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Assessment of Minerals, Heavy Metals in Soil and Vegetables Cultivated in Mbezi Luis, Ubungo Municipality: Associated Health Risks to Consumers

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Abstract:

The present study was intended to determine the levels of minerals and heavy metals in Green Leafy Vegetables (GLV) and soil at Ubungo, Dar es Salaam City, so as to establish the risk associated with consumption of these vegetables. These GLV can absorb heavy metals through contaminated soil and irrigation water sources. The samples were digested by dry-ashing techniques and the minerals and heavy metals were determined using atomic Absorption Spectrophotometry (AAS).The concentration of Pb in all GLV samples ranged between 0.23 and 8.51 mg/kg, where about 78% were higher than TBS acceptable limit (0.3 mg/kg). Zinc concentration ranged from 26.24 mg/kg to 57.34 mg/kg where about 22% of these GLV detected high concentration than joint FAO/WHO allowable limit of 47.4 mg/kg. The heavy metals concentration in the soil was 24.41 mg/kg for Pb and 9.60 mg/kg, both of them lower than WHO/FAO permissible limit of 50 mg/kg and 300 mg/kg respectively. The ratio between sodium and potassium in all samples analysed is < 1. Therefore, consumption of the selected leafy vegetables in this study could probably serve to reduce high blood pressure diseases to consumers. The Target Hazard Quotient (THQ) showed that Pb ranged between 0.001 – 0.026, while Zn ranged between 0.081 – 0.178. These values were far less than 1 in all the vegetables species. Therefore, there is no health risk associated with the current level of exposure to a given substance and the population under study is considered to be safe. Mineral content analyzed in this study showed that the vegetables contained appreciable amounts of macro-minerals like magnesium, calcium and potassium which work synergistically to maintain optimal health by keeping the body and tissue fluids from being too acidic or too alkaline and hence allowing for exchange of nutrients between body cells.

Keywords: *green leafy vegetable, daily intake, heavy metals, hazard quotient, Dar es Salaam*

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1. Introduction

In Sub-Saharan Africa, the urbanization phenomena has led to an increase in urban food demand and changes in diets that are coupled with increased demands for a wider range of food types that serve the emerging middle-class markets (Laura, 2016). The rapid urbanization that is taking place goes together with a rapid increase in urban poverty and urban food insecurity (Boeing, 2016). The most striking feature of urban agriculture, which distinguishes it from rural agriculture, is that it is integrated into the urban economic and ecological system: urban agriculture is embedded in interacting with the urban ecosystem (Skar, *et al.*, 2020). Such linkages include the use of urban residents as laborers, use of typical urban resources like organic waste as compost and urban wastewater for irrigation (Laura, 2016). Also direct links with urban consumers, direct impacts on urban ecology (positive and negative), being part of the urban food system, competing for land with other urban functions, being influenced by urban policies and plans (Algert, *et al.*, 2006).

Other than increase in urban food demands, the increase of urban populations has far outpaced sanitation infrastructure and service delivery (Asoka, *et al.*, 2013). About 2.6 billion people in the developing world lack access to basic sanitation infrastructure. Hutton and Varughese (2016) estimated that in 2012 the proportion of Tanzania's Gross Domestic Product (GDP) that was invested in sanitation was less than 0.1%. People living in these areas usually use traditional latrines which are not connected to a septic tank and so wastewater soaks into the ground. This is particularly problematic during rainy season when rainwater washes the latrine waste into city water sources, streams, rivers and streets and hence used to irrigate GLV grown around these contaminated water sources due to scarcity of treated water supply.

The effect of heavy metal contamination of GLV cannot be underestimated as these foodstuffs are important components of human diet. The GLV are rich sources of vitamins, minerals, and fibers and also have beneficial ant oxidative effects (Sathawara, *et al.*, 2004). The study conducted earlier in Bangladesh by Tasrina, *et al.*, (2015), detected the concentration of lead (Pb) in vegetables was found in toxic level, which were varied from 0.119 mg/kg to 1.596 mg/kg. The highest lead content was found in spinach amarantha (1.596 mg/kg) while in cabbage it was lowest in concentration (0.119 mg/kg).

Africa is not exceptional in heavy metal contamination in vegetables. For example Afolayan and Bvenura (2012) in South Africa, in their study conducted in vegetables cultivated in home gardens; in *Brassica oleracea* (cabbage), *Daucus carota* (carrot), *Allium cepa* (onion), *Spinacia oleracea* (spinach) and *Solanum lycopersicum* (tomato), they detected the concentrations vegetables in the ranged from 0.01mg/kg – 1.12 mg/kg for cadmium, 0.92 mg/kg – 9.29 mg/kg for copper, 0.04 mg/kg – 373.38 mg/kg for manganese and 4.27 mg/kg – 89.88 mg/kg for zinc in the respective vegetables.

In another study conducted in Dar es Salaam city (Kihampa, 2013) detected high levels of several heavy metals in streams/rivers, soils and vegetables grown along streams and river banks. According to Kihampa, *et al.*, (2011), the primary source of the heavy metals is considered to be untreated or treated wastewater from industries that discharge their wastewater directly into streams and rivers, effluents from municipal wastewater treatment plants (MWWTPs).

The heavy metal pollution is one of the serious ecological/environmental concerns due to the fact that they are not easily biodegradable or metabolized, thus precipitating far reaching effects on the biological system such as human, animals, plants and other soil biota (Saria, 2017; Yoon, 2003). Heavy metals enter the body system through food, air and water and bio-accumulate over a period of time (Duruibe, *et al.*, 2007). Excess heavy metal accumulation in the environment has toxicological implication in humans and other animals (Saria, 2016). There are several sources of heavy metals to contaminate the environment as they are summarized in Figure 1 (Khan, *et al.*, 2008).

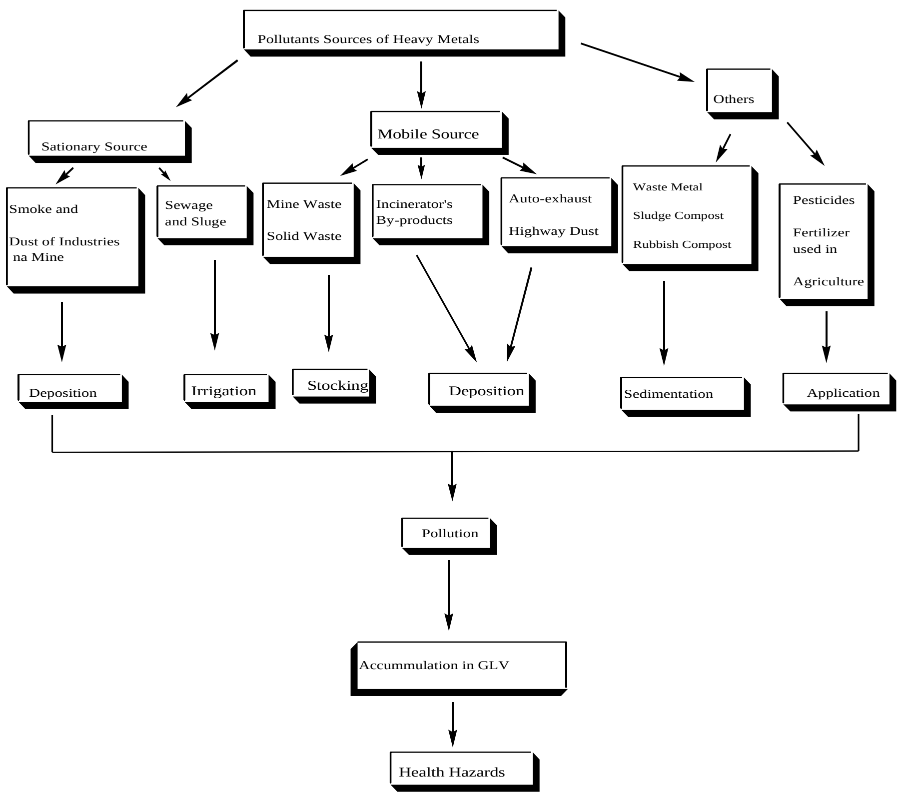

Figure 1. Sources of heavy metals in the environment

Green leafy vegetables (GLV) are precious source of vitamins, minerals, dietary fiber and anti oxidants (Sobukola, *et al.*, 2010; Sharma, *et al.*, 2009). Recently, there is an increased trend of consumption of GLV, particularly among the urban community. However, both vital and lethal elements are present in GLV. They can absorb heavy metals through contaminated soil and irrigation water sources. Further GLV have the ability to absorb the metals deposited on plant surfaces exposed to the polluted environments.

Consumption of the contaminated GLV with heavy metals in a chronic level through soil and hence to vegetables has adverse impacts on human and has harmful impacts only after several years of exposure (Ikeda, *et al.*, 2000). However, the consumption of heavy metal contaminated GLV can seriously deplete some essential nutrients in the body that are further responsible for decreasing immunological defenses. The current study was intended to determine minerals and heavy metals concentration in GLV cultivated at Ubungo, Dar es Salaam city, and then assesses the risk associated with consumption of the vegetables used in the city of Dar es Salaam.

2. Materials and Methods

2.1 Study Area

This study was conducted at Mbezi Luis Ward in Ubungo Municipality (Fig 2) (Mayunga, (2018).

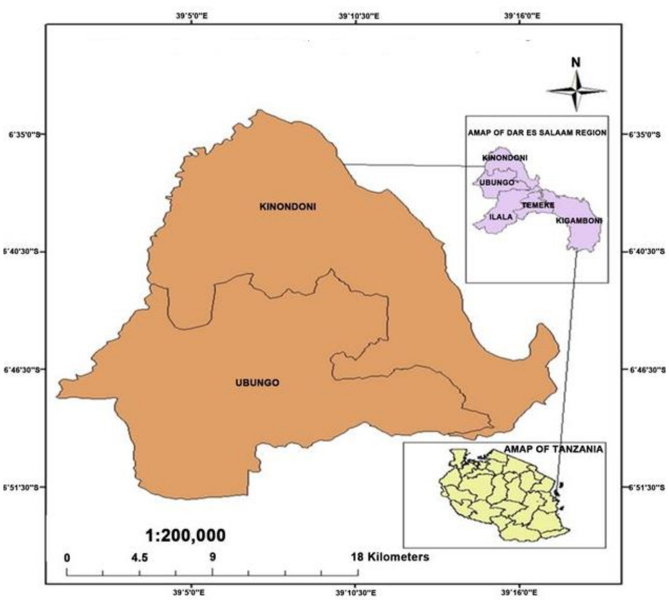

Figure 2. Map of Dar es Salaam City Showing Location of Ubungo District

The selection of Ubungo Municipality was randomly selected from the three municipal districts of the Dar es Salaam city namely; Ilala, Kinondoni, Temeke, Kigamboni and Ubungo. The Ubungo Municipality has a total area of 260.40 square kilometres. According to the 2012 population Census (URT, 2012), the Municipality had a population of 845,368 where male was 409,149 and female was 436,219. Mbezi Luis Ward Ward was selected purposely because it is the fastest growing Ward out of 14 wards of Ubungo Municipality. According to the government 2012 population census (URT, 2012), Mbezi Luis Ward has a population of 73,314 people where 35,637 were male and 37,777 were female with a growth rate of 5% (URT, 2012).

2.2 Sample Collection

Samples of each GLV identified commonly used in Ubungo Municipality were taken in an interval of seven days making a total of three samples each. About 1 kg of GLV samples were obtained from gardens of local farmers at Mbezi Luis Ward, Ubungo Municipality, over a period of three weeks from 5^{th} – 26^{th} August 2018 and kept in pre-cleaned polyethylene bags. Three soil samples (about 500 g each) were also taken from the same vegetable gardens sampling site and reserved in pre-cleaned polyethylene bags. Each day the samples were transferred to Chief Government Chemistry Laboratory for analysis.

2.2.1 Sampling of Soil Samples

Soil samples were collected at depth of about 15cm using hand auger, stored in polyethylene bags and oven dried at 60°C for 2 days, followed by grinding with mortar and pestle and sieved using a 2 mm sieve. About 1.0 g of the oven dried ground sample was weighed into a 250 mL beaker which has been previously washed with nitric acid and distilled water. The mixture of 5 mL of HNO_3, 15 mL of concentrated H_2SO_4 and 0.3 mL of $HClO_4$ were added to the sample using pipette. The mixture was digested in a fume cupboard, heating continued until a dense white fume appeared which was then digested for 15 minutes, set aside to cool and diluted with distilled water. The mixture was filtered through acid washed Whattman No.44 filter paper into a 50 mL volumetric flask and diluted to mark volume. The sample solution was then aspirated into the Atomic Absorption Spectroscopic machine at intervals.

2.2.2 Sampling and Treatment of Green Leafy Vegetables

An investigation survey was conducted at Mbezi Luis Ward Ward to identify locally grown vegetables, site history and marketing areas. Nine sampling locations were established along the cultivated area of closed river Mbezi. Twenty seven samples (500 g each) of leaves vegetable from nine different types of vegetables namely *Ipomoea sp, Brassica L, .Corchorus L,.Lactuca Inermis Forssk, Amaranthus sp, Cucurbita sp, Solanum sp, Manihot esculenta Crantz, Bidens pilosa L* were collected. The collected samples were wrapped in aluminium foils and stored in polythene bags according to their type and brought to the laboratory for preparation and analysis. The vegetable species were authenticated at the Herbarium of the Department of Botany at the University of Dar es Salaam, Tanzania where voucher specimens are preserved.

Triplicate of each sample had their stalks removed, rinsed with de-ionized water and the residual moisture evaporated at room temperature before sun-drying for 2 -3 days on a clean paper with constant turning over to avert fungal growth.

Sample portions were dried in a drying oven, at 105°C, until constant weight was obtained then cooled to ambient temperature, crushed by means of a clean pestle and mortar to obtain homogenized samples. About 2.0 g of each of the processed samples was weighed and subjected to dry aching in a well-cleaned porcelain crucible at 550 ^{0}C in a muffle furnace. The resultant ash was dissolved in 5.0 mL of $HNO_3/HCl/H_2O$ (1:2:3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5.0 mL of de-ionized water was added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100.0 mL volumetric flask by filtration through Whatman No.42 filter paper and the volume was made to the mark with de-ionized water. This prepared solution was used for elemental analysis in Perking Elmer Analyst 100 AAS with Perking Elmer HGA 850 Graphite Furnace and Perking Elmer and AS 800 Auto-sampler made in Germany.

2.2.3 Flame Atomic Absorption Analysis

For Lead (Pb) and Zinc (Zn), measurements were made using standard hollow cathode lamps. The limit of detection (LOD) of the analytical method for each metal was calculated as being triple the standard deviation of a series of measurements for each solution, the concentration of which is distinctly detectable above the background level. The value was 0.001 mg/kg for both elements and the limit of quantification (LOQ) of these elements were calculated to be 0.003 mg/kg respectively.

For the rest of other metals the procedure followed standardized method (Jońca and Lewandowski, 2004; Temminghoff and Houba, 2004). The concentration values in correspond with measurements performed using acetylene-nitrous oxide flame were 1.0 mg/L for sodium, potassium, 2.0 mg/L, magnesium 0.5 mg/L and calcium 7.0 mg/L. This requires a multiple increase of the dilution factor depending on the concentration in the sample.

The standard operating conditions for the analysis of heavy metals using atomic absorption spectrometry used in our experiments are given in Table 1 (Perkin-Elmer, 1996).

Table 1. Standard Atomic Absorption Conditions for Different Elements

Element	λ (nm)	Slit (nm)	Flame
Ca	422.7	0.2	Nitrous oxide-acetylene
K	766.5	0.2/0.4	Air-Acetylene
Mn	285.2	0.2	Nitrous oxide-acetylene
Na	589.0	0.2/0.4	Air-acetylene
Pb	405.8	0.2	Nitrous oxide-acetylene
Zn	213.9	0.2	Nitrous oxide-acetylene

2.3 Quality Assurance

Strict quality assurance / quality control measures were taken to ensure reliability of the study results. All reagents and chemicals used were of good or high purity. Thoroughly glassware was cleaned with detergent and rinsed several times using deionized water before use. For quantification and detection limits of the Atomic Absorption Spectrophotometer purposes, a blank solution was read twenty five times, and the standard deviations were considered for the noise generation levels for each of the heavy metals.

The reproducibility and accuracy of the analytical procedure was done by spiking and homogenizing three replicates of each of three samples selected. The triplicate of each sample was spiked with three diverse concentrations of the metal of interest and preserved in a manner similar as the samples as per literature (Scott and Nancy, 2000). The absorbance measured by the atomic absorption spectrophotometer was converted to concentrations using standard calibration curves. A 1000 mg/l single element standards of the metals of interest, found from Fluka Analytical (Sigma Aldrich Chemie GmbH, Switzerland), were diluted using 10% HNO_3 and used to generate the calibration curves for the atomic absorption spectrophotometer analysis.

2.4 Soil to Vegetable Transfer Coefficients

Soil to plant transfer is one of the key components of human exposure to metals through food chain. Transfer Factor (TF) or Plant Concentration Factor (PCF) is a parameter used to describe not only the transfer of trace elements from soil to plant body but also function of both soil and vegetables properties. The transfer coefficient was calculated by dividing the concentration of heavy metals in vegetables by the total heavy metal concentration in the soil (Kachenko and Singh, 2006).

The transfer coefficient quantifies the relative differences in bioavailability of metals to plants and is a function of both soil and plant properties. The coefficient is calculated using equation (1). The higher transfer coefficient represents relatively poor retention in soils or greater efficiency of plants to absorb metals. Low coefficient demonstrates the strong sorption of metals to the soil colloids (Coutate, 1992).

$$\text{TF (PCF)} = \frac{\text{Concentration in Vegetable}}{\text{Conc in Soil}} \quad (1)$$

2.5 Daily Intake Rate (DIR)

The Daily Intake Rate (DIR) is the average metal content in each vegetable calculated and multiplied by the respective consumption rate. The DIR was determined by the following equation (2) (Sajjad *et al.,* 2009; Arora *et al.,* 2008):

$$\text{DIR} = \text{Concentration in Vegetables} \times \text{C (Factor)} \times \text{D (Vegetable Intake)} \ldots\ldots\ldots(2)$$

Where, C (Metal conc.) = Heavy metal concentration in vegetables (mg/kg); C (Factor) = Conversion factor (0.085); D (Vegetable intake) = Daily Intake of Vegetable (kg $person^{-1} day^{-1}$ FW). The conversion factor of 0.085 is set to convert fresh vegetable weight to dry weight based on calculation in literatures (Rattan, *et al.*, 2005). The average daily consumption of vegetables suggested by WHO (1989), guidelines in human diet is 0.300 to 0.350 Kg per person. Therefore, mean of 0.325 kg/person/day was used in calculating the ADI values in this paper. An average weight of person was considered to be 60 kg (Rattan, *et al.*, 2005).

2.6 Hazardous Quotient (HQ)

Risk to human health by the intake of metal-contaminated vegetables was characterized using a Total Hazard Quotient (THQ) (USEPA, 2013). The THQ is the ratio between exposure and the reference oral dose (Rf D). If the ratio is lower than one (1), there will be no obvious risk. An estimate of the potential hazard to human health (THQ) through consumption of vegetables grown in heavy metal contaminated soil is described in Eq. (3):

Hazardous Quotient (HQ) for the locals (consumers) through the consumption of contaminated vegetables was assessed by the ratio of Daily Intake Rate (DIR) to the oral reference dose (RfDo) for each metal (USEPA, 2013) where for Pb and Zn is 0.0035 and 0.300 mg/kg/day respectively (USEPA, 2010).

$$THQ = \frac{EF \times ED \times FIR \times C}{RFD \times WAB \times TA} \times 10^{-3} \quad \ldots\ldots(3)$$

Where EF is the exposure frequency (350 days/year); ED is the exposure duration (According to the latest WHO data published in 2015 life expectancy in Tanzania is 62 years; lifetime); FIR is the food ingestion rate. According to Weinberger and Swai (2006) vegetable consumption values for Tanzanian adult is 63 g/person/day); C is the metal concentration in the edible parts of vegetables (mg/kg); RFD is the oral reference dose (Pb = 0.0035 while Zn = 0.300), WAB is the average body weight (65 kg for adults vegetable consumer in Tanzania) and TA is the average exposure time for non-carcinogens (ED x 365days/year). If the THQ value is greater than 1, the exposure is likely to cause obvious adverse effects (USEPA, 2013).

3 Results and Discussion

3.1 Minerals and Heavy Metals in Vegetables and Soil

Table 2 shows the concentrations of metals investigated in soil and Green Leafy Vegetables (GLV) commonly consumed in Mbezi Luis ward. The values are given in mean of three replicates. The metal levels determined were based on plants dry weight. Heavy metals affect the nutritive values of agricultural materials and also have deleterious effect on human beings.

National and international regulations bodies on food quality set the acceptable maximum permissible levels of heavy metals in human food; hence an increasingly important aspect of food quality should be to control the concentrations of heavy metals in food (Radwan and Salama, 2006).

Except of two samples; *Ipomoea sp*, *Co chorus L.* which register 1.07 mg/kg, 0.23 mg/kg respectively, other samples register high concentration level of Pb above Tanzania Bureau of Standard (TBS) (2007) maximum acceptable limits in vegetables which is 0.3 mg/kg. The sources of lead accumulated in the investigated vegetables are envisaged to be water used for irrigation and hence soil used for cultivation. These were conceived to be the sources due to the fact that during its operation the dump the river and discharge of waste water from hospitals, houses, schools were directed to Mbezi River.

Table 2. Levels of Minerals and Heavy Metals from Selected Commonly Used GLV (mg/kg)

S/No	Swahili	Family	Genus and Species	Zn	Pb	Ca	K	Mg	Na
1	Matembele	Convolvulaceae	*Ipomoea sp*	26.24	1.07	361.98	3163.51	3001.90	361.98
2	Sukuma Wiki	Brassicaceae	*Brassica L.*	57.34	4.45	936.39	36116.42	3393.78	936.39
3	Mlenda	Tiliaceae	*Corchorus L.*	35.62	0.23	538.93	42251.03	3135.13	538.93
4	Mchunga	Compositae	*Lactuca Inermis Forssk*	33.59	3.15	436.14	44692.46	3195.69	436.14
5	Mchicha	Amaranthaceae	*Amaranthus sp*	45.64	7.74	858.78	23233.21	3408.57	858.78
6	Maboga	Cucurbitaceae	*Cucurbita sp*	37.23	8.51	467.23	42924.33	3360.07	467.21
7	Mnavu	Solanaceae	*Solanum sp*	36.69	3.95	923.17	24689.41	3666.58	923.17
8	Kisamvu	Euphorbiaceae	*Manihot esculenta Crantz*	48.52	5.98	761.48	24443.02	3583.82	761.48
9	Mashona nguo	Compositae	*Bidens pilosa L*	46.31	4.88	527.92	23742.22	3331.42	537.95
10	Soil			9.60	24.41	13781.00	412.11	2819.10	479.14

Also all wastes such as medical waste, batteries, waste cloths, newspapers, paints, glass and bottles, industrial dust, ash, tires, metal cans, inks, plastics, used motor oils, ceramics, electronics and containers, were thrown in the river, hence contaminate the irrigating water and The level of lead in the soil detected 24.41 mg/kg, which is lower than WHO/FAO (2001) permissible limit of 50.00 mg/kg for soils.

Zinc is an essential mineral for human health. The recommended dietary allowances (RDAs) for adult woman are 8 mg while for man is 11 mg per day (Van Jaarsveld, *et al.,* 2014). Zinc levels ranged from 26.24 mg/kg to 57.34 mg/kg with *Ipomoea sp* register the lowest while Brassica L. registered the highest. About 22% of these GLV detected high concentration than joint WHO/FAO (2001), allowable limit of 47.4 mg/kg Zn levels in edibles. However, these values are lower than the one detected earlier (Kihampa, *et al.,* 2011) in *V. unguiculata* in which in their study zinc concentration level was detected to be 122.88 mg/kg. All the analyzed samples registered lowest value compared to recommended value by TBS (2007) in vegetables, which is 60.0 mg/kg. The mean concentration of zinc (Zn) in the soil was 9.60 mg/kg, which were about 31 times lower than WHO/FAO (2001) permissible limit of 300.00 mg/kg for soils.

Fresh vegetables are highly recommended in any diet virtually without quantitative restriction and the roles of vegetables in maintenance of good health are well known. Green leafy vegetables form an indispensable constituent of diet in Tanzania. Sodium and potassium are two critical minerals that have consistently been identified as nutrients of concern in the diet. These two cations have an inverse relation in the body, complicating this known intake imbalance. Because of this, it is important to examine not only individual mineral intakes but also the ratio of these two minerals in the diet. Recent studies (Food and Nutrition Board 2008; Yang *et al.,* 2014), suggests that the dietary sodium-to-potassium ratio (Na:K) is more strongly associated with an increased risk of hypertension and cardiovascular disease (CVD)-related mortality than the risk associated from either sodium or potassium alone (Perez and Chang 2014; Cook, *et al.,* 2009). The level of Na ranged from 361.98 mg/kg in *Ipomoea sp* up to 936.39 mg/kg in *Brassica L.* while K ranged from 3163.51 mg/kg (*Ipomoea sp)* up to 44692.46 (*Lactuca Inermis Forssk).* These values are higher than values detected by Akpana, *et al.,* (2017). The values are higher due to excessive use of organic manure especially chicken and cow as well as inorganic fertilizer especially NPK and urea in the sampling site. According to Institute of Medicine (Institute of Medicine, Food and Nutrition Board 2005), the RDA for potassium for both normal healthy males and non-pregnant females between the ages of 19 and 50 years is 4700 mg/day. The range of potassium content reported in this study shows that the vegetables may be a poor source, capable of providing about 0.67% to 9.5% of RDA for healthy living.

The ratio between sodium and potassium in all samples analyzed is < 1 (Table 3).

Table 3. The Ration of Na and K in Different Samples of GLV Analyzed

Vegetable	1	2	3	4	5
Na:K	0.114	0.026	0.013	0.010	0.037
	6	7	8	9	
	0.011	0.037	0.031	0.023	

1 = *Ipomoea sp;* 2 = *Brassica L.;* 3 = *Corchorus L.,* 4 = *Lactuca Inermis Forssk; 5 = Amaranthus sp;* 6 = *Cucurbita sp;* 7 = *Solanum sp;* 8 = *Manihot esculenta Crantz;* 9 = *Bidens pilosa L*

The ratio is in line with a related study (Caunii, *et al.*, 2010). Thus, the consumption of the selected leafy vegetables in this study could probably serve to reduce high blood pressure diseases to consumers, due to the less than one value obtained for their Na/K ratio (Drewnowski, *et al.*, 2015). This may be due to harvesting stage, seasonal variations, soil differences and differences in methods used in analysis (Chawanje, 1998).

Magnesium is known to plays an essential role in many of the functions of the energy production. This element is an integral part of the energy (ATP) and protein (enzymes - as co-factor and as a structural component of the muscle protein, myosin) molecules without which the energy to contract and relax the heart does not occur properly (WHO, 1989). The absence of magnesium in diet might result in weak, underdeveloped or poor bone growth (Effiong and Udo, 2010). Result of magnesium content ranged from 3001.90 mg/kg to 3666.58 mg/kg. The magnesium content of the samples is higher than the value obtained recently by Akpana, *et al.*, (2017).

Calcium plays an important role in building strong and keeping healthy bones as well as teeth at both early and later life. The concentration detected ranged from 361.98 mg/kg to 936.36 mg/kg in *Ipomoea sp* and *Brassica L.* respectively. The detected values are lower than the one determined by other researchers (Iyaka *et al.*, 2014) which ranged between 3870 – 9060 mg/kg.

The concentrations of Pb in vegetables were lower than that of the corresponding soils. This might be attributed to the root which seems to act as a barrier to the translocation of metals. To evaluate the accumulating capacity of heavy metals from soils to plant, a quantitative evaluation of the relationship between metals concentration in vegetable and in corresponding soils was made by calculating the transfer factor for the soil/plant system. The transfer factor varies from one plant to another plant due to a selectivity of the plants in absorbing respective elements from soils.

3.2 Soil-Vegetable Transfer Coefficients

To estimate the heavy metals transferred to plants, the transfer coefficient, a function of both soil and plant properties, is used due to its representative bioavailability of heavy metals to plants. The leafy vegetables are found to show a higher transfer factor among the studied vegetables (Figure 3)

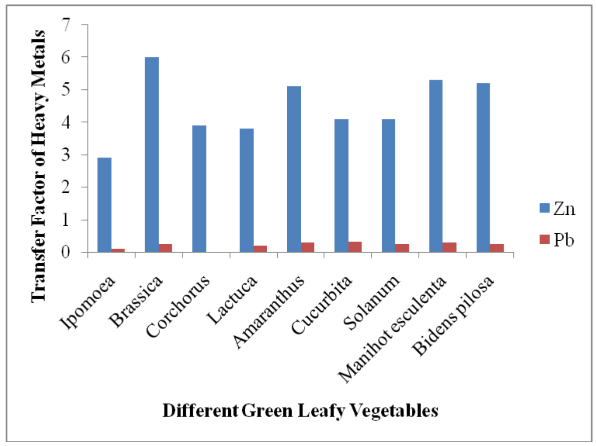

Figure 3. Transfer Factors of Heavy Metal from Soils into the Vegetable Samples.

The TF value for toxic element Zn (2.733 – 5.973) is quite high compared to Pb (0.009 – 0.349). The higher concentrations of these heavy metals are due to the waste water irrigation, solid waste disposal and sludge applications, solid waste combustion, agrochemicals and increase in geologic and anthropogenic activities. The present result agrees with the investigation made by Satter, (2012) who found that the transfer of Zn and Pb from soil to plant *Enhydra fluctuans* and *Oryza sativa* is 1.762 and 1.05; and 5.519 and 1.20 respectively, which is quite high. Soil electrolyte plays an important role in the process of metal transfer. The electrochemical properties of soil reflected through the temperature, pH, and electrolyte concentration etc. thus influence the migration transformation ability of toxic metal indirectly (Iyaka, *et al.*, 2014). These green leaf plants are widely consumed by human, toxic elements can be transferred to human body creating disruption in various biological systems.

3.3 The Daily Intake Rate

The average daily intake rate (DIR) of heavy metals obtained is given in Figure 4. The DIR values for Pb range from 0.005 – 0.162 mg/day which is below the recommended level by Joint WHO/FAO (2007) indicated to be 0.214 mg/day.

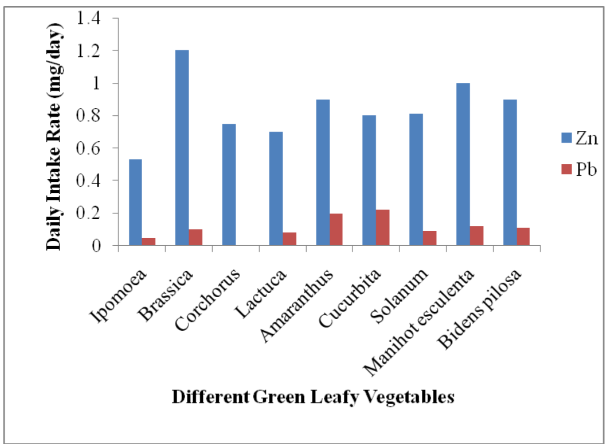

Figure 4. The Daily Intake Rate (DIR in mg/day) for Zn and Pb in Respective Vegetables

However they are very close to the values determined by earlier researchers (Orisakwe, *et al.*, 2012). The DIR value for Zn ranged from 0.551 – 1.204 mg/day which is far below the 60 mg/day set by WHO/FAO (2007).

The THQ values of, Pb and Zn due to vegetable consumption for the populace (adults) of the study area are shown in Figure 5. The THQ values range showed that Pb was 0.001 – 0.026, Zn was 0.081 – 0.178. These results concur with the values detected earlier (Hannah, *et al.*, 2016), in which Pb ranged from 0.150 to 0.587 and Zn was 0.021 – 0.190. These results reflected the risk associated with Pb, Zn exposure for the period of life expectancy considered. In this study, the THQ in all metals is far less than 1 in all the vegetables species; therefore, it does not pose health risk concern.

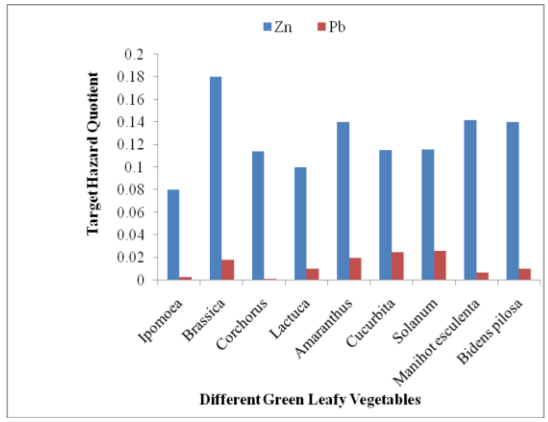

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Figure 5. The Target Health Hazard of Pd and Zn

Higher THQ for Pb, were reported by Singh, *et al.*, (2010) in vegetables area which use waste water for irrigation. Higher THQ for Pb in an area near a lead (Pb) and antimony (Sb) smelter in Nanning, China, was also reported by Zhou *et al.*, (2016) in vegetable species planted in contaminated soils. However, for women who are pregnant, the potential health risks of heavy metal accumulation through vegetable consumption were likely to be higher than for the normal population.

4 Conclusions and Recommendations

The present study was performed to assess mineral elements and heavy metal levels of commonly consumed vegetables and their associated health risks in Mbezi Luis, Ubungo district. Generally, the heavy metals concentrations in the various vegetables are all above the maximum TBS (2007), permissible limit. The individual hazard quotient values were all below 1 except suggesting an acceptable level of non-carcinogenic adverse risk. Based on the findings of this study; it is recommended that further research work should be carried out to study the levels of heavy metals in vegetables in and around Dar es Salaam City in order to maintain and/or improve measures to reduce their levels in vegetables and ultimately prevent these avoidable health problems.

No matter how the concentration of heavy metals present in vegetables, their presence is not desirable. Therefore, this study suggests the regular scrutiny of the heavy metals present in soil, irrigating water, and foodstuff to avoid extreme accrual in the food chain and thus elude human health risks. Consequently, this study encourages administrators, environmentalists and public health workers to create public awareness to avoid the consumption of vegetables grown in contaminated soils, hence reducing health risks to consumers.

5 Acknowledgement

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