Faculty of Natural and Applied Sciences Journal of Scientific Innovations
Print ISSN: 2814-0877 e-ISSN: 2814-0923
www.fnasjournals.com
Volume 6; Issue 3; May 2025; Page No. 96-105.

Heavy Metal Concentrations in Pumpkin Leaf, Water Leaf, and Soil from Selected Dumpsites in Port Harcourt Metropolis, Nigeria

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Abstract
Samples of pumpkin leaf, water leaf as well as soil were collected from six locations around Port Harcourt metropolis, and analyzed for heavy metal concentration. Samples preparation followed standard procedure and analysis carried out using AAS (VGB 210 System) afforded the following detectable values (mg/kg) in soil; Cu (0.531±0.027 - 3.616±0.019) , Mn (2.776±0.020 - 4.819±0.027), V (1.084 ± 0.026 - 0.753±0.026), Cd (0.274±0.013 - 0.070 ± 0.013), Co (0.104±0.126 - 0.253±0.013), in Pumpkin leaf; Cu (18.599±0.007 - 3.432±0.033), Mn (0.152±0.028 - 0.018±0.022), V (3.264±0.011 - 0.417±0.127), Cd (2.630±0.678 - 0.070±0.099), Co (ND - 0.391±0.037) and in water leaf: Cu (11.308±0.034 - 9.479 ± 0.029), Mn (0.004±0.091 - 0.016 ± 0.017), V (1.084 ± 0.026 - 0.753±0.026), Cd (0.274±0.013 - 0.070 ± 0.013), (ND - 0.530± l0.002). The levels in leafs were generally higher than those in the soil. However the trend which was attributable largely to anthropogenic inputs and comparable with similar studies within and outside Nigeria, identified Manganese (Mn) as a major contaminant of the soil. Cu, recorded the highest contaminant on both leaves. The values of the heavy metals obtained at the different dumpsites were lower than their corresponding permissible limit. From each of the observed metals in the edible vegetable (Pumpkin leaf and water leaf), and soil, the highest values were obtained in parts of Port Harcourt where there is serious presence of industrial discharge or activities. The transfer factor (Tf) index revealed that Cu and Cd values from the dumpsites afforded greater than 1 value, indicating a greater concentration level of the metal in the plant than in the soil. While Mn indicated less than 1 value, Co reported values within normal range in plant. It may therefore be plausible to say that solid waste dumpsites in Port Harcourt Metropolis are laden with high concentrations of heavy metals which are later absorbed and assimilated by plants growing within such sites. The study therefore calls for regular monitoring to mitigate the dangers implicit in the continuous consumption of the leaves.

Keywords: Heavy metal; Concentration; Pumpkin Leafs; water leafs; Dumpsites, Contamination, soil

Introduction

Trace metals occur naturally in the environment, but may also be introduced as a result of land use activities such as agriculture, burning of fossil fuel and indiscriminate dumping of waste. Some common trace metals are Copper, Nickel, Chromium, Lead, Cadmium, Mercury, Vanadium, Zinc, Cobalt and Iron, etc. Heavy metals such as iron and nickel are essential to the survival of all forms of life, if they are low in Concentration (Leah et al., 2014). Waterleaf (*Talnium triangulare*) is one of the most common leafy vegetables in Nigeria. Waterleaf is common almost throughout the year, even during the dry seasons, because it has the ability to survive drought. *Talnium triangulare* is known to be a perennial herbaceous plant widely grown and consumed as a vegetable. Studies have shown that waterleaf contains important nutrients and phytochemicals such as flavonoids and polyphenols, crude protein, lipids, essential oils, cardiac glycosides, omega -3-fatty acids, minerals, soluble fiber's and vitamins. The availability and nutritional composition make it one of the most sought vegetables. However, sources of this vegetable, particularly in Port Harcourt, need assessment, considering the current scope of pollution in Nigeria cities (Oluyemi et al., 2008; Oladebeye et al., 2017).

The uptake and distribution of heavy metals such as (Fe, Pb, Zn, and Ni) in pumpkin (*Telfairia occidentalis)* has become imperative since it is the most cultivated and consumed vegetable in Port Harcourt metropolis. The indiscriminate cultivation of pumpkin vegetable in every available space especially within Trans Amadi area, domestic dumpsite, and industrial dumpsites and the common uncontrolled urban dumpsites is of much concern. Demirezen and Ahmet (2006) reported that, the levels of some trace metals such as Cd, Pb, Ni, Cu, etc. in different vegetables from areas that play host to industries were higher than those in non-industrialized areas in parts of Turkey. Consumption of vegetables containing trace metals is therefore one major way in which these elements enter the human body.

Wilson and Pyatt (2007) reported that trace metals accumulation in vegetables could occur by various means but considered soil as the major one. Vegetables take up heavy metals and accumulate them in their edible and non-edible parts at quantities high enough to cause clinical problems to both animals and human beings. Jarup (2003) reported however, that toxic metals are made available to human beings through food systems. Among such food systems, vegetables have been identified to be most potent for doing so due to their aerial burden with respect to environmental pollution. Naturally trace metals occur in the ecosystem with large variations in concentration (Oluyemi, et al., 2008). Some of the terrestrial pollutants of the environment are metals, and this is as a result of human and industrial activities, being non-biodegradable substances. They usually persist for a long time in ecosystem (Leah et al., 2014). The presence of trace metals in the environment is of great ecological significance due to their toxicity at certain concentration, translocation through food chains and non-biodegradability which is responsible for their accumulation in the biosphere (Awololu, 2005).

The use of dumpsites as farm lands is a common practice in urban and sub-urban centers in Nigeria because of the fact that decayed and composited wastes enhance soil fertility (Ogunyemi, et al., 2003). Some of the wastes contained in dumpsites are rusted packing, remnant of food, rusted packing paper, polythene, metal containers, and battery containers (Ademoroti, 1996). They are characterized with irritating offensive odor. Humans are exposed to heavy metals through three basic routes, such as, Inhalation, Ingestion, and Skin absorption, (Ogunyemi, et al., 2003). Some trace metals like As, Cd, Hg and Pb are heavy metals that are particularly hazardous to plant, animals and humans (Alloway & Ayres, 1997). Exposure to these metals may cause some negative effects such as blood, bone disorders, kidney damage, decreased metal capacity and neurological damage (Asuquo et al., 2004). It is unfortunate however that, trace metals are not subject to chemical degradation. A trace metal is normally chronic when it is exposed. (Exposure over a long period of time) due to food chain transfer (Zulikes, 1994). Trace metal pollution has the tendency to constitute serious environment and health hazards, in communities within our country and localities (Keller et al., 2005). Heavy metals are hazardous because they tend to bio-accumulate, which means, an increase in the concentration of chemical in a biological organism's overtime, compared to the chemical concentration in the environment (Helmenstine, 2014). The present study therefore, is to ascertain the heavy metal levels of *Telfeiria occidentalis* (Pumpkin leaves), *Talnium triangulare* (water leaves) and soil from selected dumpsites in Port Harcourt metropolis.

Materials and Methods

Study Area

Port Harcourt, the capital of Rivers State in southern Nigeria, is a major economic and industrial hub, particularly in the oil and gas sector. Established in 1912 by the British colonial administration. The city has grown significantly due to its strategic location along the Bonny River, which facilitates maritime trade and petroleum exportation. Port Harcourt is characterized by a tropical monsoon climate, experiencing heavy rainfall and high humidity, particularly between April and October. Its environment includes mangrove swamps, rainforests, and numerous creeks, making it a region of rich biodiversity but also one prone to environmental challenge such as flooding coastal erosion, and pollution. Economically, Port Harcourt is known as the "Oil Capital of Nigeria" due to its role in the countries petroleum industry. Major multinational corporations, including shell, ExxonMobil, and Total Energies, have operational bases in the city. The presence of oil refineries, petrochemical plants, and related industries has fueled rapid economic growth and urbanization. Beyond oil, the city also has a strong commercial sector, a busy seaport, and a thriving informal economy. Rapid urbanization has led to significant infrastructural development, including road networks, bridges, and residential estates (Wokekoro & Owei, 2006). However, the city also faces numerous challenges, such as traffic congestion, inadequate housing, poor waste management, and slum development. The Port Harcourt International Airport, a railway system, and highways connect the city to other parts of Nigeria, but inefficient urban planning continues to hinder sustainable growth. Port Harcourt is plagued by several environmental and social issues, primarily due to oil exploration and industrial activities. Oil spills, gas flaring, and air pollution –

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particularly the black soot crisis – have negatively impacted human health and environment. The city's growing pollution has also contributed to unemployment, crime, and an increase in informal settlements, many of which lack essential services. Despite these challenges, Port Harcourt remains one of Nigeria's most vital cities, contributing significantly to the nation's economy Ukoje et al., (2021).

Sample Collection

This study was conducted at six different locations, within Port Harcourt and Obio-Akpor local Government areas which incudes, Choba, Diobu, Rumuolumeni, Trans Amadi, Eleme Junction and Port Harcourt- Town Rivers state, Nigeria.

Telfairia occidentalis, (pumpkin leaf) and *Talnium triangulare* (waterleaf) were found growing on farm lands close to refuse dumps and were randomly collected by cutting at a height of 5 cm above the soil surface using a knife, the samples was then packed into plastic bags. Soil samples were collected at four (4) points (about 20 *m* apart and depending on the availability of the plant) by means of a stainless steel hand auger, within the areas Plants samples were also taken in order to achieve representative soil samples. All samples were placed in polythene bags for onward transportation to the laboratory for storage.

Sample Preparation

The vegetables were thoroughly washed with tap water, rinsed with distilled water in order to remove debris and insects, and were then partitioned into parts (leaves, stems) and the leaves were oven-dried at 70 ^{0}C. The dried sample were pulverized into fine powder using an agate pestle mortar and preserved in a desiccator. Soil samples were oven-dried at 60 ^{0}C for 3 days, pulverized and sieved through 1 *mm* mesh screen to remove coarse materials.

Sample Digestion

5 g of the dried sample of vegetables and soil were treated with 1:3:1 mixture of $HClO_4$, HNO_3, and H_2SO_4 and were digested on a hot plate until volume reduced to near dryness. The solutions were filtered using Whatmann No.1 filter paper and the filtrates were made up to mark with distilled water in a 50 ml volumetric and kept for analysis.

Sample Analysis

The digested samples of the vegetables and soil were analyzed to determine the concentrations of Cu, Mn, Cd and Co. The determination of the heavy metals contents of the sample solutions was carried out following the procedure of Allen et al. (1974), using Atomic Absorption

Spectrophotometer (AAS VGB 210). In order to test the integrity of the results, reagent blanks, replicates, and standard reference materials (*SRM* 1515 for plants and *SRM* 2709 for soil) representing about 10 % of each of the total sample population were incorporated in the analysis to detect not only possible contamination, but also assess precision and bias of the procedure and the recovery rates for the metals in the standard reference materials were between 89 - 97%.

Results and Discussion

The levels of heavy metals in *Telfeiria occidentalis* (Pumpkin leaf), *Talinum triangulare* (Water leaf) and soil are listed in Tables 4.1 – 4.3. Transfer factor of *Telfeiria occidentalis* and *Talinum triangulare* are presented in Tables 4.4 – 4.5

Table 4.1: Mean levels (*mgkg^{-1}*, *dry weight*) of heavy Metals in *Telfairia occidentalis* (Pumpkin leafs) Samples Collected from Six locations in Port Harcourt metropolis

		Sample Locations				
HM	Choba	Diobu	Rumuolumeni	Eleme Junct.	T-Amadi	PH – Town
Cu	3.616±0.019	2.965±0.126	0.613±0.184	3.178±0.027	3.265±0.043	0.531±0.027
Mn	4.819±0.027	4.594±0.215	4.193±0.167	2.776±0.020	3.979±0.026	4.679±0.085
V	0.061±0.066	0.061±0.088	0.065±0.317	0.1036±0.015	0.122±0.056	0.124±0.017
Cd	0.038±0.014	0.054±0.013	0.113±0.162	0.038±0.027	0.012±0.055	0.020±0.095
Co	0.253±0.013	0.195±0.042	0.104±0.126	0.253±0.017	0.190±0.014	0.245±0.017

Eleme – Junct. = Eleme Junction, T- Amadi = Trans Amadi, PH -Town = Port Harcourt - Town

Table 4.2: Mean Levels (*mgkg^{-1}, dry weight*) of heavy metals in in (waterleaf) *Talinum triangulare* (mg/kg) samples collected from six locations in Port Harcourt metropolis.

		Sample Locations				
HM	Choba	Diobu	Rumuolumeni	Eleme Junct.	T-Amadi	PH – Town
Cu	1.838±0.038	2.965±0.126	0.613±0.184	3.178±0.027	3.265±0.043	0.531±0.027
Mn	3.299±0.049	4.594±0.215	4.193±0.167	2.776±0.020	3.979±0.026	4.679±0.085
V	0.059±0.073	0.061±0.088	0.065±0.317	0.1036±0.015	0.122±0.056	0.124±0.017
Cd	0.019±0.046	0.054±0.013	0.113±0.162	0.038±0.027	0.012±0.055	0.020±0.095
Co	0.208±0.036	0.195±0.042	0.104±0.126	0.253±0.017	0.190±0.014	0.245±0.017

Table 4.3: Mean Levels (*mgkg^{-1}, dry weight*) of heavy metals in soil (mg/kg) samples collected from six locations in Port Harcourt metropolis.

		Sample Locations				
HM	Choba	Diobu	Rumuolumeni	Eleme Junct.	T-Amadi	PH – Town
Cu	3.616±0.019	2.965±0.126	0.613±0.184	3.178±0.027	3.265±0.043	0.531±0.027
Mn	4.819±0.027	4.594±0.215	4.193±0.167	2.776±0.020	3.979±0.026	4.679±0.085
V	0.061±0.066	0.061±0.088	0.065±0.317	0.1036±0.015	0.122±0.056	0.124±0.017
Cd	0.038±0.014	0.054±0.013	0.113±0.162	0.038±0.027	0.012±0.055	0.020±0.095
Co	0.253±0.013	0.195±0.042	0.104±0.126	0.253±0.017	0.190±0.014	0.245±0.017

Table 4.4: Transfer factor (TF) of heavy metals of some selected dumpsite pumpkin (*Telfairia occidentalis*) in Port-Harcourt metropolis.

Samples Location	**Cu**	**Mn**	**V**	**Co**	**Cd**
Choba	0.51	0.61	0.97	1	0.79
Diobu	0.19	0.91	0.53	0.44	1.06
Rumu	4.12	0.31	0.58	0.15	0.59
Eleme Junct.	1.03	1.51	1.11	0.55	1.55
Trans Amadi	1.13	1.04	1.01	2.58	ND
PH- Town	2.93	0.83	1.48	0.9	0.52

E.J. = Eleme Junction, T.A. = Trans Amadi, PH-T = Port Harcourt-Town, Rumu =Rumuolumeni

Table 4.5: Transfer factor (TF) of heavy metals of some selected dumpsite (waterleaf) *Talinum triangulare* (mg/kg) in Port-Harcourt metropolis.

Samples Location	**Cu**	**Mn**	**V**	**Co**	**Cd**
Choba	0.15	0.83	0.97	0.15	0.13
Diobu	0.66	1.04	0.53	0.39	ND
Rumu	2.33	0.84	0.58	0.21	5.09
Eleme Junct.	0.57	1.48	1.11	0.03	0.65
Trans Amadi	0.62	78.8	1.01	6.25	1
P- Town	6.76	0.94	1.48	2.1	1.64

Discussion

Heavy metals in *Telfairia occidentalis* (Pumpkin leafs)

Table 4:1 showed the mean concentration of Copper (Cu) in *Telfairia occidentalis* occurred between (l3.259±0.060 - 3.682±0.040) mg/kg. Eleme Junction indicated higher values of l3.259±0.060 Mg/kg, followed by 3.682±0.040 mg/kg while Diobu recorded the lower value 0.553 ±0.028 mg/kg.). The concentration of Copper (Cu) in this study recorded

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a higher value (0.77 mg/Kg) reported by Ikhajlagbe et al. (2016) at Benin. Diobu reported values of (0.553± 0.028) within the concentration of (0.77) mg/Kg according to the report of Ikhajiagbe et al. (2016). Copper (Cu) is known to be an important nutrient for Humans, high toxicity of Cupper (Cu) can cause adverse health effects such as acute stomach and intestine aches, and Liver damage (Oladebeye, 2017)

The concentration of Manganese (Mn) in *Telfairia occidentalis* (Pumpkin leaf) of the study ranged from 4.418±0.034 to 1.578±0.033 mg/kg. Report shows that Trans Amadi recorded the highest value (4.418 ± 0.034) mg/kg, followed by Eleme Junction and Diobu, while Rumuolumeni recorded the lowest value (1.578 ± 0.033) mg/kg. However, Uwah et al. (2011), reported higher range (5.23 ± 0.06 to 11.75 ± 1.04) mg/kg in vegetable. Manganese (Mn) is required as a catalytic cofactor for mitochondrial superoxide dismutase, and pyruvate carboxylase and it is also an activator of several other enzymes. Extremely high levels of Manganese exposure have been shown to affect brain development and cause severe symptoms of Manganese disease Micheal et al. (2009) and ATSDR (2012).

The concentration of Vanadium (V) in *Telfairia occidentalis* (Pumpkin leaf) in the six dumpsites varied from (0.184±0.017 to 0.059±0.073) mg/kg. Port – Harcourt Town recorded the highest value (0.184 ± 0.017) mg/kg, while Choba recorded the lowest value (0.059 ± 0.0073) mg/kg. The sample locations of Vanadium (V) were all dictated for the six various locations in Port Harcourt Metropolis. At very low concentrations, vanadium can enhance plant growth, nitrogen fixation, and enzymes activity in some species. Bioaccumulation in plants and animals can pose risk to human health through food consumption.

The mean metal concentration of Cadmium (Cd) in *Telfairia occidentalis* (Pumpkin leaf) ranged between (0.031±0.032 to 0.017±0.033) mg/kg; Trans Amadi recorded the highest value (0.031±0.032) followed by Diobu (0.024±0.017) mg/kg while Rumuolumeni recorded the lowest value (0.017±0.033) mg/kg. The values recorded in the study were within the values (0.0043) mg/kg at Makurdi reported by (Adams et al., 2011). Uptake and other, essential elements by plants may also be hindered by exposure to Cadmium (Echem, 2014). For example, Cadmium (Cd) can substitute for Zn an essential trace element, causing the malfunctioning of metabolic process (Kalagbor et al., 2015; Oladebeye 2017). Cadmium (Cd) exposure can be toxic to the liver and lungs, inducing nephrotoxicity and ototoxicity, and impairing function of the immune system. Cadmium (Cd) is known to affect several enzymes in the body responsible for reabsorption of proteins in kidney tubules causing renal damage (Kalagbor et al., 2015; Oladebeye, 2017). The presence of Cadmium (Cd) can also cause toxic effects such as abnormal and inhibition of growth by inducing choruses, necrotic lesions, wilting and disturbances in mineral nutrition and carbohydrate metabolism. Cadmium (Cd) is reported to be present as impurity in products such as phosphate fertilizers, detergents and refined petroleum products.

The mean concentration of Cobalt (Co) in the vegetable (*Telfairia occidentalis*) studied ranged from (0.430±0.025 to 0.061±0.039) mg/kg for the six dumpsites. Diobu dumpsite recorded the highest value to be 0.430 ± 0.025 mg/kg, while Rumuolumeni dumpsite recorded the lowest value to be 0.061 ± 0.039 mg/kg, and Trans Amadi was not detectable (ND). The daily recommended range of Cobalt (Co) in human diet is 0.005 mg/day (ATSDR 2004). The analyzed values were above the recommended range and above 30 Mg/day which have been shown to cause digestive and skin disorders in human (ATSDR 2004). Cobalt (Co) has been confirmed to be a carcinogen in animal studies and is considered a possible carcinogen in humans.

Heavy metals in water leaf (*Talinum triangulare*)

The concentration of Copper (Cu) in *Talinum triangulare* ranged between (3.587±0.002 to 0.543±0.017) mg/kg. Port-Harcourt -Town recorded the highest value, followed by Trans Amadi (2.039±0.047) while Choba occurred with a lower value of (0.53± 0.017). The permissible limit according to WHO standard (2011) is 10 mg/kg. The plant (*Talinum triangulare*) samples at the six locations fall below WHO standard (2011). Onder et al. (2007), reported higher values of Copper (Cu) concentration in plants which ranged between 28.55 to 115.2 mg/kg, this shows to have exceeded the permissible limit of Copper (Cu) according to WHO standard (10 mg/kg). Copper (Cu) is known to be a micro element which is essential in plant growth and occurs generally in soil, sediments and air. Copper (Cu) content has been reported to differ according to the soil type and pollution source (Onder et al., 2007).

The mean metal concentration of Manganese (Mn) in *Talinum triangulare* ranged from (4.755± 0.036 to 3.134±0.018) mg/kg. The highest value recorded was Diobu (4.755 ± 0.036) mg/kg, followed by Port –Harcourt Town

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(4.352±0.011) mg/kg, while Trans Amadi recorded the lowest value of Manganese (Mn) in *Talinum triangulare* with the value of (313.452 ± 0.026) mg/kg respectively. In the study it is reported that Manganese (Mn) is among the other metals to record higher values in *Talinum triangulare*. Umah et al. (2011) reported higher values of Manganese (Mn) in *Talinum triangulare* to be (5.23 ± 0.06 to 11.75 ± 1.04) mg/kg. Extremely high levels of Manganese (Mn) exposure have been shown to affect brain development and cause server symptoms of Manganese disease Michael et al. (2009) and ATSDR, (2012).

The mean metal concentration of Vanadium (V) in *Talinum triangulare* following the six dumpsites varied from (2.115 ± 0.031 to 0.057 ± 0.021) mg/kg. The highest value of dumpsite recorded is Trans Amadi (2.115 ± 0.031) mg/kg and the lowest dumpsite value recorded is Choba (0.057 ± 0.021) mg/kg. The sample locations of Vanadium (V) were all dictated for the various locations. Molaltheji, (2005) reported higher levels of Vanadium (V) value than those of the study which is between 31 to 35 mg/kg in plants. Vanadium is believed to play a role in enzyme function and metabolism, though its necessity in human nutrition is still debated. Some studies suggest it may help regulate blood sugar levels and mimic insulin activity. Inhalation of vanadium dust or fumes (e.g., from industrial processes) can cause respiratory issues such as coughing, bronchitis, and lung irritation. Cadmium levels recorded in *Talinum triangulare* ranged between (0.075 ± 0.011 to 0.001±0.019) mg/Kg. The highest dumpsite recorded was Trans Amadi (0.075 ± 0.011) mg/kg, while the lowest dumpsite recorded was Eleme Junction (0.001 ± 0.019) Mg/kg. Comparing the work of Shauibu and Ayodele (2002), Cadmium levels recorded in *Talinum triangulare* ranged between 0.10 and 0.30 mg/kg-1, the low concentration in plant may be attributed to the metal

being non-essential for growth and metabolism (Shauibu & Ayodele, 2002). The values Cadmium (Cd) reported in *Talinum traiangulare* is however not high enough to cause photon –toxicity. According to Vecera (1999), Photon toxicity can occur above the range of 0.10 - 1.20 mg/kg-1. However, the range of Cadmium (Cd) in Plant recorded in this study is higher than 0.03 - 0.05 µg/g-1 but lower than 113 - 1.67 mg/Kg reported by Udosen et al. (2006) respectively. The mean metal concentration of Cobalt (Co) in *Talinum triangular* ranged from (0.530 ± l0.002 to 0.035±0.0l27) mg/kg. Rumuolumeni recorded the highest value (0.530±l0.002) while the lowest value recorded was at Choba (0.035 ± 0.027) mg/kg, respectively. The dumpsite at Diobu was not dictated (ND), (The daily recommended range of Cobalt (Co) in human diet is 0.005 Mg/day (ASTDR, 2004). The analyzed values recorded were above the daily recommended range. Cobalt (Co) has been confirmed to be a carcinogen in animal studies and is also considered a possible carcinogen in humans (Admas et al., 2011).

Trace metals in the soil

The natural range of concentration of Copper (Cu) in soils is (2-100) mg/kg (Ebong et al., 2008). The concentrations as found in the study are as follows: Choba (3.616 ± 0.019) mg/kg, Diobu (2.965 ± 0.126) mg/kg, Rumuolumeni (0.631 ± 0.184) Mg/kg, Eleme junction (3.178 ± 0.027) mg/kg, Trans Amadi (3.265 ± 0.043) Mg/kg, Port Harcourt-Town (0.531 ± 0.027) mg/kg, Choba, Eleme Junction and Trans Amadi has the highest levels of Copper (Cu) in the soil. According to Dara (1993), the high concentration of Copper (Cu) at the dumpsites might be attributed to biodegradable waste introducing metallic Copper (Cu) into the soil. World Health Organization (1984) stated that, the injection of Copper (Cu) can lead to severe muscular irritation, nausea, vomiting, and diarrhea, intestinal cramps, severe gastrointestinal irritation and other dangerous health defects. The control site recorded high level of concentration of Copper (Cu) in the soil, these could be as a result of other external factors from the environment that may have affected the soil, signifying that the entire studied area may have been contaminated.The soil analyzed for Manganese (Mn) in this study had a mean metal concentration which ranged from Choba (4.819 ± 0.021) mg/kg, Diobu (4.594 ± 0.215) mg/Kg, Rumuolumeni

(4.193±0.167) mg/kg, Eleme Junction (2.776 ± 0.020) mg/kg, Trans Amadi (3.979 ± 0.026) mg/Kg, and PH- Town (4.679 ± 0.085) mg/kg. Choba recorded a higher value compared to the six other locations. Studies carried out by Kabata (1992), and Haluschak (1998) reported manganese values (4.819 ± 0.110) mg/Kg to occur within the ranges similar to those of this study. However, other works have recorded lower levels than those of this study. Awokunmi (2010), McGrath et al. (2001) and Kimani (2007). Higher levels of exposure to Manganese in drinking water are associated with increased intellectual impairment and reduced intelligence quotient in school age children (Elsner et al., 2005). The permissible range for the concentration of Manganese (Mn) in soil is 200- 9000 mg/kg (Eddy et al., 2006).

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The mean soil concentration of Vanadium (V) found in the soil ranged from Choba (0.061 ± 0.066) Mg/kg, Diobu (0.061 ± 0.088) mg/kg, Rumuolumeni (0.061 ± 0.317) mg/kg, Trans Amadi (0.122 ± 0.056) mg/kg, Port Harcourt-Town (0.124 ± 0.107) mg/kg. Port Harcourt – Town recorded the highest value, followed by Trans Amadi. (Krishma et al., 2007), reported Vanadium (V) concentrations similar to those of this study in India while on the other hand, Molatlhegl et al. (2005) reported values as high as 5340 mg/kg in South Africa. Excess Vanadium in soil can inhibit seed germination, root elongation, and overall plant growth. It interferes with photosynthesis and disrupts nutrient uptake, leading to leaf and necrosis. Long term exposure to high levels can lead to neurotoxicity, kidney damage, and gastrointestinal issues. Some studies suggest Vanadium compounds may have carcinogenic potential, though conclusive evidence is lacking.

The mean metal concentration of Cadmium (Cd) in the soil ranged from Choba (0.038 ± 0.014) mg/Kg, Diobu (0.054 ± 0.013) mg/kg, Rumuolumeni (0.113 ±0.162) mg/kg, Trans Amadi (0.012 ± 0.055) mg/kg, Port Harcourt-Town (0.020 ± 0.095) mg/kg. Trans Amadi, Port-Harcourt Town and Eleme Junction recorded values above the WHO/FAO (2001) permissible limit of 3.0 mg/Kg for soil. Cadmium (Cd) is very much connected with non-residual fractions of heavy metals and thus makes them mobile for uptake by plants. The accepted range of Cadmium (Cd) in the soil as stated by Ebong et al. (2008) is (0.01-300) mg/kg

The concentration level of Cobalt (Co) in the soil sample varied from Choba (0.253 ± 0.013) mg/kg, Diobu (0.195 ± 0.042) mg/kg, Rumuolumeni (0.104 ± 0.126) mg/kg, Eleme Junction (0.253 ± 0.017) mg/kg, Trans Amadi (0.190 ± 0.014) mg/kg, and Port Harcourt-Town (0.245 ± 0.017) mg/kg. The result indicated that Diobu recorded the highest concentration of Cobalt (Co) followed by Rumuolumeni, and Eleme Junction. The concentration of Cobalt (Co) is below the WHO/FAO permissible limit of 2-110 mg/kg. The low concentration of Cobalt in the studied area could be as a result of dumping of less Cobalt (Co) content waste. Though Ebong et al. (2008) opines that Cobalt (Co) enters the air through burning of oil and Cobalt (Co) containing compounds used in industries, trace metals additives in agriculture and medicine. Cobalt (Co) after it enters the air is then associated with particles which will eventually settle to the ground within few days (Ebong et al., 2008).

Transfer factor (Tf) of (*Telfairia occidentalis*) pumpkin

The transfer factor (tf) of Copper (Cu) ranged from 0.51 to 4.12. Location 1 and 2, which includes Choba and Diobu were within the normal range in plant. The lowest transfer factor (tf) was indicated at location 1 (Choba). The highest transfer factor (tf) was indicated at location (3), (Rumuolumeni). Locations (4 and 5) were Eleme Junction and Trans Amadi they indicated values greater than unity (<1). The normal (tf) of all the elements are within normal range in plant expect for location (3) which exceeded the range and may lead to plant shutdown or reduced capacity. The transfer factor (tf) of Mn occurred in the range (0.61 to 1.51). Location 1, 2 and 3 namely; Choba, Diobu and Rumuolumeni, recorded values less than 1, which indicated that plants grown at such locations are not good bio accumulators of Manganese (Mn). Location 3 and 5 reported were Rumuolumeni and Trans Amadi obtained values greater than 1, which indicated that location 3 and 5 can function as hyper accumulators of Manganese (Mn). The higher transfer factor of the metal occurred at Eleme Junction (location 4), which indicated a greater concentration level of the plant in the soil, and this could lead to threat in health of the consumers/ general public. The transfer factor (tf) for Vanadium (V) recorded values from (0.53 – 1.48). Location 1, 2 and 3 indicated (tf) less than 1. Location 4 and 5, indicated (tf) greater than 1. The highest transfer factor (tf) of Vanadium (V) occurred at Port Harcourt – Town (location 6). The report showed that all the locations were within the normal range in plant. The transfer factor of Cadmium (Cd) varied from (1 - 2.53). In location 1 (Choba) the transfer factor (tf) was in unity (<1) which indicated that the concentration of the metals in the plant was equal to that of the soil. Diobu, Rumuolumeni and Eleme Junction (location 2, 3 and 4) obtained values less than unity. The highest transfer factor (tf) occurred at Trans Amadi (location 5), which is greater than unity (<1) indicating that metal uptake was controlled by variable such as soil type. The transfer factor (tf) for Cobalt (Co) obtained different values at the dumpsites. The transfer factor of Cobalt (Co) ranged from (0.52 to 1.55). (Location 1, 3 and 6) ; Choba, Rumuolumeni, and Port Harcourt-Town, obtained indices of the metal (Co) to be less than 1. Diobu and Eleme Junction (location 2 and 4) revealed the (tf) of the metal (Co) to be greater than unity (<1). The transfer factor (tf) for location 5 (Trans Amadi) was not detected (ND). The highest occurred transfer factor was in Eleme junction (location 4) indicating a higher concentration of transfer factor (tf) in the metal than in the soil.

Cite this article as:
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Transfer factor (TF) of (*Talinum triangulare*) waterleaf

The transfer factor (tf) mean of Copper (Cu) range 0.15 – 2.33. Location 1, 2, 4 and 5 fall within the normal range of plant, and they recorded values less than unity. The lowest transfer factor (tf) was obtained at location 1 (Choba). Rumuolumeni (location 3) recorded a high transfer factor (tf) higher than unity, followed by (location 6, PH- Town) which revealed the highest transfer (tf) greater than unity, indicating a higher concentration of the metal in the plants than in the soil?

The transfer factor (tf) of Mn occurred in the range (0.83 – 78.8) respectively. From the result of study, location 1, 3 and 6 which includes; Choba, Rumuolumeni and Port Harcourt-Town, recorded values less than 1, which indicated that plants grown at such locations are not good bio accumulators of Manganese (Mn), while, location 2 and 4 namely; Diobu and Eleme Junction obtained transfer factor (tf) values greater than 1. This indicates that plants grown at location 2 and 4 can function as hyper accumulators of Manganese (Mn). The highest transfer factor of the metal occurred at Trans Amadi (location 5), which indicated a greater concentration level of the plant in the soil, and this could lead to threat in the health of the consumers/ general public.

The transfer factor (tf) of Vanadium (V) revealed the range from (0.39 – 17.3). From report location 2, 3 and 4, which are; Diobu, Rumuolumeni and Eleme Junction indicated transfer factor (tf) less than 1, which turns out that plants grown at such locations are not good bio accumulators of Vanadium (V). Location 1 (Choba), indicated transfer factor (tf) greater than 1. These therefore, implied that plants that are cultivated on such location can function as hyper accumulators of Vanadium (V). The highest transfer factor (tf) occurred at Trans Amadi (location 5). All the locations obtained for transfer factor of the metal (V) were within the normal range in plant.

The transfer factor indices obtained for Cadmium (Cd) range between (0.15 - 6.25). Judging from the report, location 1, 2, 3 and 4, namely (Choba, Diobu, Rumuolumeni and Eleme Junction), the transfer factor (tf) was less than unity (<1). A high transfer factor (tf) occurred at Port Harcourt-Town (location 6), which is greater than unity (<1), these revealed that plants cultivated on such area can function as bio accumulators of Cadmium (Cd). The highest transfer factor occurred at Trans Amadi (location 5), which is greater than 1. This indicates that metal uptake was controlled by variable such as soil type organic matter content etc. According to Fleming and Parle (1977), the uptake of trace metals varies widely depending on the plant species being studied.

The transfer factor of Cobalt (Co) occurred in the range of (1 to 5.09). Location 5 (Trans Amadi) was in unity (<1) which indicated that the concentration of the metal (Co) in the plant was equal to that of the soil. Locations 1 and 4 were Choba, and Eleme Junction, revealed the indices of the metal Cobalt (Co) to be less than unity. Port Harcourt -Town (location 6) revealed that the transfer factor (tf) of the metal Cobalt (Co) to be greater than 1. The transfer factor (tf) for location 2 (Diobu) was not detectable (ND). The highest occurred transfer factor (tf) was Rumuolumeni (location 3), indicating a higher concentration of transfer factor (tf) in the metal than in the soil.

Conclusion

This study investigated the levels of heavy metals in pumpkin leaf (*Telfairia occidentalis*), water leaf (*Talinum triangulare*), and soil samples from selected dumpsites in Port Harcourt Metropolis, Rivers State, Nigeria. The findings indicated that the concentrations of heavy metals such copper (Cu), Manganese (Mn), vanadium (V), cadmium (Cd) and cobalt (Co) varied across the sampled locations. Some of these metals exceeded the permissible limits set by international regulatory bodies such as the (WHO) and the Food and Agriculture Organization (FAO), suggesting potential environmental and health risk. The accumulation of heavy metals in the edible vegetables poses a significant concern, as these plants are widely consumed by the local population. The uptake of toxic metals by plants grown near dumpsites highlighted the risk of bioaccumulation and subsequent entry into the food chain, soil contamination from waste disposal activities is a major contributor to heavy metal pollution, which can persist for long periods and adversely affect soil fertility and crop productivity. Overall, the results of this study underscore the urgent need for proper waste management and environmental monitoring in Port Harcourt to mitigate the adverse effects of heavy metal contamination on public health and agricultural sustainability.

Recommendations

Based on the study, the following recommendations were adopted;

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1. The government and environmental agencies should enforce stricter regulations on waste disposal and promote sustainable waste management practices to reduce soil contamination.
2. Periodic assessment of soil and plant contamination levels should be conducted to track heavy metal accumulation and prevent long term environmental damage.
3. Farmers should be advised to cultivate vegetables away from dumpsites and industrial zones to minimize exposure to heavy metals.
4. Phytoremediation (using plants to absorb heavy metals), soil amendment with organic matter, and controlled landfill practices should be adopted to reduce heavy metal concentrations in affected areas.
5. Communities should be educated on the dangers of consuming vegetables grown in contaminated areas and encouraged to cultivate crops in safer environments. Also, industries should be mandated to treat and properly dispose of their waste to prevent environmental contamination.

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