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Heavy Metal Contamination in Telfairia occidentalis (Pumpkin Leaves) Cultivated on Waste-Dump Soils in Port Harcourt Metropolis

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Abstract
Disposal of solid waste poses serious risks to human health and degrades the environment. The objective of this research was to ascertain the concentration of heavy metals in the pumpkin leaves (Telfairia occidentalis) gathered from certain dumpsites in the Port Harcourt Metropolis, namely the Trans Amadi Dumpsite, the East West Dumpsite, the Eastern By-Pass Dumpsite, and the Rukpokwu Dumpsite. Analytical methods for heavy metals were developed utilizing a Perkin-Elmer type 403 atomic absorption spectrophotometer. Results showed that the amounts of lead (6.88 mg/kg), iron (4891.41 mg/kg), valence (71.71 mg/kg), copper (95.23 mg/kg), zinc (15.0 mg/kg), and manganese (95.23 mg/kg) in the Telfairia occidentalis (Pumpkin Leaves) obtained from the dumpsites exceeded the maximum allowable levels (MAL) for lead (0.3 mg/kg), iron (1000 mg/kg), valence (0.03), copper (40 mg/kg), zinc (50 mg/kg), and manganese (30 mg/kg). The residents of Port Harcourt need to be informed about the risks of eating vegetables produced near the dumpsite so they may avoid eating these products in the future. The farmers who are now cultivating edible crops in the area should be strongly urged to switch to alternative crops that may both provide income and help restore the soil. Additionally, the dumpsite approach should be used.

Keywords: Heavy Metals, Health Risk, Telfairia Occidentalis, Solid Waste, Health

Introduction

Port Harcourt inhabitants have a significant issue with one of the most pressing environmental problems: trash disposal. Solid waste disposal is a big problem in modern cities, slowing down efforts to improve urban sanitation, cleanliness, and the environment (Adeniji, 2018). People in urban areas tend to live in more degraded conditions due to the accumulation of solid waste and the careless disposal of trash, and this problem has been named as one of the main reasons for the urban degradation in Nigeria (Adingbade, 2015). Due to its prevalence and the overall deterioration of the environment, the garbage issue in the Port Harcourt city has become famous. The abundance of blooms and verdant foliage across the city earned Port Harcourt the nickname "garden city of Nigeria" due to its exceptional cleanliness. Port Harcourt may now be more accurately described as a "garbage city" due to the widespread prevalence of rubbish mounds across the city. It is still typical for people to throw off food scraps, paper, polyethene, textiles, metal scraps, broken glasses, wood, plastic, etc., in the gutters and on street corners. The situation is so terrible that it blocks traffic, and there's a chance that the leachates from these dumps might pollute drinking water if they mingle with rainwater. It would seem that the four main steps of solid waste management—collection, transportation, sorting, and disposal—are very inefficient (Ayotamuno & Gobo, 2004).

The physical environment undergoes dramatic changes due to industrial advances, rapid and somewhat disorganized urban growth, and insufficient waste management, which in turn increases the buildup of municipal trash. Indeed, the management of solid, liquid, and hazardous waste has emerged as a major issue in developing-world urbanization, particularly in Africa. Inadequate solid waste legislation and hazardous waste disposal facilities are present in some municipalities. According to Kimani (2007), and Wang et al. (2005), this kind of trash might be radioactive or hazardous. The cities in question exhibit certain characteristics of the waste-management problem, such as overflowing garbage cans, refuse-covered roadways, trash-choked streams, and hazardous waste sites that pose a threat to the health of nearby residents (Ebong et al., 2008; Rotich et al., 2006). Consumers of vegetables from unregulated urban sewage farms in Africa are at risk of heavy metal toxicity (Ebong et al., 2008). Vegetables grown on abandoned trash dumps may absorb heavy metals from the soil, according to studies (Benson and Ebong, 2005; Cobb et al., 2000), yet this hasn't stopped their widespread usage as farming locations. Research on dumpsite soils has shown that heavy metal concentrations and types vary with soil age, contents, and location. Odukoya and colleagues (2000). Soil column studies and field investigations both found that high quantities of cadmium, copper, chromium, and zinc leached very quickly (Singar et al., 2008). Heavy metals as arsenate, cadmium, copper, mercury, manganese, nickel, and zinc leak out of municipal garbage dumps and into the soil (Singar et al., 2008).

Environmental heavy metal contamination, even at low levels, and the subsequent cumulative health impacts is a major global health problem (Oluyemi et al., 2008). A number of environmental and health risks may be attributed to open dumps. Organic matter decomposition releases methane, which may explode and contaminate both surface and underground water sources via leachates. Oyelola et al. (2009) agreed that it detracts from the land's aesthetic value. Even for those who don't live in close proximity to the dumps, the sites pose a health risk. This is because microorganisms' actions on the organic waste produce a really unpleasant odor. The employees and pickers who deal with solid garbage are negatively impacted by the severe environmental degradation caused by the unregulated burning of this material. When asbestos and other toxic and hazardous materials are burned together, they may release carcinogenic fibers into the smoke (Oyelola et al., 2009; Woodward, 2007). It has come to light that certain towns' dumpsite administrators purposefully light fires at the dumps on a regular basis. This is done to lower the amount of garbage, make place for more rubbish, and ultimately prolong the life of the landfills. Because metals are more easily recovered from ash than from mounds of mixed garbage, human scavengers may deliberately start fires (USEPA, 2002; Pruss et al., 2000). Everyone from the general population to municipal officials and business owners is very interested in and worried about these problems (Ebong et al., 2008). There is a risk to the environment from the accumulation and persistence of heavy metals in soils caused by trash dumps (Fytianos et al., 2001). The phytotoxicity of these metals to plants and the possible health consequences to people and animals ingesting these vegetables make this a major environmental and health problem (Ellen et al., 2006; Pillay et al., 2003). Okoronkwo et al. (2005), Okoronkwo et al. (2005)a, and Albores et al. (2000) found that heavy metal concentrations in soil and subterranean water may be increased by municipal trash. Soils, crops, and people's health might all be impacted by this (Nyle and Ray, 2003). Heavy metal concentrations have a significant effect on the environmental implications of municipal trash.

Anxieties about environmental pollution's effects on public health, especially the worldwide epidemic of sickness, has grown in the previous 30 years (USEPA, 2002). On the other hand, most of these environmental illnesses aren't always obvious, and they might sneak up on people in their twenties and thirties (Kimani, 2007). Household food prep, cooking, and serving scraps; food storage, sales, and market trash make up the bulk of the south south region's solid waste. Birds, rodents, insects, and other creatures are drawn to the dump by these wastes. It has been suggested that animals that graze at the landfill might potentially infect nearby humans (Oyelola et. al., 2009; Eddy et al., 2006). Ashes, street sweepings, abandoned cars, non-hazardous industrial trash, building and demolition debris, rubber, leather, paper, plastic, bottles, glass, ceramics, and metal cans all comprise non-biodegradable solid waste (Kimani, 2007; Achankeng, 2006). The massive gaping manholes left exposed during quarrying operations for the Port Harcourt highway's construction in 1986 were filled up by dumping rubbish at Port Harcourt dumpsites (Aarne, 2009). The landowners made a little money off of the rubbish dump. The sort of solid trash put there could not be controlled since no one was in specific charge. Debris dumped illegally at the site for years until the Ministry of Environment and Natural Resources finally shut it down in 2007. Posting a notice stating dumping was no longer allowed in the area served this purpose.

In spite of the warning, people still toss trash at the dumpsite; however, they are more covert about it now, using wheelbarrows rather than refuse trucks and dropping it off at night rather than during the day. According to the Environmental Management and Coordination Act (EMCA) of 1999, the appropriate ministries and agencies have done very little to restore the site since then. There has been no communication with the landowners on how to recover the property for agricultural benefit. Despite the obvious danger of toxic metal contamination from the garbage, the landowners continue to utilize the dumpsite and surrounding soils for farming due to their fundamental challenges. Meanwhile, people continue to use tap water for household uses. No one knows how bad it has become for the residents living near some Port Harcourt dumpsites. With this knowledge, the research was conducted. The research aims to

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measure the concentration of heavy metals in soil and vegetables found surrounding the dumpsites in Trans-Amadi, East-West, and Eastern By-Pass in an effort to alleviate a portion of this issue.

Materials and Methods

Study Area

Trans-Amadi, East-West, Eastern By-Pass, and Rukpokwu (control site), all of which are locations close to or in the vicinity of dumpsites, were the subjects of the research. Obio-Akpo and Port Harcourt LGAs in Rivers State, Nigeria, were chosen as the locations for the dumps. Humid tropical weather is typical of the region. With an average value close to 400 mm, the precipitation is substantial. The months of April through November constitute the rainy season, whereas the months of November through March constitute the dry season. A tropical rain forest covers the landscape. However, due to forest clearance for cultivation, the natural rain forest has almost vanished in most regions. Port Harcourt, the site of the research, is the most populous and strategically placed city in Nigeria's Niger Delta region, and the capital of the state of Rivers. Situated on a peninsula between 60 551 and 70 081 East longitude and latitude 40421 and 40 471 North, Port Harcourt is in the sub-equatorial area. The metropolitan area encompasses about 180,000 hectares of land and is situated in the eastern section of Rivers State (Port Harcourt Master Plan, 1975)..

Telfairia occidentalis Sample Collection and Preparation

Following the protocol laid forth by Melville and Welsh, (2001), samples of Telfairia occidentalis were gathered along transect lines. Every sample location had a transect line cut across it. Trans-Amadi, East-West, Eastern By Pass, and Rukpokwu (as a control site) were the locations from where Telfairia occidentalis samples were taken. After that, along each transect line, three Telfairia occidentalis samples were collected. Prior to laboratory examination, Telfairia occidentalis samples were dehydrated, ground, placed in sterile polythene bags, and left at room temperature.

Analysis of Heavy Metals in Plant.

The *Telfairia occidentalis* samples were washed, oven-dried at 60°C into a 125ml Erlenmeyer flask which has been previously washed with acid and distilled water, Perchloric acid, 25bml concentration of HNO3and 2 ml of concentrated H2SO4 in a fume hood. The content was blended and heated gradually at low to medium on a hot plate under perchloric acid fume hood until thick white vapors arise, crushed to fine powder and ashes in the furnace for the three hours at 600ºC. 1g of the ground plant material was weighed into a 50ml Kjeldahi flask, 25ml of concentrated HNO3 (16N, 70%w/w) was poured down the side of the flask and swirled until the plant material was fully wetted. The sample was filtered using Whatman N0. 42 filter paper into a 100ml volumetric flask and made up to the mark with deionized waster. The amounts of heavy metals in all the samples were measured using the Perkin-Elmer model 403 Atomic absorption Spectrophotometer. The concentrations of Mn, Fe, Zn, V, Cu, and Pb were measured, and the findings were presented as mg/kg of dry matter.

Results

Telfairia occidentalis (Ugu)

The findings of heavy metal content in Telfairia occidentalis is reported in Table 1. On average, the content of manganese was found to be 63.71±2.99 mg/kg at Site 3, with Sites I, 2, and 4 following at 41.06±26.24, 13.73±0.83 and 8.45+1.06 mg/kg, respectively. Sites I, 3, and 4 exhibited mean concentrations of 5.99±1.96mg/kg, 5.19±0.63mg/kg, and 1.91+1.64 mg/kg, respectively, of zinc in Telfairia occidentalis leaves, however there was no significant difference in the Zn content across the sites. Site I had the greatest concentration of lead in the leaf, with an average value of 82.64±118.9 mg/kg. Sites 3, 2, and 4 stood next, with average values of 4.02±0.47 mg/kg, 3.34±1.23 mg/kg, and 2.75+0.21 mg/kg, respectively. Iron content in Telfairia occidentalis leaves was found to be 1929.9±2625.33 mg/kg at Site I, 1735.03±1.23 mg/kg at Site 2, 250.74±62.83 mg/kg at Site 3, and 353.7±3.13 mg/kg at Site 4, respectively. There was no statistically significant difference in the results ($P<0.05$). Site 3, with a level of 13.08±16.06mg/kg, had the highest V levels in the leaf. Sites 2, I, and 4 had mean values of 10.35±11.41mg/kg, 3.73±0.63mg/kg, and 2.97±1.39mg/kg, respectively. Site 3, with an average concentration of 4.55±1.60 mg/kg, had the highest concentration of Cu in the Telfairia occidentalis leaf, while Sites 2, I, and 4 recorded average concentrations of 3.24±0.32 mg/kg, 1.71±1.48 mg/kg, and 31.7+6.66 mg/kg, respectively, which were not statistically significant ($P<0.05$).

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Table 1: Mean Heavy Metals Concentration in *Telfairia occidentalis* (Ugu*)*

	Site	Mn (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Fe (mg/kg)	V (mg/kg)	Cu (mg/kg)
Site 1	Trans Amadi Dumpsite	**41.06±26.24[a]**	5.99±1.96[a]	**82.64±118.9[a]**	**1929.9±2625.33[ab]**	**3.73±0.63[a]**	1.71±1.48[a]
Site 2	East west Dumpsite	13.73±0.83[a]	8.96±6.23[a]	**3.34±1.23[a]**	**1735.03±1.23[ab]**	**10.35±11. 41[a]**	3.24±0.32[a]
Site 3	Eastern By-Pass	**63.71±2.99[a]**	5.19±0.63[a]	**4.07±0.47[a]**	250.74±62.83[ab]	**13.08±16.06[a]**	4.55±1.60[a]
Site 4 (Control)	Rukpokwu	8.45±1.06 [a]	1.91±1.64[b]	**2.75±0.21[b]**	353.7±3.13[ab]	**2.97±1.39 [b]**	31.7±6.66 [a]

Table 2: Permissible Maximum Limit for soil and edible vegetables
Maximum Permissible limit of edible vegetables (mg/kg)

Heavy Metal	Maximum Permissible Level of Vegetables (FAO/WHO 2007)
Mn	30
Zn	50
Pb	0.3
Fe	1000
V	0.03
Cu	40

Table 3: Daily Metal Intake and Hazard Risk Index for *Telfairia occidentalis* (Ugu*)*

Site		Mn (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Fe (mg/kg)	Cu (mg/kg)
Site1 (Trans Amadi Dumpsite)	DIM	0.23	0.03	0.47	11.09	0.01
	HRI	**5.60**	0.2	**5.71**	**1.74**	3.75
Site 2 (East west Dumpsite)	DIM	0.07	0.05	0.01	9.97	0.01
	HRI	**1.70**	0.16	**2.85**	**14.24**	0.02
Site 3 (Eastern By- Pass)	DIM	0.36	0.02	0.02	**1.44**	0.02
	HRI	**8.18**	0.16	**5.71**	**2.05**	0.5
Site 4 (Rukpokwu)	DIM	0.03	0.01	0.13	3.00	0.01
	HRI	1.23	0.1	1.50	1.90	0.1

Health Risk Index (HRI) is higher than 1, the substance may produce an adverse effect (Han et al., 1998)

Discussion

Metal Concentrations in Vegetables

One of the biggest threats to public health is the buildup of metals in vegetables (Cui et al., 2005). The manganese metal concentrations in the vegetables tested here varied from 3.45 to 92.81 mg/kg. This is more than the manganese levels found in the vegetables tested by Harmanescu et al. (2011), which ranged from 1.38 to 10.47 mg/kg. Identical values ranging from 5.23 ±0.06 to 11.75 ± 1.04 mg/kg were recorded in the veggies by Uwah et al. (2011). Zinc concentrations in the vegetables tested ranged from 4.71 mg/kg to 169.20 mg/kg, according to the results. Similarly, Muhammad et al. (2008) found that 0.461 mg/kg of spinach, 0.705 mg/kg of coriander, 0.743 mg/kg of lettuce, 1.893 mg/kg of radish, 0.777 mg/kg of cabbage, and 0.678 mg/kg of cauliflower were found in samples of leafy vegetables. Zinc levels ranging from 1.06 ± 0.02 to 2.82 ± 0.01 mg/kg were observed in another research on Amaranthus hybridus vegetables conducted by Akubugwo et al. (2012).

Zinc inhibits copper absorption by interacting with metallothionein at the brush edge of the intestinal lumen when enough zinc is consumed. Metallothionein is a protein that both copper and zinc seem to attach to. However, copper has a stronger affinity for metallothionein and may therefore displace zinc from the protein. When the mucosal cells are shed, the copper-metallothionein complex remains in the cell and is not easily transported to the plasma. As a result, it is expelled in the feces. According to Gyorffy and Chan (1992) and Barone et al. (1998), copper insufficiency may occur when there is an overabundance of zinc in the diet because less copper is available. According to Table 1, the quantities of lead in Telfairia occidentalis were higher than the safe limit set by the FAO/WHO (2017), except in the control location, where the concentrations were lower. One possible explanation for the high amounts of lead in Telfairia occidentalis is the garbage that ends up in landfills. Because its Health Risk Index is more than one, it has the potential to harm those who eat it. In a 2006 study conducted by Luilo and Othman in Dar es Salaam, couch grass was shown to have elevated amounts of lead. The combustion of fossil fuels releases Pb into the air, which may then be absorbed by land or surface water via precipitation. According to Ellen et al. (2006), lead does not serve any useful biological purpose and is known to accumulate in the body. Because lead is a neurotoxic that irreversibly disrupts normal brain development, it poses a particular threat to the health of pregnant women and young children.

The content of iron metal in the vegetable Ugu ranged from 136.06-4.891.41 mg/kg. The iron concentration in this research was much higher than in the study by Aweng et al. (2011), which found a range of 0.65 to 2.76 mg/kg in the fruits and vegetables. The iron content of the greens has been the subject of further research. In a study conducted by Tsafe et al. (2012), the iron level was found to be 54.05 mg/kg. In contrast, Uwah et al. (2011) found an iron content of 15.96 ± 0.18 mg/kg in vegetables of the Amaranthus caudatus species, and 42.84 ± 0.27 mg/kg in vegetables of the Lactuca sativa species. Factors such as plant age, species, soil pH, soil type, and climate may have influenced the rate of metal absorption by the vegetables, which in turn would have changed the observed amount of heavy metals (Alloway and Ayres, 1997; Uwah, et al., 2009). varying vegetables may have had varying metal concentrations due to variations in element absorption and transfer factors (Cui et al., 2004).

Elevated iron consumption in the diet increases the risk of estrogen-induced kidney tumors in Syrian hamsters and carcinogen-induced mammary cancers in rats. Giving hamsters estrogen causes them to store more iron and makes it easier for cells in culture to absorb iron. Several estrogen-induced malignancies are more likely to occur in persons whose iron reserves are larger (Liehr and Jones, 2001). A wide variety of metabolic processes rely on iron as a catalytic core. Several enzymes in the body need iron to operate properly, including enzymes involved in energy synthesis (cytochromes) and the immune system. Some instances of iron deficiency anemia have been associated with low blood copper levels, which may indicate that iron status influences copper metabolism (Michael et al., 2009).

The V metal content in all of the locations is higher than the 0.03 mg/kg limit that has been set by the FAO and the WHO in 2007. Because of plants' relatively strong accumulation capacity with regard to V, Molatlhegi (2005) found lower V levels in his research. The concentration of copper in this research falls within the FAO/WHO permissible limit, ranging from 0.61 to 41.71 mg/kg (2007). In contrast, Uwah et al. (2011) found copper concentrations of 0.81 mg/kg in spinach and 1.75 mg/kg in lettuce that were cultivated in Nigeria, respectively. The findings obtained in the vegetable studies conducted by Muhammad et al. (2008) are comparable, falling within the ranges of 1.20 to 3.42 mg/kg and 0.25 mg/kg to 0.92 mg/kg, respectively. Anaemia, immunotoxicity, developmental toxicity, liver and kidney damage, and excessive copper exposure are among the many negative health impacts that may occur. These side effects are often seen when macromolecules or membranes are damaged by oxidative stress. Inhibiting the enzymes' ability to defend cells from free radical damage, copper may attach to their sulfhydryl groups. Enzymes like glucose-6phosphatase and glutathione reductase are affected by this. ATSDR (2004a).

Soil organic materials and minerals are known to bind copper strongly. This means it settles on the ground rather than dispersing following discharge (Alloway, 2001). As a vital element, copper (Cu) has several negative health consequences when consumed in small amounts, including as damage to the liver and kidneys, anemia, immunotoxicity, and developmental toxicity (ATSDR, 2004a). The Health Risk Index (HRI) is a crucial metric for determining the amount of metals that people are exposed to via their diet. Telfairia occidentalis may pose a significant health danger to humans since the Health danger Index for manganese, lead, and iron was more than one across all locations. Chemicals with Health Risk Index (HRI) values greater than 1 are more likely to have negative side effects (Han et al, 2008). People need to keep an eye on the amounts of metals they eat since eating too much of them might lead to health problems (Voiculescu et al., 2010). In order to prevent an abnormal accumulation of metals in the human body, it is recommended that residents in polluted regions limit their consumption of contaminated vegetables.

Conclusion

Intake of *Telfairia occidentalis* from the examined dumpsites may constitute a substantial danger to public health, as the health risk index (HRI) of Pb, Mn, and Fe in sites 1, 2, and 3 surpasses 1. Soil testing is an important step before planting crops, and farmers should be encouraged to do it. This will help ensure that their crops thrive in areas without a dumpsite. To stop people in Port Harcourt from eating the tainted crops that grew near the trash, health educators should spread the word about the hazards of eating *Telfairia occidentalis*. The farmers who are now cultivating edible crops in the area should be strongly urged to switch to alternative crops that may both provide income and help restore the soil. Additionally, the dumpsite approach should be used. Additionally, an efficient waste management system and regular dumpsite monitoring are recommended to prevent the possible use of unsanitary Telfairia occidentalis and food items. The production of energy, the application of compost as soil fertilizers, the storage of carbon in landfills, and the avoidance of primary materials through recovery and reuse are all ways in which proper waste management can lessen the amount of metals dumped and save greenhouse gas emissions. Get Well Soon Crushed glass may be used with asphalt to create new pavement. Cullet, made from crushed and color-sorted glasses, is a key element in the glassmaking process. Steel cans are baled and delivered to mills as scrap, while smelters reuse aluminum, which is baled or compacted. Among MSW, aluminum has the greatest recyclability value, making it one among the most valuable materials overall.

To separate the newspapers from any corrugated or mixed materials, the old ones are put on a conveyor belt and handled by hand in the paper stream. After that, they are either loose-loaded or baled before being sent to paper mills to be recycled for use in newspaper production. Tissue mills purchase mixed paper after sorting it from corrugated paper. Revulcanization is a method that can be used to recover rubber from solid waste by shredding, reforming, and remolding it. "Tire playgrounds" are made from recycled tires and used as swing sets and other play equipment for kids. Decomposing garbage releases methane, which may set off explosions and contaminate both surface and underground water sources via leachates. According to Cointreau-Levine (2007) and Oyelola et al. (2009), it detracts from the land's aesthetic value. You may make cooking gas from the methane that garbage produces.

Recommendations

Based on the findings of this work, the following recommendations were made:

1. 1.Research has shown that *Telfairia occidentalis* (ugu leaves) are deficient in Zinc and copper, which are essential elements, and contain high levels of other metals such as manganese, lead, iron, and vanadium, that are toxic to plants. The people should cut less on ugu leaves. Farmers should carry out soil tests before

planting, and avoid dumpsite locations. Farmers should not also plant edible crops in close proximity to dumpsite locations, conduct of Agriculture and Public Health and Sanitation must work together to launch public awareness campaigns

2. To ensure the best possible cultivation of *Telfairia Occidentalis* (ugu), farmers should be educated about the dangers of heavy metals pollution and farming in waste contaminated regions. Nigerian groups concerned with food safety and public health should work to ensure that the public has easy access to restrictions on food contaminants, including both the minimum and maximum permissible levels. We must immediately put an end to the illegal dumpsites and ensure that anyone that refuse to obey the law will face severe punishment.
3. Bioremediation may be achieved in two ways: either by planting phytoremediants in soils that have been exposed to waste, or by cleaning the soil with bacteria that decompose waste products.
4. Given the above, it is essential that regulatory agencies establish postEIA environmental inspection and Accountable environmental authorities should be involved to make sure that the right processes are followed friendly and helps to avoid contamination.

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