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COMPARATIVE ANALYSIS OF HEAVY METALS IN *TALINUM TRIANGULARE* (WATER LEAF) GROWN IN INDUSTRIAL, RESIDENTIAL AND COMMERCIAL AREA OF LAGOS STATE, NIGERIA

Adu A.A.[1], Aderinola O.J.[2] and Mekuleyi G.O.[3*]

[1]Department of Botany, Faculty of Science, Lagos State University, Nigeria
[2]Department of Zoology, Faculty of Science, Lagos State University, Nigeria
[3]Department of Fisheries, Faculty of Science, Lagos State University, Nigeria
[*]Corresponding author: tosingabriel76@yahoo.com

ABSTRACT: *This study was conducted to determine the concentration of heavy metals (copper (Cu), zinc (Zn), magnesium (Mg), calcium (Ca), lead (Pb), cadmium (Cd), chromium (Cu) and iron (Fe)) in Talinum triangulare (water leaf plant) and soil collected from commercial, residential, and industrial sites of Lagos State. The heavy metals present in water leaf and soil were analyzed using Inductively Coupled Plasma–Optical Emission Spectrometer (Agillent 710 Axial). The results showed that Zn, Mg, Pb, Fe, Cr, Cu from all sites were within the safe limit. However, calcium in Talinum triangulare was detected highest in commercial site (2971.850±116.319 mg/kg) and least in residential site (1416.05±40.659 mg/kg). Cadmium concentration was highest in industrial site (0.58±0.33 mg/kg) and least in residential and commercial (0.50±0.00 mg/kg). Calcium in all the sites was beyond the WHO/FAO, and Food and Nutrition recommended dietary intake of 1000 mg/kg. Enrichment factor (EF) showed moderate enrichments of all metals (except Cr and Cu) in the soil across the sites. EF of Cr and Cu respectively at industrial site were significant and extremely high. The I_{geo} value of Ca (2.52) at Commercial site indicated moderate contamination, Igeo values of Mg (3.82,3.61) at Industrial and residential sites implied heavily contaminated while the Igeo values of Ca (4.58, 5.01) from industrial and residential sites indicated extremely contaminated. The Water leaf plants from all the sites are still safe for consumption but high calcium contamination in the vegetable could cause health problem. However, water leaf plants from these sites can be suggested in conditions of calcium deficiencies.*

KEYWORDS: Safety, Consumption, *Talinum triangulare*, Metals, Water Leaf, Lagos

INTRODUCTION

Vegetables are part of daily diets in many households forming an important source of vitamins, fibres and minerals for human health. They are made up of chiefly cellulose, hemi-cellulose and pectin substances that give them their texture and firmness (Sobukola and Dairo, 2007). These substances help to build bone, teeth and protect the body from diseases. Leafy vegetables are used to increase the quality of soup and for dietary purposes (Sobukola et *al.*, 2007). Vegetable also contain 70-75% water which is essential to the body system and have antioxidative effects (Jena *et al.*, 2012). They are very important protective foods, useful for the maintenance of health, prevention and treatment of various diseases (D'Mello, 2003). Studies have shown that soil-to-plant transfer of heavy metals is the major pathway of human exposure to soil contamination (Cui *et al*., 2004). Thus, heavy metal contamination of vegetables cannot be underestimated as these foodstuffs are important components of the human diet. Heavy metal concentrations in edible parts of plants is directly associated with their concentrations in soils, but their levels differ significantly with plant species, and sometimes with the genotypes within the same plant species (Kabata- Pendias and Pendias, 1984). The importance of vegetables health-wise has led to an increasing demand for vegetables. As such, many people in semi-urban areas of Lagos including the study sites are involved in urban agriculture.

Although some consumers consider undamaged, dark green and big leaves as characteristics of good quality leafy vegetables, however, the external morphology of vegetables cannot guarantee safety from contamination. Mapanda *et al.* (2005) reported that heavy metals rank high amongst the chief contaminants of leafy vegetables. Based on persistent and cumulative nature, as well as the probability of potential toxicity effects of heavy metals as a result of consumption of leafy vegetables and fruits, there is a necessity to test and analyze this food items from time to time to ensure that the levels of these trace elements meet the agreed international requirements. Therefore, the present study aimed to compare levels of heavy metals in commonly consumed vegetable (*Talinum triangulare)* collected from industrial, residential and commercial areas of Lagos State, Nigeria.

MATERIAL AND METHODS

Collection of Vegetable and Soil Samples

Sample of *Talinum triangulare* were collected from three different locations: Residential site (LASU, Ojo Campus), commercial site (Iyana-Iba Market) and Industrial site (Agbara Estate) and prepared in two replicates for metal analysis using standard methods. *Talinum triangulare* and soil samples that were randomly collected from these locations were tested to see which plant grown on these sites is better for edibility and which is toxic.

Digestion of Plants for Metal Determination

A 20g of the *Talinum triangulare* from each sampling site was washed gently with deionized water, and then air dried. A 10g representative of the plant was placed in a porcelain crucible and ignited in a furnace at 550°C for 2 hours until ashed. The ash was dissolved in dilute acid and then made up to a volume of 100ml, with deionized water. The filtrate was saved for the determination of the metals (copper, zinc, magnesium, calcium, lead, cadmium, chromium and iron) in *Talinum triangulare* (water leaf plant). The metals were determined on the filtrate of sole digestate by optical emission spectroscopy, using inductively coupled plasma, optical emission spectrometer (Agilent ICP-OES 710 Axial). Test results were validated with calibration curves obtained with certified metal standards (AccuStandard, Inc, USA) while quantitation was obtained with Agilent Expert ll software.

Digestion of Soil for Metal Determination

20ml of acid extracting solution was added to 10g of soil sample in a beaker. The mixture was heated on hotplate at 100°C for 30 minutes. The mixture was allowed to cool to 25°C. Thereafter, 2ml of charcoal suspension was added to the mixture and shaken for 5 minutes.

The mixture was then filtered. The heavy metals in the filtrate were analyzed using Inductively Coupled Plasma–Optical Emission Spectrometer (Agillent 710 Axial).

Statistical Analysis

Data were computed with SPSS and the mean values of heavy metals across the three sampling sites were tested with one-way ANOVA, while the differences in the mean were separated using LSD at $p<0.05$ significant level.

Enrichment Factor (EF)

Enrichment factor, put forward by Zoller *et al.* (1974) is used to estimates the anthropogenic impact on soil. In this study, sample reference metal used is iron (Fe) since Fe has a relatively high concentration in the earth while Residential site (LASU Ojo Campus) is used as control site, as it contains iron with low occurrence variability.

$EF = (C_i/C_{ie})_s / (C_i/C_{ie})_{rs}$

Where C_i = content of element i in the sample of interest

C_{ie} = content of immobile element in the sample

$(C_i/C_{ie})s$ = heavy metal to immobile element ratio in the samples of interest

$(C_i/C_{ie})rs$ = heavy metal to immobile element ratio in the selected reference sample (Zhang *et al.*, 2007). Based on enrichment factor, 5 contamination categories are recognized namely $EF<2$ = minimal enrichment, $2\leq EF<5$ = moderate enrichment, $5\leq EF<20$ = significant enrichment, $20\leq EF<40$ = very high enrichment, and $EF>40$ = extremely high enrichment.

Index of Geo-Accumulation (I_{geo}):

Index of geo – accumulation is used in determining metal contamination in soil by comparing current concentration with pre- industrial levels (Muller, 1969).

$I_{geo} = \text{Log } 2\ (C_i / 1.5\ C_{ri})$

Where C_i = measured concentration of the examined metal i in the soil

C_{ri} = geochemical background concentration of the metal i.

Factor 1.5 helps to minimize possible variations in background values for a given metal. Background value for this study was considered from world average value in shale (mg/kg).

Muller (1969) classified geo-accumulation index into 7 categories namely:

Class 0 = $I_{geo} \leq 0$ (practically uncontaminated), Class 1= $0< I_{geo} < 1$(uncontaminated to moderately contaminated), Class 2= $1< I_{geo} < 2$ (moderately contaminated), Class 3= $2< I_{geo} < 3$(moderately to heavily contaminated), Class 4= $3< I_{geo} < 4$(heavily contaminated), Class 5= $4< I_{geo} < 5$(heavily to extremely contaminated),Class 6= $5< I_{geo} > 6$(extremely contaminated).

RESULTS

Table 1 showed the mean concentration of heavy metals investigated in leafy vegetable (water leaf plant) and soil samples. The peak cadmium (Cd) value in *Talinum triangulare* (0.058±0.033 mg/kg) and highest cadmium in soil (0.50±0.255 mg/kg) were detected from industrial site, while the least Cd(0.05±0.00 mg/kg) in the soil were recorded in residential site. However, there was not significant (p>0.05) difference in the mean value of Cd in *T. triangulare* and soil samples across the three sampling sites. On the other hand, the highest calcium concentration (2971.850±116.39 mg/kg) in *T. triangulare* was recorded from commercial site while the highest level of calcium detected in soil (999.50±45.962 mg/kg) was obtained at residential site. The lowest levels of calcium in *T. triangulare* (1416.05±40.659) and soil (502.450±126.784 mg/kg) were recorded in residential and commercial sites respectively. There were significant (p<0.05) differences in value of calcium recorded for the plant and soil across the sites. The highest copper (0.078±0.013 mg/kg) detected in *T. triangulare* was from residential site while the highest levels of copper in soil sample (0.470±0.083 mg/kg) was from industrial site. The lowest level of copper in *T. triangulare* was found to be 0.038±0.014 mg/kg in commercial site while the lowest Cu in soil sample (0.006±0.001 mg/kg) was recorded from residential site. There was no significant (p>0.05) difference in the value of copper for *T. triangulare* and soil samples across the sites. Similarly, the level of chromium in water leaf plant (0.023± 0.016 mg/kg) and soil sample (0.163±0.083 mg/kg) gotten from industrial site were not significantly (p>0.005) different from lower level of chromium (0.004±0.001 mg/kg) detected in *T. triangulare* and soil samples (0.007±0.001 mg/kg) both from residential site.

On the contrary, the highest iron (5.890±1.541 mg/kg) content in *T. triangulare* was recorded from commercial site while the least iron (0.280±0.057 mg/kg) in water leaf was obtained from residential site. In the soil sample, the peak iron value (43.465±15.210 mg/kg) was detected in industrial site and least iron content (25.575±7.856 mg/kg) in residential site. There was significant (p<0.05) differences in the value of iron recorded across the sites. The highest level of magnesium (449.500±72.09 mg/kg) in *T. triangulare* was recorded from commercial site and least level of magnesium (117.500±11.03 mg/kg) from residential site. However, the peak concentration of magnesium in soil sample was detected in industrial site (665.400± 142,684 mg/kg) and least in commercial site (121.800±4.243 mg/kg). In *T. triangulare,* the highest lead was detected from industrial site (0.167±0.050 mg/kg) and least in residential site (0.050±0.000 mg/kg) whereas, high lead levels were detected in soil sample from industrial site (0.270±0.038 mg/kg) and least in soil sample from residential site (0.021±0.004 mg/kg). However, the differences in the lead values across the sites are not significant (p>0.05). As shown in Table 1, the level of zinc was highest in plant sample from commercial site (0.680±0.042 mg/kg) and least in plant sample from residential site (0.360±0.085 mg/kg) while for soil samples, amount of zinc was highest at residential site (1.340±0.339 mg/kg) and least in commercial site (0.275±0.092 mg/kg).

Table 2 present the values of enrichment factor (EF) and index of geochemical accumulation (Igeo) of the soil samples across the three sites. The EF values of heavy metals for Commercial sites (Iyana-Iba Market) are: Cd(3.70), Ca(0.32), Cu(9.94), Cr(5.74), Fe(1.00), Mg(0.12), Pb(4.50) and Zn(0.13). On the other hand, Industrial (Agbara Estate) soil had EF values of Cd(5.88), Ca(0.54), Cu(46.06), Cr(13.69), Fe(1.00), Mg(0.62), Pb(0.68) and Zn(7.56), while EF obtained from Residential(LASU Ojo Campus), the control site have constant EF(1.00) for all the metals.

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The I_{geo} value of Ca (2.52) at Commercial site was under class 3, Igeo values of Mg(3.82,3.61) at Industrial and residential sites respectively were under class 4, while the Igeo values of Ca(4.58, 5.01) from industrial and residential sites respectively are within class 5. However, other metals from the three sites fall within Class 0.

Table 1: Heavy Metals Concentration in Soil and Water Leaf (*Talinum triangulare*) Samples from Commercial, Residential and Industrial Sites in Lagos, Nigeria

	Commercial Site		Residential Site		Industrial Site	
Metals	**Soil Sample**	**Water leaf**	**Soil Sample**	**Water leaf**	**Soil Sample**	**Water leaf**
Cadmium	0.295 ±0.177[a]	0.050 ±0.000[a]	0.050 ±0.000[a]	0.050 ±0.000 [a]	0.500 ±0.255[a]	0.058 ±0.033[a]
Calcium	502.450 ±126.784[a]	2971.850 ±116.319[c]	999.500 ±45.962[b]	1416.050 ±40.659[bb]	911.900 ±122.047[ac]	1821.100 ±240.275[aa]
Copper	0.095 ±0.011[a]	0.038 ±0.014[a]	0.006 ±0.001[a]	0.078 ±0.013[a]	0.470 ±0.083[a]	0.066 ±0.016[a]
Chromium	0.064 ±0.013[a]	0.013 ±0.008[a]	0.007 ±0.001[a]	0.004 ±0.001[a]	0.163 ±0.083[a]	0.023 ±0.016[a]
Iron	40.750 ±22.500[a]	5.890 ±1.541[b]	25.575 ±7.856[ab]	0.280 ±0.057[bb]	43.465 ±15.210[c]	3.750 ±2.333[ac]
Magnesium	121.800 ±4.243[a]	449.800 ±72.691[aa]	630.000 ±172.251[ab]	117.500 ±11.031[b]	665.400 ±143.684[c]	420.050 ±62.438[bc]
Lead	0.151 ±0.053[a]	0.063 ±0.008[a]	0.021 ±0.004[a]	0.050 ±0.000[a]	0.270 ±0.0380[a]	0.167 ±0.050[a]
Zinc	0.275 ±0.092[a]	0.680 ±0.042[a]	1.340 ±0.339[a]	0.360 ±0.085[a]	0.900 ±0.127[a]	0.535 ±0.191[a]

Mean values with superscript across the row are significant ($p<0.05$)

Table 2: Enrichment Factor (EF) and Index of Geochemical Accumulation (IGEO) of Soil from Commercial, Residential and Industrial Sites in Lagos, Nigeria

Sites	**Index**	**Cd**	**Ca**	**Cu**	**Cr**	**Fe**	**Mg**	**Pb**	**Zn**
Commercial	**EF**	3.70	0.32	9.94	5.74	1.00	0.12	4.50	0.13
	IGEO	0.20	2.52	0.0004	0.0001	0.0002	0.69	0.002	0.005
Industrial	**EF**	5.88	0.54	46.06	13.69	1.00	0.62	0.68	7.56
	IGEO	0.33	4.58	0.002	0.0004	0.0002	3.82	0.002	0.002
Residential	**EF**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	IGEO	0.03	5.01	0.002	0.00002	0.0001	3.61	0.002	0.003

DISCUSSION

Cadmium is a non-essential element in food and its excess ingestion accumulates principally in the kidneys and liver (Divrikli *et al.,* 2006). Various sources of environmental contamination have been implicated for its presence in foods (Adriano, 1984). The values of Cd obtained from this study were below 1.2-2.5 mg/kg reported by Deribachew *et al.* (2015) in cabbage samples. The present study was in line with result reported by Prabu (2009) that

Cd accumulation was more in leafy vegetables such as lettuce, Swiss chard, spinach and radish (*Raphanus sativus*). Some values previously reported for leafy vegetables include 0.090 mg/k for fluted pumpkin by Sobukola *et al.* (2007), and 0.049 mg/kg (Muhammed and Umer, 2008). However, the values of Cd recorded across the sites in this study were within the WHO/FAO safe limit.

Calcium is an essential nutrient for all living organisms. It helps in patients suffering from insomnia and irregular heartbeats, and is essential for preventing high blood pressure. Calcium aids in blood clotting (Inya-agha, 2006). When calcium is combined with pectin, the "glue" that holds plant cells together, calcium forms a pectate salt that helps the cell walls to be sturdy and rigid. Vitamin D is a precursor to a hormone that regulates calcium metabolism (Akpata, 2011). Calcium values recorded at all sites in this study from plant sample (*Talinum triangulare*) was higher than the recommendations by the Food and Nutrition Board for adequate intakes of calcium set at 1000 mg daily for adult men and women age 19 – 50years, including women during pregnancy and lactation (WHO/FAO 2001). Akpata (2011) in his studies revealed that leafy vegetables; pumpkin leaves contained the highest calcium concentration of 3.38±0.012mg/g and that bitter leaf was next to it in concentration of 3.01±0.012mg/g. The study of Adotey *et al*. (2009) also showed high calcium content in onion (0.60g kg^{-1}); the mean content in garden egg was the lowest (0.10 g/kg). Copper is an essential micro nutrient which functions as a biocatalyst required for body pigmentation in addition to iron, maintain a healthy central nervous system. It prevents anaemia and interrelated with the functions of zinc and iron in the body (Mekuleyi *et al.*, 2019). However, most plants contain the amount of copper that is inadequate for normal growth which is usually ensured through artificial or organic fertilizers (Wuana *et al*.,2011). In the present study, the concentrations of copper in *Talinum triangulare* from both residential and industrial sites were higher than the findings of Divrikli *et al.* (2006) and Ozcan (2004) who reported copper concentrations of 0.02 mg/kg and 0.0081 mg/kg respectively for indian basil. However, the Cu levels in the present study were within the FAO/WHO permissible limits for copper intake which is 2.0 mg/kg.

Chromium (Cr) plays a vital role in the metabolism of cholesterol, fat, and glucose. Its deficiency causes hyperglycemia, elevated body fat, and decreased sperm count, while at high concentration it is toxic and carcinogenic (Chishti *et al*., 2011). Exposure of human to chromium may occur through breathing, drinking, or eating food containing chromium or even through skin contact. Exposure to elevated levels of chromium leads to skin irritation, ulceration, damage to circulatory and nerve tissues which cause health problems. However, daily uptake of it within a certain range of concentrations (up to 200 μg/day) by human beings and animals is considered to be essential for carbohydrate and lipid metabolism (Girmaye, 2012). The levels of chromium obtained in the present study were within the safe limits of 1.2mg/kg recommended by WHO/FAO (2001). While Deribachew *et al*. (2015), reported cabbage with concentrations of Cr above the safe limits at Haramaya University vegetable farm, Adah *et al.* (2013) reported low Cr concentrations for *T. occidentalis*, *T. triangulare* and A. hybridus respectively.

Iron is the most abundant and an essential constituent for all plants and animals. On the other hand, at high concentration, it causes tissues damage and some other diseases in humans. It is also responsible for anaemia and neurodegenerative conditions in human being (Fuortes and Schenck, 2000). All the iron values recorded in this study were lower than the FAO/WHO (2001) permissible limit of iron intake which was 425.00 mg/kg. Akubugwo *et al.* (2012)

reported iron metal content of up to 147.41 mg/Kg in the *Amaranthus hybridus* vegetables while Apkata (2011) recorded a lower value of iron in Bitter leaf. Magnesium is a mineral of tremendous importance for bone health, energy production and overall healthy functioning throughout the body since it activates more than 300 cellular enzymes. Like calcium, magnesium must be constantly supplied to maintain optimal function of the body. Magnesium deficiency seems to be carcinogenic, in the case of solid tumour, a high level of supplemented magnesium inhibits carcinogenesis (Durlach *et al.*, 1986). In this study, magnesium content in plant sample from commercial site was higher than the recommended daily intake stated in most literatures such as reports of Apkata, (2011) on bitter leaf and pumpkin leaf, and Adotey *et al*. (2009) which examined the levels of magnesium in tomato, garden egg, onion, pepper and carrot. Lead is a serious cumulative body poison which enters the body through air, water and food and cannot be removed by washing fruits and vegetables (Divrikli *et al*., 2003). The high levels of lead in some plants may probably be attributed to pollutants in irrigation water, farm soil or due to pollution from highways traffic (Qui *et al.*, 2000). In this study, lead detected in the plant samples were lower than the safe limit set by FAO/WHO (2001) which is 5 mg/kg.

Among all heavy metals, zinc is the least toxic and an essential element in human diet as it is often requiring for maintaining the function of the immune system. All the level of zinc recorded in this study was below the recommended daily intake as stated in literatures. For instance, Muhammad *et al*. (2008) reported that the zinc concentrations in lettuce was 1.893 mg/kg and in cabbage was 0.678 mg/Kg. However, the zinc level in this study was higher than that reported by Akubugwo *et al*. (2012) on *Amaranthus hybridus* vegetables.

Enrichment factor (EF) calculated for soil samples in this study showed moderate enrichment of all metals (except Cr and Cu) in the soil across the sites. EF of Cr and Cu respectively at industrial site were significant and extremely high. The I_{geo} value of Ca (2.52) at Commercial site indicated moderate contamination, Igeo values of Mg(3.82,3.61) at Industrial and residential sites implied heavily contaminated while the Igeo values of Ca(4.58, 5.01) from industrial and residential sites indicated extremely contaminated. This finding was different from the report on Abattoir soil from PortHarcourt in which the soil was not contaminated by Fe, Cu, Pb, Cr and Cd (Edori and Kpee, 2016).

CONCLUSION

This study showed that the plant samples contain high concentrations of calcium while the soil was contaminated with Cr, Cu, Ca and Mg. Although the concentrations of iron, chromium, copper, magnesium, lead and zinc established for water leaf (*T. triangulare*) were lower than the permissible intake by WHO/FAO, however, there could be a cumulative effect on sustained intake of calcium, as they are not easily removed from the body and thus excess calcium may cause detrimental effect when over accumulated in the body system.

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