ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/317236317

# Heavy Metals and Essential Elements in Selected Medicinal Plants Commonly Used for Medicine in Tanzania

**Article** · May 2017

DOI: 10.9734/CSIJ/2017/31963

CITATIONS
0

READS
177

**2 authors**, including:



Leonid Leopold Nkuba
Tanzania Atomic Energy Commission (TAEC)
**5** PUBLICATIONS **1** CITATION

SEE PROFILE

**Some of the authors of this publication are also working on these related projects:**




Establishment of Background ionising radiation levels of densely populated areas in Tanzania View project

All content following this page was uploaded by Leonid Leopold Nkuba on 30 May 2017.

The user has requested enhancement of the downloaded file.



*Chemical Science International Journal*

***19(2): 1-11, 2017; Article no.CSIJ.31963***
***ISSN: 2456-706X***
*(Past name: American Chemical Science Journal, Past ISSN: 2249-0205)*

# Heavy Metals and Essential Elements in Selected Medicinal Plants Commonly Used for Medicine in Tanzania

**Leonid L. Nkuba[1*] and Najat K. Mohammed[2]**

*[1]Tanzania Atomic Energy Commission, Directorate of Radiation Control, P.O. Box 80479, Dar es Salaam, Tanzania.*
*[2]Department of Physics, College of Natural and Applied Sciences, University of Dar es Salaam, P.O. Box 3506, Tanzania.*

***Authors' contributions***

*This work was carried out in collaboration between both authors. Author LLN designed the study, performed the statistical analysis and literature searches and wrote the first draft of the manuscript. Author NKM supervised the analyses of the samples, reviewed the first draft and wrote the final manuscript. Both authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/CSIJ/2017/31963
Editor(s):
(1) Nagatoshi Nishiwaki, Kochi University of Technology, Japan.
Reviewers:
(1) Rakesh Choure, Shri Vaishnav Vishwavidhyalaya Vidhyapeeth, India.
(2) Birsa Mihail Lucian, Alexandru Ioan Cuza University of Iasi, Romania.
(3) Dumitru Gabriela, Alexandru Ioan Cuza University, Romania.
Complete Peer review History: http://www.sciencedomain.org/review-history/19215

***Original Research Article***

***Received 31st January 2017***
***Accepted 2nd April 2017***
***Published 27th May 2017***

## ABSTRACT

Several plants in Tanzania are known to be of potential therapeutic value and are used in traditional medicine system of the country. In this paper, two medicinal plants *Moringa oleifera* (leaves and roots), and *Hibiscus sabsdariffa* (rosella calyces) were analysed for elemental concentration. Essential and non-essential heavy metals like Mg, K, Mn, Fe, Ni, Cu, Zn, Cd and Pb were quantified in selected medicinal plants by EDXRF technique. The main purpose of this study is to document the presence and the levels of heavy metals in these herbs. High Potassium contents were observed to be 20882.20 ± 253.65 mg/kg in *Moringa oleifera* roots, in *Hibiscus sabsdariffa* (rosella calyces) 15732.03 ± 191.27 mg/kg, and 14541.08 ± 206.83 mg/kg in *Moringa oleifera* leaves. Magnesium was the second abundant element with concentration (5058.13 ± 115.80 mg/kg in *Moringa oleifera* leaves, 4328.86 ± 132.85 mg/kg *Hibiscus sabsdariffa* and 1400.59.59 ± 72.09

**Corresponding author: E-mail: leonid_nkuba@yahoo.co.uk;*

mg/kg in *Moringa oleifera* roots), followed by Iron (716.57 ± 48.05 mg/kg in *Hibiscus sabsdariffa*, 556.44 ± 11.77 mg/kg and 309.57 ± 8.96 mg/kg in *Moringa oleifera* roots and leaves respectively. Except Fe and Ni in all plant samples and Mg in leaves of *Moringa oleifera* and calyces of *Hibiscus sabsdariffa* as well as Mn in roots of *Moring oleifera*, the concentrations of other metals were below the permissible limits in plants set by FAO/WHO. The results presented that there is no risk associated with consumption of analysed medicinal plants. However, since Cd was not detected and it is highly toxic even at very low concentrations. Therefore, further analysis which will employ other analytical techniques and includes more samples is needed to have a definite statistical conclusion on the safety consumption of the analysed medicinal plants. The results also show that the analysed plant species are beneficial sources of appropriate and essential trace elements.

*Keywords: Heavy metals; essential elements; medicinal plant; Moringa oleifera; EDXRF; Hibiscus sabsdariffa.*

## 1. INTRODUCTION

The consumption of medicinal plants for therapeutic purposes is recognized as one of the earliest traditional forms of medical practice of mankind. These plants are also used for the prevention of diseases, sustainability of health and to cure diseases in modern medicine [1]. At the same time, they are utilized as a nutritional supplements, spice, herbal tea and taste condiment in nutrition as well as in various fields of industry (food, perfumery, cosmetics, polishes, pesticides) [2]. These uses tend to grow over the years, both in developed and developing countries [3]. Today, the number of medicinal and aromatic plants used in the world is around 20,000 according to the World Health Organization (WHO) and 4,000 of these drugs are still used widely in the World [4]. In this paper, two medicinal plants which are *Moringa oleifera* (leaves and roots), and *Hibiscus sabsdariffa* (rosella calyces) which are mostly used for medicinal purposes in Tanzania were analysed for elemental concentration.

*Moringa oleifera* Lam (synonym: *Moringa pterygosperma Gaertner*) belongs to an onogeneric family of shrubs and tree, Moringaceae and is considered to have its origin in Agra and Oudh, in the northwest region of India, south of the Himalayan Mountains [5]. Every plant part such as leaves, roots, fruits, bark is used for medicinal purposes as well as food because of their high nutritional value. The young leaves are edible and are commonly cooked and eaten like spinach or used to make soups and salads. They are an exceptionally good source of provitamin A, vitamins B, C and minerals (iron in particular). Powder produced from the seed is used as an effective primary coagulant for water treatment [6,7,8], and also possess the potential to remove cadmium from aqueous system [9]. Leaves and roots of *Moringa oleifera* are used for therapeutic purposes and reported to cure several disease as shown in Table 1.

*Hibiscus sabsdariffa* also known as rosella, is an ideal crop for developing countries as it is relatively easy to grow, can be grown as part of multi-cropping systems and can be used as food and fibre. In China the seeds are used for their oil and the plant is used for its medicinal properties, while in West Africa the leaves and powdered seeds are used in meals. Additionally, it is used in the pharmaceutical and food industries. Fresh or dried calyces of *Hibiscus sabsdariffa* are used in the preparation of herbal drinks, hot and cold beverages, fermented drinks, wine, jam, jellied confectionaries, ice cream, chocolates, flavouring agents, puddings and cakes [2,10]. In the West Indies the calyces can also be used as colouring and flavouring ingredient in rum [11]. The seeds are eaten roasted or ground in meals, while the leaves and shoots are eaten raw or cooked or as a sour-flavoured vegetable or condiment [12]. In Tanzania, calyces are used for medicinal purposes and for making juice. A limited number of reviews on *Hibiscus sabsdariffa* are available for medicinal purposes as shown in Table 1.

Plants have the ability to accumulate metals such as, Mg, Fe, Ms, Zn, Cu, Mo and Ni which are essential to their growth. Some plants even have the ability to accumulate metals like Hg and Cr that have no known biological function to them. Reports have also shown that the levels of minerals in the plants depend on the soil properties and the geographical locations where the plant grows [21]; also their excessive

**Table 1. Indigenous medicinal herbs used in Tanzania**

| Plant species and part used | Medicinal use/properties |
|---|---|
| *Moringa oleifera* (leaves) | Purgative, applied as poultice to sores, rubbed on the temples for headaches, used for piles, fevers, sore throat, bronchitis, eye and ear infections, scurvy and catarrh; leaf juice is believed to control glucose levels, applied to reduce glandular swelling [13,14,15,16]. |
| *Moringa oleifera* (roots) | Antilithic, rubefacient, vesicant, carminative, antifertility, anti-inflammatory, stimulant in paralytic afflictions; act as a cardiac/circulatory tonic, used as a laxative, abortifacient, treating rheumatism, inflammations, articular pains, lower back or kidney pain and constipation [13,15,17,18]. |
| *Hibiscus sabsdariffa* (Calyces) | Used as source of antioxidants, soothes colds, astringent, lowering blood pressure, blood lipids and for prophylaxis against cancer and liver cirrhosis especially for alcoholics, promote kidney function, helps in digestion, reduce fever, helps in cardiac and nerve diseases. It treats hangover, cough and stomach problems (indigestion). They are rich in vitamins A and C [19,20]. |

accumulation is toxic to most plants [22]. Studies conducted elsewhere have shown that parts of *Moringa oleifera* have been found containing high levels of Ca, Mg, K, Na, Mn, Fe, Zn, Co, Se, Pb and Cd [4,23,24]. And for the case of *Hibiscus sabsdariffa* the studies revealed that-the plant contains metals like Al, Ca, Mg, K, Na, Mn, Fe, Zn, Co, Se, P, Pb and Cd [10,25,26]. Some heavy metals like Pb, Zn, Cd, Hg and Th are of great concern because of their potential effects on human health and environment. As the concentration of metals in plants depends on the environment, it is also important to analyse medicinal plants grown and used in Tanzania. Therefore, considering this contamination issues and the uses of *Moringa oleifera* and *Hibiscus sabsdariffa* in Tanzania, this study aimed at investigating the presence of metals and elements like Mg, K, Mn, Fe, Ni, Cu, Zn, Cd and Pb in plant samples (as dry extracts) by using Energy Dispersive XRF.

## 2. MATERIALS AND METHODS

### 2.1 Sampling and Post Harvesting Treatment of Plant Material

*Moringa oleifera* and *Hibiscus sabsdariffa* were identified as herbal plants mostly used in Tanzania for healthcare. Five (5) plants of *Moringa oleifera* and seven (7) plant of *Hibiscus sabsdariffa* (Calyces) were collected from different parts of Tanzania. The parts of the plant mostly recommended and/or used for medicine purposes were washed to remove surface deposition then sun dried for a week. Then the samples were dried into oven at 48℃ for 4 days. And finally were grinded and sieved through a 2 mm-sieve into powder, packed and stored into the desiccator for a week to attain a constant weight before analysis.

A dry weight of 12 grams of *Moringa oleifera* root sample with 2.7 grams of cellulose binder were put into a bowl together with four spherical balls, each with 3 mm radius and fixed to a pulveriser machine which was further ground and homogenized. The machine was set at a speed of 150 revolutions per minute (rpm) for 15 minutes. The analyte was placed into a polished, lapped thrust piece with a smooth surface and fixed into hydraulic press machine. A pellet in tablet form was obtained by applying an average pressure of 12.5 tons. The same processes were applied to 12 grams of *Moringa oleifera* (leaves) and *Hibiscus sabsdariffa* (calyces) samples. Each pellet was labeled and subsequently placed in a transparent plastic sample holder ready for measurements in Energy Dispersive X-Ray Fluorescence (EXRDF) Machine.

### 2.2 Sample Analysis

The elemental analyses of samples were conducted using a bench top energy dispersive X-ray spectrometer of Tanzania Atomic Energy Commission (TAEC) in Arusha. The machine which is operated by automated turbo-quant X-lab Pro$^{TM}$ software uses a 0.003 beryllium window X-ray tube with copper body anode and ceramic envelope with palladium target. The X-ray tube was operated at a power of 50 W and 50kV voltage. The florescent X-rays were collected by a Si (Li) detector having a resolution (FWHM) at $MnK_{\alpha}$ ≤ 160 eV.

The excitation of elements in the sample was carried out using three secondary targets. Light elements from Na-V were excited using high oriented pure graphite (HOPG) target (intense monochromatic polarized X-Rays). The Elements from Cr-Zr and Pr-U were excited using Mo secondary target (intense monochromatic non-polarized X-Rays). The high energy elements Y-Ce were excited using Barkla target (Al2O3) (intense polychromatic polarized X-Rays) [27]. The spectrum was generated after 20 min and it gave a good continuity statistics and resolution of the peaks.

Concentrations of elements in the samples were calculated by the inbuilt software called X-lab Pro$^{TM}$ with Turboquant (Tq 9232) algorithm for matrix effect correction [28]. The software corrects for the matrix effects (*Mi*) and the interference effects (*Ki*) basing on fundamental parameter methodology. The software corrects also for the background effect on a spectral line intensity (*Ii*), given as counts per second (cps). After all the corrections, the software converts the intensity into concentration of the element using Equation below [29].

$$C_i = K_I \times I_I \times M_a \quad (1)$$

Where *Ci* is the concentration of a given element *i*; Ma is the correction factor for matrix effects. *Ki* is the constant of proportionality; *Ii* is the intensity of the fluorescent radiation from the element *i.*

## 2.3 Quality Control

Quality control was carried out using two IAEA reference materials for Trace and Minor Elements. The first one was Cabbage coded as IAEA 359 [30]. And the second was Soil coded as IAEA-Soil 7 [31]. Both were analyzed simultaneously with the samples. As Table 1 shows, the experimental values were all in good agreement with the recommended values and there were also within 95% confidence interval given in the reference sheets except for Cd only.

## 3. RESULTS AND DISCUSSION

The results of EDXRF system confirming the presence of several chemical elements including Mg, K, Mn, Fe, Ni, Cu, Zn, Cd and Pb in all analysed medicinal plants at a wide range of concentrations. As seen in Table 2, it can be observed a variation in the concentration of the quantified elements both essential and non-essential or heavy metals. However, it was not possible to establish any reason about this difference as all the plant samples were from rural areas. The discussion part of this paper will be based on permissible limit given by FAO/WHO and the related organisations.

The observed mean concentrations of the mineral elements in *Moringa oleifera* leaves (Table 2) were 5058.13 ± 116.80 mg/kg, 14541.08 ± 207.83 mg/kg, 73.47 ± 3.51 mg/kg, 309.57 ± 8.96 mg/kg, 2.25 ± 0.46 mg/kg, 4.35 ± 0.68 mg/kg, 19.88 ± 0.22 mg/kg and 0.35 ± 0.01 mg/kg for Mg, K, Mn, Fe, Ni, Cu and Zn respectively. For heavy metal, Pb was 0.35 ± 0.01 while Cd was not detected. As expected, except for Mg and Cu, the root samples of *Moringa oleifera* had highest level of metal concentration than its leaves. As seen in Table 2, Mg was higher in *Hibiscus sabsdariffa* followed by K and Fe. Also Cd was not detected and Pb recorded high concentration of 6.62 mg/kg when compared to the concentration of Pb found in leaves and roots of *Moringa oleifera.* However, it was below the permissible limits set by FAO/WHO.

Magnesium (Mg), the concentration of Mg in analysed plants herbs ranged from 4748.79 - 6346.55 mg/kg, 1372.42 - 1477.53 mg/kg and 3232.76 - 4480.26 mg/kg for leaves and roots of *Moringa oleifera* and *Hibiscus sabsdariffa* (calyces) respectively. With a mean concentration of 5058.13 ± 115.80 mg/kg, 1400.59.59 ± 72.09 mg/kg in leaves and roots of *Moringa oleifera* and 4328.86 ± 132.85 mg/kg in *Hibiscus sabsdariffa*. The lowest concentration was observed in roots of *Moringa oleifera* (Table 2). The concentration levels in leaves were higher than the reported values in Nigeria, India and Thailand [23,24,32]. Also, the concentration level of Mg in roots of *Moringa oleifera* from this study was higher compared to the reported level from Nigeria [2]. In this study, the concentration levels of Mg in *Hibiscus sabsdariffa* were compared to that reported in Gabon, the mean value was within the range reported (2469 – 4579 mg/kg). However, the reported mean concentration of Mg in present research was higher compared to that reported from Libreville in Gabon [25]. The permissible limit of Magnesium set by WHO in plants was 2000 mg/kg, while its daily intake is set to be 350 mg/day for men and 300 mg/kg for women [33]. After comparison, except for Mg levels in roots of *Moringa oleifera*, Mg concentration levels in the

**Table 2. Experimental and recommended values (mg/kg) of reference material trace and minor elements (K, Mn and Ni) in cabbage [30] and minor elements (Mg, Fe, Cu, Zn, Cd and Pb) in IAEA-Soil 7 [31]**

| Elements | Experimental values | Recommended values | 95 % confidence Interval from the data sheet |
|---|---|---|---|
| Mg | 76.36 | 60.00 | 49 – 77 |
| K | 32800 | 32500 | 31810 – 33190 |
| Mn | 32.3 | 31.9 | 31.3 – 32.5 |
| Fe | 150.00 | 148.00 | 144.1 - 151.9 |
| Ni | 1.09 | 1.05 | 1.00 – 1.10 |
| Cu | 5.48 | 5.67 | 5.49 - 5.85 |
| Zn | 36.77 | 38.60 | 37.9 – 39.3 |
| Cd | 0.09 | 0.12 | 0.115 – 0.125 |
| Pb | 55.44 | 60.00 | 55 – 71 |

studied medicinal herbs were above the permissible limit set by FAO/WHO in plants. The leaves of *Moringa oleifera* and calyces of *Hibiscus sabsdariffa* contains unsafe levels of Mg and hence might be detrimental to consumers' health.

Mg is required in the plasma and extra cellular fluid, where it helps in maintaining osmotic equilibrium. It is required in many enzyme catalyzed reactions, especially those in which nucleotide participate where the reactive species is the magnesium salt, e.g. $MgATP^{2-}$. Lack of Mg is associated with abnormal irritability of muscle and convulsions and excess Mg with depression of the central nervous system.

Potassium (K), as seen from Table 2, K was the most abundant element present in all analysed medicinal herbs. The levels ranged from 12091.05-17234.11 mg/kg in leaves, 17600.36-21211.10 mg/kg in roots of *Moringa oleifera* respectively, and 10537.02-15919.70 mg/kg in calyces of *Hibiscus sabsdariffa*. The mean concentrations of K were 14541.08 ± 206.83 mg/kg in *Moringa oleifera* leaves, 20882.20 ± 253.65 mg/kg in *Moringa oleifera* roots and 15732.03 ± 191.27 mg/kg in *Hibiscus sabsdariffa*. The highest value was observed in root of *Moringa oleifera* (Table 2). The mean value of K in *Moringa oleifera* leaves and roots were higher than 8010 mg/kg and 4750 mg/kg respectively, reported from Nigeria [4]. In *Hibiscus sabsdariffa*, concentration of K was much higher than 5326 mg/kg reported from Libreville in Gabon [25].

K is important in for its diuretic nature and helps in the proper function of the brain as well as nerves, thereby preventing stroke. It plays part in acid-base and water regulation in the blood and tissues. K has been reported that a high-potassium diet lowered blood pressure in individuals with raised blood pressure [34]. In addition to its contribution to the electrolytes and function of the nerves in the human body, K has been linked to bone health and osteoporosis prevention according to studies of intake of 2500 mg/day done in United Kingdom [35].

The concentrations observed for Manganese (Mn) in this study ranged from 59.81 to 84.08 mg/kg in *Moringa oleifera* leaves, with its mean value of 73.47 ± 3.51 mg/kg. This concentration range of Mn in *Moringa oleifera* leaves in the present study falls within the concentration range reported in the previous studies (50-90 mg/kg) [36]. For roots of *Moringa oleifera*, Mn ranged from 196.20-317.23 mg/kg with mean concentration of 308.46 ± 10.27 mg/kg. In *Hibiscus sabsdariffa*, Mn ranged from 12.07-27.09 mg/kg and the mean value was 24.16 ± 1.00 mg/kg. The reported mean value of Mn in leaves of *Moringa oleifera* in this study was the same as that reported in Nigeria [23] but higher when compared to 48.73 mg/kg reported from Thailand [24]. In roots of *Moringa oleifera*, the levels of Mn were much higher than 78.9 mg/kg reported from Nigeria [4]. *Hibiscus sabsdariffa* had low concentration of Mn, when compared to 453.71 mg/kg reported from Serbia [10]. The permissible level set by FAO/WHO in medicinal plants is 200 mg/kg, and a daily intake is 11 mg/day [37]. In the present study, except for Mn levels in roots of *Moringa oleifera*, Mn concentration levels in the studied medicinal herbs were below the permissible limit set by FAO/WHO in medicinal plants. The roots of *Moringa oleifera* contain higher levels than the permissible limits set for Mn in plants. Hence, they contain unsafe levels of Mn and might be detrimental to consumers' health. Manganese (Mn) is a trace element necessary for plant,

animal and human as enzyme cofactor [38]. However, the deficiency of manganese in humans may lead to immunodeficiency disorder, rheumatic arthritis in adults, disorder of bony cartilaginous growth in infants, as well as myocardial infarction and other cardiovascular diseases [39].

The observed concentration levels of iron (Fe) in analysed medicinal plants ranged from 89.02–553.46 mg/kg, 246.44–572.81 mg/kg to 380.56 – 798.43 mg/kg for leaves and root of *Moringa oleifera* and in *Hibiscus sabsdariffa*, respectively. Highest levels of Fe were reported in *Hibiscus sabsdariffa* (716.57 ± 48.05 mg/kg) followed by concentration in roots (556.44 ± 11.77 mg/kg) and then in leaves (309.57 ± 8.96 mg/kg) of *Moringa oleifera* (Table 2). The Fe concentration levels in *Hibiscus sabsdariffa* in present study was higher than the levels reported from Turkey, Serbia, Gabon and Nigeria [2,10,25,26]. The obtained Fe level of 309.57 ± 8.96 mg/kg in the leaves of *Moringa oleifera* was slightly higher to that reported in Nigeria [40]. But much higher when compared to that reported in Thailand [24]. Also a similar study, reported a range of 203.1 to 376 mg/kg [41] which was closer to that of the present study. WHO permissible limits for Fe specifically in medicinal plants is 20 mg/kg, while its daily intake is 10-28 mg/day [37]. After comparison, Fe levels in all studied medicinal herbs were above the permissible limits set by WHO in medicinal plants. Generally, the analysed medicinal plants contain unsafe levels of iron. Iron overdose is associated with symptoms of dizziness, nausea and vomiting, diarrhea, joint pain and liver damage [42,43]. Iron has several key functions in human body including oxygen supply, energy production and immunity. Deficiency of Fe may result in anaemia.

The concentration levels of Nickel raged between 0.09–4.89 mg/kg, 0.33–3.08 mg/kg and 0.98–2.15 mg/kg in *Moringa oleifera* leaves, roots and *Hibiscus sabsdariffa*, respectively. With a mean concentration of 2.25 ± 0.46 mg/kg, 2.28 ± 0.88 mg/kg and 1.98 ± 0.06 mg/kg in *Moringa oleifera* leaves, roots and *Hibiscus sabsdariffa*, respectively. In this study, the concentration levels of nickel (Ni) in *Moringa oleifera* leaves and roots were higher than that in calyces of *Hibiscus sabsdariffa*. Ni in *Moringa oleifera* leave was almost the same as the value (2.56 mg/kg) reported in Thailand [24]. The permissible limits for Ni in medicinal plants established by WHO is 1.5 mg/kg [44]. It was also reported that FAO/WHO set the permissible limits to 1.63 mg/kg [45] for edible plants. Nickel concentrations in all analysed plant samples in the present study were above the permissible limits set for both medicinal plants and edible plants (Table 2). Therefore, the results show that all analysed medicinal plants contain unsafe levels of nickel and this might cause toxic effects to human health. The Ni toxicity in human is not a very common occurrence because its absorption the body is very low [46]. The most common ailment arising from Ni is an allergic dermatitis known as nickel itch, which usually occurs when the skin is moisture state [47]. Nickel has been also identified as carcinogen and adversely affects lungs and nasal cavities [47]. Ni is required in minute quantity for body as mostly in the pancrease and hence plays an important role in the production of insulin. Its deficiency results into liver disorder [46]. The daily intake of Ni is recommended to be less than 1 mg/day, beyond this it's a toxic [48].

The copper (Cu) concentration varied from 1.58 - 6.22 mg/kg, 1.20 - 3.79 mg/kg and 0-0.42 mg/kg in *Moringa oleifera* leaves, roots and *Hibiscus sabsdariffa*, respectively. The mean concentrations of Cu were 4.35 ± 0.68 mg/kg, 3.26 ± 0.50 mg/kg and 0.33 ± 0.13 mg/kg in *Moringa oleifera* leaves, roots and *Hibiscus sabsdariffa*, respectively. The mean levels of Cu in *Moringa oleifera* leaves in this study was higher to 1.02 ± 0.08 mg/kg reported in Nigeria [23] but the reported value (6.63 mg/kg) from Sam Phran, Thailand was higher than the levels of Cu in present study [24]. Also the concentration levels of Cu in root of *Moringa oleifera* reported from Nigeria and India were very low compared to that of this study [32, 49].However, for *Hibiscus sabsdariffa* the levels were much lower when compared to that reported from Turkey, Serbia and Nigeria [2, 10, 26]. WHO permissible limits in Cu for medicinal plants is 10 mg/kg, while its intake in food is 2-3 mg/day [44]. Also, the permissible limit set by FAO/WHO in edible plants is 3 mg/kg. China and Singapore had set limits for Cu in medicinal plants at 20 mg/kg and 150 mg/kg respectively [50]. In the present study, the concentrations of Cu in all medicinal plants were below the permissible limits set by FAO/WHO in both medicinal plants and edible plants. The results of from this study have shown that copper concentration is not a matter of concern from the toxicity point of view for the observed herb.

**Table 3. The average concentration of heavy metals (mg/kg ± SD) in selected medicinal plants**

| Elements | Concentrations of heavy metals in ( mg/kg ± SD) | | |
|---|---|---|---|
| | ***Moringa oleifera*** **(leaves), n = 5** | ***Moringa oleifera*** **(roots), n = 5** | ***Hibiscus sabsdariffa*** **(calyces), n = 7** |
| Mg | 5058.13 ± 116.80 (4748.79-6346.55) | 1400.59 ± 72.09 (1372.42-1477.53) | 4328.86 ± 132.85 (3232.76 - 4480.26) |
| K | 14541.08 ± 207.83 (12091.05-17234.11) | 20882.24 ± 254.65 (17600.36-21211.10) | 15732.03 ± 191.27 (10537.02-15919.70) |
| Mn | 73.47 ± 3.51 (59.81-84.08) | 308.46 ± 10.27 (196.20-317.23) | 24.16 ± 1.00 (12.07-27.09) |
| Fe | 309.57 ± 8.96 (89.02-553.46) | 556.44 ± 11.77 (246.44-572.81) | 716.57 ± 48.05 (380.56 – 798.43) |
| Ni | 2.25 ± 0.46 (0.09-4.89) | 2.28 ± 0.88 (0.33-3.08) | 1.98 ± 0.06 (0.98 – 2.15) |
| Cu | 4.35 ± 0.68 (1.58-6.22) | 3.26 ± 0.50 (1.20-3.79) | 0.33 ± 0.13 (0 - 0.42) |
| Zn | 19.88 ± 0.22 (8.67-23.54) | 25.95 ± 0.85 (15.51-27.13) | 12.67 ± 0.35 (7.09 – 15.08) |
| Cd | BDL | BDL | BDL |
| Pb | 0.35 ± 0.01 (0.01-0.07) | 0.77 ± 0.19 (0.36-1.05) | 6.62 ± 0.13 (2.32-8.74) |

*Note: The values in bracket represent the range*
*BDL = Bellow Detection Limits*

Copper is essential to the human body since it forms a component of many enzyme systems, such as cytochrome oxidase, lysyl oxidase and ceruloplasmin, an iron-oxidizing enzyme in blood. Copper deficiency results in anemia and congenital inability to excrete copper resulting in Wilson's disease [51]. However, copper could be toxic depending on the dose and duration of exposure [42].

The concentration of Zn in the analysed plant samples raged between 8.67-23.54 mg/kg, 15.51-27.13 mg/kg and 7.09 – 15.08 mg/kg in *Moringa oleifera* leaves, roots and *Hibiscus sabsdariffa*, respectively. With a mean concentration of 19.88 ± 0.22 mg/kg, 25.95 ± 0.85 mg/kg and 12.67 ± 0.35 mg/kg. The mean concentration levels in leaves and roots of *Moringa oleifera* were high compared to the levels reported in Nigeria [4,49] and in Salem, Tamil Nadu- India [32]. Also the concentration level of Zn in *Hibiscus sabsdariffa* was low to that reported in Turkey, Serbia and in Adama State in Nigeria [2,10,26]. FAO/WHO set the permissible limit for Zn in medicinal plat to be 50 mg/kg, while its intake in food is 11 mg/day [44]. Also in 1984, FAO/WHO recommended that the permissible limit of Zn in edible plant to be 27.4 mg/kg [33]. Therefore, the levels of Zn in all analysed medicinal herbs were below the permissible limits of both medicinal and edible plants set by FAO/WHO. Medicinal plants evaluated contained safe level of zinc as far as the permissible levels in edible plants and in medicinal plants are concerned. Zinc is essential trace element necessary for proper growth, blood clotting, thyroid function and protein and DNA synthesis. Zinc intake beyond permissible limits produces toxic effects on the immune system of the body and disrupts copper levels [52].

Cadmium is a nonessential element with uncertain direct functions in both plants and humans [53]. In this study, Cd was not detected in all plant samples (Table 2). However, metals like Cd might be highly toxic even at very low concentrations [54]. WHO recommended limit for medicinal plants is 0.3 mg/kg [55]. Similarity, permissible limits in medicinal plants for Cd set by Canada was 0.3 mg/kg in raw medicinal plant material and 0.006 mg/day in finished herbal products [44]. It is also reported that the lowest level of cadmium which can cause yield reduction in plants is 5 to 30 mg/kg and the maximum acceptable concentration for foodstuff is about 1 mg/kg [56]. Cadmium accumulates in human body and damages mainly the kidneys and liver. Higher levels of Cd pose serious toxicological impacts on human health and it gets into human body through food ingestion, especially plant-based foodstuff. The kidney, liver and other internal organs, especially the renal tract, is the critical organ of intoxication after exposure to Cd. Excretion is slow, and it

accumulates in human kidney and renal, resulting in an irreversible impairment in the re-absorption capacity of renal tubules [43,57].

In all analysed plant samples, lead (Pb) ranged from 0.01-0.07 mg/kg and 0.36-1.05 mg/kg with mean concentration value of 0.35 ± 0.01 mg/kg and 0.77 ± 0.19 mg/kg for *Moringa oleifera* leaves and roots respectively. The mean concentration value of Pb in the leaves was low while the mean value in roots was high than the reported mean concentration levels of Pb in the same plant samples from Keshere, Gombe state in Nigeria [49]. In *Hibiscus sabsdariffa*, the concentration of Pb ranged from 2.32- 8.74 mg/kg with mean value of 6.62 ± 0.13 mg/kg. The Pb in *Hibiscus sabsdariffa* recorded highest level compared to Pb levels in leaves and roots of *Moringa oleifera* (Table 2). The reported concentration levels of Pb in analysed medicinal plants were below the permissible limits of 10 mg/kg [55]. It was reported that the permissible limits of Pb in edible plants was 0.43 mg/kg, while the dietary intake was set to 3 mg/week [33]. Except for *Moringa oleifera* leaves, lead concentrations in other analysed plant samples were higher than the permissible limit set in edible plants. Pb is non-essential trace element having functions neither in human's body nor in plants. Its exposure may have an adverse effect on the blood, nervous, renal, skeleton muscular, reproductive and cardiovascular systems causing poor muscle coordination [58]. The study revealed that lead (Pb) concentration is not a matter of concern from the toxicity point of view for the observed medicinal herb as far as permissible level in medicinal plants is concerned.

## 4. CONCLUSION

Most of people in Tanzania believe that herbal medicines are safe and non-toxic unlike modern chemotherapeutic agents and they are unaware of toxic potential of these medicinal plants. Therefore, the present study gives a new perspective about the presence of heavy metals and essential elements in the medicinal plants. The above results showed that except for Mg, Mn, Fe and Ni, all other concentrations of heavy metals and essential elements including K, Cu, Zn, Pb and Cd in *Moringa oleifera* roots and leaves and calyces of *Hibiscus sabsdariffa* samples were found within permissible limits set for medicinal plants or the permissible limits of metals in edible plants. It was determined that leaves and roots of *Moringa oleifera* and calyces of *Hibiscus sabsdariffa* in the present study were probably unsafe for human consumption because of Mg, Mn, Fe and Ni concentrations. However, some metals especially for Cd and Pb are toxic heavy metals and their presence even at very low concentration causes toxic effects to human health [59]. Also essential elements like Cu, Fe, and Zn, their excessive concentrations in herbal plants can cause toxicity in consumers [60[. These essential elements interact with some organic compounds such as flavonoids, influencing their biological activity so they must be removed if they are in excess. Hence, people should be aware of the daily consumption of heavy metals accumulated in analysed medicinal plants. Therefore, further analysis which will include more samples is needed to have a definite statistical conclusion on the safety consumption and to assess their long-term cumulative risk on consumer health.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Kitula RA. Use of medicinal plants for human health in Udzungwa Mountains forests: A case study of New Dabaga Ulongambi Forest Reserve, Tanzania. Jour. of Ethnobiology and Ethnomedicine. 2007;3:7.
   DOI: 10.1186/1746-4269-3-7
2. Tercan HC, Ayanoglu F, Bahadirli NH. Determination of heavy metal contents and some basic aspects of widely used herbal teas in Turkey. REV. CHIM. (Bucharest). 2016;67(5):1019-1022.
3. World Health Organization (WHO). Guidelines on Good Agricultural and Collected Practices (GACP) for Medicinal Plants: Geneva, Switzerland, WHO; 2003.
4. Fakankun OA, Babayemi JO, Utiaruk JJ. Variations in the mineral composition and heavy metals content of *Moringa oleifera*. African Journal of Environmental Science and Technology. 2014;7(6):372-379.
5. Anwar F, Bhanger MI. Analytical characterization of *Moringa oleifera* seed oil grown in temperate regions of Pakistan. J Agric Food Chem. 2003;51:6558–6563.
6. Bhuptawat H, Folkard GK, Chaudhari S. Innovative physico-chemical treatment of

wastewater incorporating *Moringa oleifera* seed coagulant. J. Hazard. Mater. 2007; 142:477–482.

7. Pritchard M, Craven T, Mkandawire T, Edmondson AS, O'Neill JG. A study of the parameters affecting the effectiveness of *Moringa oleifera* in drinking water purification. Phys. Chem. Earth. 2010;35: 791–797.
8. Sánchez-Martín J, Ghebremichael K, Beltrán-Heredi J. Comparison of single-step and two-step purified coagulants from *Moringa oleifera* seed for turbidity and DOC removal. Bioresour. Technol. 2010; 101:6259–6261.
9. Sharma P, Kumari P, Srivastava MM, Srivastava S. Removal of cadmium from aqueous system by shelled *Moringa oleifera* Lam. seed powder. Bioresour. Technol. 2006;97:299–305.
10. Mihaljev Z, Zivkov-Balos M, Cupic Z and Jaksic S. Levels of some Microelements and Essential Heavy Metals in Herbal Teas in Serbia. Acta Poloniae Pharmaceutica - Drug Research. 2014; 71(3):385–391.
11. Ismail A, Ikram EHK and Nazri HSM. Roselle (*Hibiscus sabsdariffa* L.) seeds nutritional composition protein quality and health benefits. Food. 2008;2(1):1-16.
12. Wilson FD, Menzel MY. Kenaf *(Hibiscus cannabinus),* roselle *(Hibiscus sabsdariffa).* Economy Botany. 1964;18(1):80-91.
13. The Wealth of India (A Dictionary of Indian Raw Materials and Industrial Products). Raw Materials, Vol. VI: L-M; Council of Scientific and Industrial Research: New Delhi. 1962;425–429.
14. Padmarao P, Acharya BM, Dennis TJ. Pharmacognostic study on stembark of *Moringa oleifera* Lam. Bulletin of Medico-Ethno-Botanical Research. 1996;17:141–151.
15. Dahot MU. Vitamin contents of flowers and seeds of *Moringa oleifera*. Pak J Biochem. 1988;21:1–24.
16. Ruckmani K, Kavimani S, Anandan R, Jaykar B. Effect of *Moringa oleifera* Lam on paracetamol-induced hepatoxicity. Indian J Pharm Sci. 1998;60:33–35.
17. Morton JF. The horseradish tree, Moringa pterygosperma (Moringaceae). A boon to arid lands. Econ Bot. 1991;45:318–333.
18. Makonnen E, Hunde A, Damecha G. Hypoglycaemic effect of Moringa stenopetala aqueous extract in rabbits. Phytother Res. 1997;11:147–148.
19. Ngamjarus C, Pattanittum P, Somboonporn C. Roselle for hypertension in adults. Cochrane Database Syst Rev. 2010;20(1):CD007894.
20. Mozaffari-Khosravi H, Jalali-Khanabadi B, Afkhami-Ardehani M, Fatehi F. Effects of sour tea (*Hibiscus sabsdariffa*) on lipid profile and lipoproteins in patients with Type II diabetes. J Altern and Comp Med. 2009;15(8):899-903.
21. Anjorin TS, Ikokoh P, Okolo S. Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. Int. J. Agric. Biol. 2010;12:431–434.
22. Memon AR, Aktoprakligul D, Zdemur A, Vertii A, Butak T. Heavy metal accumulation and detoxication mechanisms in plants. Turk. J. Bot. 2001; 25:111-121.
23. Offor IF, Ehiri RC, Njoku CN. Proximate nutritional analysis and heavy metal composition of dried *Moringa oleifera* Leaves from Oshiri Onicha L.G.A, Ebonyi State, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT). 2014; 8(1):57-62.
24. Limmatvapirat C, Limmatvapirat S, Charoenteeraboon J, Phaechamud T. Inductively coupled plasma mass spectrometric determination of heavy metals in *Moringa oleifera* Lam. Leaves. Research Journal of Pharmaceutical, Biological and Chemical Sciences (RJPBCS). 2013;4(1):161-168.
25. Mebale AJA, Ndong RO, Affane ALN, Omanda HM, Nziengui PP, Biyogo RM and Ondo JA. Assessment of metal content in leafy vegetables sold in markets of Libreville, Gabon. IJCRR. Section: Healthcare. 2014;06 (01).
26. Alexander P, Ubandoma WH. Determination of some heavy metals in selected vegetables grown along River Yedzaram in Uba area Adama State, Nigeria. African Journal of Pure and Applied Chemistry. 2014;8(4):78-82.
27. Schramm R, Heckel J. Fast analysis of traces and major elements with ED (P) XRF using polarized X-rays: Turboquant. Journal of Physics. 1998;4:335-342.
28. Spectro. XRF Fundamentals, Ametek, Spectro Analytical Equipment; 2005 Available:www.spectro.com
(Accessed: 15 January 2014)

29. Rousseau RM, Bouchard M. Fundamental algorithm between concentration and intensity in XRF analysis–2, practical application. J. Analytical Chemistry, X-ray Spectrometry. 2005;13(3):121-125.
30. IAEA. Analytical Quality Control services. Reference Material sheet for trace and minor elements in cabbage (IAEA-359). Vienna, Austria; 2000.
31. IAEA. Analytical Quality Control services. Reference Material sheet for trace elements in soil (IAEA-Soil 7). Vienna, Austria; 2000.
32. Subramanian R, Gayathri S, Rathnavel C, Raj V. Analysis of minerals and heavy metals in some medicinal plants collected from local market. Asian Pacific Journal of Tropical Biomedicine. 2012;74-78.
33. FAO/WHO. Contaminants. In Codex Alimentarius, Vol. XVII, Edition 1. FAO/WHO Codex Alimentarius Commission, Rome; 1984.
34. He FJ, MacGregor GA. Beneficial effects of potassium on human health. Physiologia Plantarum. 2008;133(4):725-735.
35. Susan A, Lanham-New. The balance of bone health: tipping the scales in favour of potassium-rich, bicarbonate-rich foods. J. Nutr. 2008;138:172S-177S.
36. Sauveur A, Broin M. Growing and processing Moringa leaves. Moringa news, Moringa Association of Ghana, France; 2010.
37. WHO. Quality Control Methods for Medicinal Plants Materials. WHO, Geneva, Switzerland; 1998.
38. Crowley J, Traynor D, Weatherburn D. Enzymes and proteins containing manganese: An overview, In: Sigel A., Sigel H., eds. Metal Ions in Biological Systems, Manganese and Its Role in Biological Processes, Marcel Dekker Inc, New York, USA. 2000;37.
39. Dey S, Saxena A, Dan A, Swarup D. Indian medicinal herb. A source of Pb and Cd for humans and animals. Arch Environ Occup Health. 2009;4:164-167.
40. Oduro I, Ellis WO, Owusu D. Nutritional potential of two leafy vegetables: *Moringa oleifera* and Ipomoea batatas leaves. Sci. Res. Essay. 2008;3(2):57-60.
41. Jongrungruangchok S, Bunrathep S, Songsak T. Nutrients and minerals content of eleven different samples of *Moringa oleifera* cultivated in Thailand. J. Health Res. 2010;24(3):123-127.
42. Obi E, Akunyili DN, Ekpo B, Orisakwe OE. Heavy metal hazards of Nigerian herbal remedies. Sci. Total Environ. 2006; 369:35-41.
43. Martin S, Griswold W. Human health effects of heavy metals. in Environmental Science and Technology Briefs for Citizens Center for Hazardous Substance Research, Manhattan, Kan, USA. 2009; 15:1–6.
44. WHO. Quality Control Methods for Medicinal Plants Materials. Revised, Geneva; 2005.
45. FAO/WHO. Energy and protein requirements. Report of a Joint FAO/WHO Ad Hoc Expert Committee; 1984.
46. Pendias AK, Pendias H. Trace elements in soils and plants. 2nd Ed. Boca Raton F1: CRC Press. 1992;365.
47. Maobe MAG, Gatebe E, Gitu L, Rotich H. Profile of heavy metals in selected medicinal plants used for treatment of diabetes, malaria and pneumonia in Kisii Region, Southwest Kenya. Global Journal of Pharmacology. 2012;6(3):245-251.
48. McGrath SP, Smith S. Chromium and nickel in heavy metals in soils. In: B.J. Alloway (ed.), Blackie, Glasgow. 1990; 125-146.
49. Gidado AA, Bertha AD, Haliru I, Ahmed A. Assessment of heavy metals from roots, barks and leaves of some selected medicinal plants (*Moringa oleifera* and *Azadirachta indica*) grown in Kashere metropolis. International Journal of Scientific Engineering and Applied Sciences. 2016;2(11):124-136.
50. Ulla R, Khader JA, Hussain I, Abd Elsalam NM, Talha M, Khan N. Investigation of macro and micro-nutrients in selected medicinal plants. African Journal of Pharmacy and Pharmacology. 2012;6(25): 1829–1832.
51. Gupta U, Copper in the environment. In: Nariagu JO, Editor. John and Sons, New York. 1975;255.
52. Fosmire GJ. Zinc toxicity. American Journal of Clinical Nutrition. 1990;51(2): 225–227.
53. Cui YL, Zhu RH, Zhi RH, Chen DY, Huang YZ, Qiu Y. Transfer of metals from soils to vegetables in an area near a smelter in Nanning, China. Environ. Int. 2004; 30:785-791.
54. Flick DF, Kray Bill HF, Dimitroff JM. Toxic effects of cadmium: A review. Environment Research. 1971;4:71-85.

55. World Health Organization (WHO). Monograph on selected medicinal plants: WHO, Geneva. 1999;1.
56. Neil PO. Minor element and environmental problems. Envr. Chem. 1993;2nd Edition.
57. Li SM, Fang Y, Ning HM, Wu YX. Heavy metals in Chinese therapeutic foods and herbs. Journal of the Chemical Society of Pakistan. 2012;34(5):1091–1095.
58. Johnson FM. The genetic effects of environmental lead. Mutation Research—Reviews in Mutation Research. 1998; 410(2):123–140.
59. Pendias AK. Trace Elements in Soils and Plants, 4th ed. CRC Press, Boca Raton, Florida, USA; 2011.
60. Pendias AK, Mukherjee AB. Trace elements from soil to human. Springer-Verlag, New York, USA. 2007;294-308.

*© 2017 Nkuba and Mohammed; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://sciencedomain.org/review-history/19215*



View publication stats