetric flask and diluted to a 50mL volume with deionized water. The Atomic Absorption Spectrophotometer (AAS) was used. Through standard solutions of the heavy metals, the prepared samples were then analyzed for heavy metal content. The Atomic Absorption Spectrophotometer (AAS) calibration and analysis process was carried out for each heavy metal (Lead, Cadmium, Mercury, and Arsenic) individually.

Data Presentation and Analysis: The data for this research were presented using descriptive methods through the use of tables. This approach will allow for a clear and concise presentation of the heavy metals found across various sampling locations in Otuoke community.

Discussion: Table 1 reveals that the concentration of lead in the sugar cane tissues ranges from 0.03 mg/kg to 0.07 mg/kg, with leaf tissues generally having higher lead content than stem tissues. This suggest that leaves are more exposed to environmental sources of lead, such as atmospheric deposition. Cadmium concentrations vary from 0.008 mg/kg to 0.03 mg/kg. Higher cadmium levels in PA road samples indicate possible localised contamination or soil characteristics that favour cadmium uptake. The mercury levels are relatively low and consistent, ranging from 0.005 mg/kg to 0.008 mg/kg. This indicates a relatively uniform background level of mercury in the environment. Arsenic concentrations range from 0.015 mg/kg to 0.03 mg/kg, with the highest concentrations observed in leaf tissues, suggesting a potential accumulation or exposure mechanism specific to leaf surfaces. Table 2 shows that the concentration of lead in the plantain tissues ranges from 0.05 mg/kg to 0.09 mg/kg. The leaf tissues consistently show higher lead levels compared to pseudo-stem and fruit, indicating potential leaf-specific accumulation mechanisms. Cadmium levels range from 0.01 mg/kg to 0.02 mg/kg. Higher concentrations are seen in leaves, which might reflect both root uptake and foliar absorption. Mercury concentrations are low, between 0.003 mg/kg and 0.007 mg/kg, showing a relatively consistent environmental situation. Arsenic ranges from 0.02 mg/kg to 0.04 mg/kg, with the highest levels found in Beach road leaf tissues. This suggests environmental factors at Beach road that enhance arsenic uptake in plantain leave. Table 3 reveals that lead concentrations in cassava tubers are the highest among all tested tissues and plants, ranging from 0.10 mg/kg to 0.14 mg/kg. This indicates a significant root uptake and accumulation of lead. Cadmium levels range from 0.015 mg/kg to 0.03 mg/kg, with higher values in PA road tuber samples, suggesting site-specific factors affecting cadmium uptake. Mercury concentrations are consistently low across all cassava tissues, ranging from 0.005 mg/kg to 0.008 mg/kg, indicating a uniform environmental condition. Arsenic concentrations range from 0.01 mg/kg to 0.03 mg/kg, with higher levels generally found in leaf tissues, indicating potential leaf-specific accumulation mechanisms.

Discussion: The study analyzed the presence of heavy metals (Lead, Cadmium, Mercury, and Arsenic) in the tissues of sugar cane, plantain, and Cassava collected from three locations in Otuoke community. The data were presented in tables, providing insights into the heavy metal concentrations in different tissues of the plants. The concentration of lead (Pb) in sugar cane tissues ranged from 0.03 mg/kg to 0.07 mg/kg, with higher levels generally found in leaf tissues. The variability suggests that leaves might be more exposed to atmospheric deposition of lead (Smith *et al.,* 2018). Cadmium (Cd) concentrations varied from 0.008 mg/kg to 0.03 mg/kg, with PA road samples showing the highest levels, indicating localized contamination or specific soil characteristics (Jones & Smith, 2015). Mercury (Hg) levels were low and consistent, ranging from 0.005 mg/kg to 0.008 mg/kg, reflecting a uniform background presence (Brown *et al.,* 2011; Brown *et al.,* 2021). Arsenic (As) concentrations ranged from 0.015 mg/kg to 0.03 mg/kg, with higher concentrations in leaves, suggesting an accumulation mechanism possibly due to foliar absorption (Miller *et al.,* 2012). In table 2 Lead concentrations in plantain tissues ranged from 0.05 mg/kg to 0.09 mg/kg, with leaf tissues consistently showing higher levels, possibly due to foliar exposure to environmental sources. Cadmium levels ranged from 0.01 mg/kg to 0.02 mg/kg, with higher values in leaves, reflecting both root uptake and foliar absorption (Wang *et al.,* 2014). Mercury concentrations were low, ranging from 0.003 mg/kg to 0.007 mg/kg, showing a relatively consistent environmental presence (Lee & Kim, 2015). Arsenic concentrations ranged from 0.02 mg/kg to 0.04 mg/kg, with the highest levels found in Beach road leaf tissues, indicating specific environmental factors that enhance arsenic uptake in plantain leaves (Cheng *et al.,* 2020). Table 3 reveals Lead concentrations in cassava tissues were the highest among the tested plants, ranging from 0.10 mg/kg to 0.14 mg/kg, suggesting significant root uptake and accumulation (Williams *et al.,* 2017). Cadmium levels ranged from 0.015 mg/kg to 0.03 mg/kg, with higher values in PA road root samples, indicating site-specific factors affecting cadmium uptake (Kumar & Gupta, 2018). Mercury concentrations were consistently low across all cassava tissues, ranging from 0.005 mg/kg to 0.008 mg/kg, indicating a uniform environmental condition (Zhang & Li, 2019). Arsenic concentrations ranged from 0.01 mg/kg to 0.03 mg/kg, with higher levels in leaf tissues, suggesting leaf-specific accumulation mechanisms (Nguyen *et al.,* 2020). The plantain tissues generally have higher concentrations of heavy metals compared to sugar cane. Cassava tissues especially the tubers, show the highest concentrations of lead and cadmium among the three plants, indicating a significant accumulation (Jones & Smith, 2015, Williams *et al.,* 2017, Smith *et al.,* 2018). While there is some variability, the heavy metal concentrations are relatively consistent within each metal type (Kumar *et al.,* 2018). Likely sources include atmospheric deposition for lead and arsenic, localized soil contamination for cadmium, and minimal recent local contamination for mercury (Smith *et al.,* 2018).

Conclusion: The study on the presence of heavy metals in the tissues of Sugar Cane, Plantain, and Cassava plants in Otuoke community, reveals significant variations in the uptake and accumulation of Lead (Pb), Cadmium (Cd), Mercury (Hg), and Arsenic (As) across different plant tissues and sites. The presence of these heavy metals in food crops raises concerns about potential health risks to the local population consuming these plants. Chronic exposure to heavy metals can lead to various health issues, including neurological, renal, and cardiovascular problems. In order to protect human health and biodiversity, soil remediation techniques such as phytoremediation should be employed. Regular monitoring of heavy metal concentrations should be carried in soil and water sources to detect and address contamination early. Organic farming methods should be encouraged to reduce the use of inorganic fertilizers, herbicides and pesticides.

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Table 1: Heavy Metal Concentration in Sugar Cane Tissue

Sample ID	Location	Tissue Type	Lead (mg/kg)	Cadmium (mg/kg)	Mercury (mg/kg)	Arsenic (mg/kg)	WHO Acceptable Values (mg/kg)
SC-01	**Kakatar**	**Leaf**	**0.05**	**0.01**	**0.005**	**0.02**	**Pb: 0.03, Cd: 0.01, Hg:0.001, As: 0.01**
SC-02	**Kakatar**	**Stem**	**0.03**	**0.008**	**0.006**	**0.015**	**Pb: 0.03, Cd: 0.01, Hg:0.001, As: 0.01**
SC-03	**Beach Road**	**Leaf**	**0.06**	**0.02**	**0.007**	**0.025**	**Pb:0.03, Cd:0.01, Hg:0.001**
SC-04	**Beach Road**	**Stem**	**0.04**	**0.01**	**0.005**	**0.02**	**Pb:0.03, Cd:0.01, Hg:0.001**
SC-05	**PA Road**	**Leaf**	**0.07**	**0.03**	**0.008**	**0.03**	
SC-06	**PA Road**	**Stem**	**0.05**	**0.02**	**0.006**	**0.02**	

The WHO acceptable values on this table are applicable to all the tables below. (SC – Sugar cane)

Table 2: Heavy Metal Concentration in Plantain Tissues

Sample ID	Location	Tissue Type	Lead (mg/kg)	Cadmium (mg/kg)	Mercury (mg/kg)	Arsenic (mg/kg)
PL-01	**Kakatar**	**Leaf**	**0.08**	**0.015**	**0.004**	**0.03**
PL-02	**Kakatar**	**Pseudostem**	**0.06**	**0.01**	**0.005**	**0.025**
PL-03	**Beach Road**	**Leaf**	**0.09**	**0.02**	**0.006**	**0.04**
PL-04	**Beach Road**	**Pseudostem**	**0.07**	**0.015**	**0.007**	**0.035**
PL-05	**PA Road**	**fruit**	**0.05**	**0.01**	**0.003**	**0.02**
PL-06	**PA Road**	**Pseudostem**	**0.05**	**0.01**	**0.004**	**0.02**

Table 3: Heavy Metal Concentration in Cassava Tissues

Sample ID	Location	Tissue Type	Lead (mg/kg)	Cadmium (mg/kg)	Mercury (mg/kg)	Arsenic (mg/kg)
CS-01	**Kakatar**	**Root**	**0.10**	**0.02**	**0.006**	**0.01**
CS-02	**Kakatar**	**Leaf**	**0.09**	**0.015**	**0.005**	**0.02**
CS-03	**Beach Road**	**Root**	**0.12**	**0.025**	**0.007**	**0.015**
CS-04	**Beach Road**	**Leaf**	**0.11**	**0.02**	**0.006**	**0.025**
CS-05	**PA Road**	**Root**	**0.14**	**0.03**	**0.008**	**0.03**
CS-06	**PA Road**	**Leaf**	**0.13**	**0.025**	**0.007**	**0.02**