

Original Research Article

Heavy metals and essential elements in selected medicinal Plants commonly used for Medicine in Tanzania

Abstract

Several herbal 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 herbals *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 *M. oleifera* roots, in *Hibiscus sabsdariffa* (rosella calyces) 15732.03 ± 191.27 mg/kg, and 14541.08 ± 206.83 mg/kg *M. oleifera* leaves. Magnesium was the second abundant element with concentration (5058.13 ± 115.80 mg/kg in *M. oleifera* leaves, 4328.86 ± 132.85 mg/kg *Hibiscus sabsdariffa* and $1400.59.59 \pm 72.09$ mg/kg in *M. 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 *M. oleifera* roots and leaves respectively. Except Ni in all plant samples, the concentrations of other metals were below the permissible limits. 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.

Key Words: Heavy metals, Essential elements, Medicinal Plant, *Moringa oleifera*, EDXRF, *Hibiscus sabsdariffa*

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 (Kitula, 2007). At the same time, 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)[1]. These uses tend to grow over the years, both in developed and developing countries (WHO, 2004). 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 [2]. 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 (Anwar, 2007). 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 (Bhuptawat et al., 2007; Pritchard et al., 2010; Sánchez- Martín, 2010), and also possess the potential to remove cadmium from aqueous system (Sharma et al., 2006). Leaves and roots of *M. oleifera* are used for therapeutic purposes and reported to cure several disease as shown in Table 1.

Hibiscus sabsdariffa L. (Hs), 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 (Mihaljev, 2014; Tercan et al. 2016). In the West Indies the calyces can also be used as colouring and flavouring ingredient in rum (Ismail et al., 2008). 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 (Wilson and Menzel, 1964). In Tanzania, calyces are used for medicinal purposes and for making juice. A limited number of reviews on Hs are available for medicinal purposes as shown in Table 1.

Table- 1: Indigenous Medicinal herbs used in Tanzania (*Species/Botanical names, Local names, Part used and Medicinal use*)

Sample Code	Plant Species and part used	Medicinal Use/Properties
S01	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. (The Wealth of India, 1962; Padmarao et al., 1996; Dahot, 1988; Ruckmani et al., 1998)
S02	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. (Morton, 1991; Makonnen et al., 1997; The Wealth of India, 1962; Dahot, 1988)

**S03 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 (Ngamjarus et al. 2010; Khosrav 2009).

Plants have the ability to accumulate metals essential to their growth and developed from the water and soil- such as, Mg, Fe, Ms, Zn, Cu, Mo and Ni (MacLean, 1976). 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 (Anjorin et al., 2010). Some plants even have the ability to accumulate metals that have no known biological function to them, as Hg, Cr and others. The excessive accumulation of metals is toxic to most plants (Memon *et al.*, 2001). Studies shows that parts of *Moringa oleifera* were assessed for mineral composition and some heavy metal and found contenting higher levels of Ca, Mg, K, Na, Mn, Fe, Zn, Co, Se, Pb and Cd (Fakankun, 2013; Offor, 2014, Limmatuapira, 2016). 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 (Mebale et al. 2014; Mihaljev, 2014; Alexander and Ubandona, 2014). However, some heavy metals like Pb, Zn, Cd, Hg and Th are of great concern because of their potential effects on human health and environment. Therefore, considering this contamination issues and the uses of *Moringa oleifera* and *Hibiscus sabsdariffa* in Tanzania, this 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.

MATERIAL AND METHODS

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 °C for 4 days. And finally were grinded and sieved through a 2 mm-sieve into powder, packed and stored into the descator for a week to attain a constant weight before analysis

A dry weight of 12 grams of *M. 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 *M. 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.

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 ProTM 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 50W and 50kV voltage. The florescent X-rays were collected by a Si (Li) detector having a resolution (FWHM) at MnK_α $\leq$ 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) (Schramm, 1998). 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 ProTM with Turboquant (Tq 9232) algorithm for matrix effect correction (Spectro, 2005). The software corrects for the matrix effects (M_i) and the interference effects (K_i) basing on fundamental parameter methodology. The software corrects also for the background effect on a spectral line intensity (I_i), given as counts per second (cps). After all the corrections, the software converts the intensity into concentration of the element using Eq. (1) (Rousseu, 2005).

$$C_i = K_i \times I_i \times M_a \quad (1)$$

Where C_i is the concentration of a given element i ; M_a is the correction factor for matrix effects. K_i is the constant of proportionality; I_i is the intensity of the fluorescent radiation from the element i .

Quality Control

Quality control was carried out using two IAEA reference materials for Trace and Minor Elements. The first one was Cabbage (IAEA 359) [IAEA, 2000] and the second was Soil (IAEA-Soil 7) [IAEA, 2000b] both were analyzed simultaneously with the food 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.

Table 2. Experimental and recommended values (mg/kg) of reference material Trace and Minor Elements (Fe, Cu, Zn and Cd) in Cabbage (IAEA 359) and Minor Elements (Cr, As and Pb) in IAEA-Soil 7

Elements	Experimental values	Recommended Values	95 % Confidence Interval from the data sheet
Mg	76.36	60.00	49 – 77
K	10980.72	12100	
Mn	598.04	631	
Fe	150.00	148.00	144.1 - 151.9
Ni	23.78	26	
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

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 and the inferential statistics.

Basing on the fact that, the magnitude of herbs uses during recent decade for cure of various ailments is evident (WHO, 1998), and large populations which rely primarily on traditional medicine (largely herbs) to meet their primary healthcare needs are from developed countries (Fransworth and Soejarto, 1991). WHO recommends that medicinal plants which form the raw materials for the finished products may be checked for the presence of heavy metals, further it regulates maximum permissible limits of toxic metals like cadmium and lead, which amount to 0.3 mg/kg and 10 mg/kg, respectively in the final dosage form of the plant material (WHO, 1989, 1998).

The observed mean concentrations of the mineral elements in *M. oleifera* leaves (Table 2) were 5058.13 ± 116.80 , 14541.08 ± 207.83 , 73.47 ± 3.51 , 309.57 ± 8.96 , 2.25 ± 0.46 , 4.35 ± 0.68 , 19.88 ± 0.22 and 0.35 ± 0.01 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 (6.62 mg/kg) though it was below the permissible limits.

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, roots of *M. oleifera* and *Hibiscus sabsdariffa* respectively. The reported mean concentrations were 5058.13 ± 115.80 mg/kg, $1400.59.59 \pm 72.09$ mg/kg in leaves and roots of *M. oleifera*, and for *Hibiscus sabsdariffa* was 4328.86 ± 132.85 mg/kg. The lowest concentration was observed in roots of *M. oleifera* (Table 2). The concentration levels in leaves were higher than the reported values in Nigeria (Offor, 2014) and Sam Phran, Thailand (Limmatuapira, 2013). 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 (Mebale et al. 2014).

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 *M. oleifera* respectively, and 10537.02-15919.70 mg/kg in *Hibiscus sabsdariffa*. The mean concentrations of K were 14541.08 ± 206.83 mg/kg in *M. oleifera* leaves, 20882.20 ± 253.65 mg/kg in *M. oleifera* roots and 15732.03 ± 191.27 mg/kg in *Hibiscus sabsdariffa*. The highest value was observed in root of *M. oleifera* (Table 2). The mean value of K in *M. oleifera* leaves and roots were higher than 8010 mg/kg and 4750 mg/kg respectively, reported from Nigeria (Fakankun, 2013). In *Hibiscus sabsdariffa*, concentration of K was much higher than 532 mg/kg reported from Libreville in Gabon (Mebale et al. 2014).

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 (He and MacGregor, 2008). 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 (Susan and Lanham-New, 2008).

The concentrations observed for Mn in this study ranged from 59.81 to 84.08 mg/kg in *M. oleifera* leaves, with its mean value of 73.47 ± 3.51 mg/kg. For roots of *M. 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 *M. oleifera* in this study was the same as that reported in Nigeria (Offor, 2014) but higher when compared to 48.73 mg/kg reported from Thailand (Limmatuapira, 2013). In roots of *M. Oleifera*, the levels of Mn were much higher than 78.9 mg/kg reported from Nigeria (Fakankun, 2013). *Hibiscus sabsdariffa* had low concentration of Mn, when compared to 453.71 mg/kg reported from Serbia (Mihaljev, 2014). Manganese

(Mn) is a trace element necessary for plant, animal and human as enzyme cofactor (Crowley et al. 2000). 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 (Dey et al., 2009).

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 *M. oleifera* and in *Hibiscus sabdariffa*, respectively. Highest levels of Fe was reported in *Hibiscus sabdariffa* (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 *M. oleifera* (Table 2). The Fe concentration levels in *Hibiscus sabdariffa* in present study was higher than 203.4 mg/kg reported by Mersin and Mustafa (2016). The obtained Fe level of 309.57 ± 8.96 mg/kg in the leaf was almost similar (282.9 mg/kg) to that reported in Nigeria by Oduro (2008). But much higher when compared to that reported in Thailand (Limmatuapira, 2013). Also similar analysis, Jongrungruangchok et al. (2010) reported a range of 203.1 to 376 mg/kg was closer to the present study. WHO limits for Fe in medicinal plants has not been yet established.

Iron has several key functions in human body including oxygen supply, energy production and immunity. Iron overdose is associated with symptoms of dizziness, nausea and vomiting, diarrhea, joint pain and liver damage (Obi et al., 2006; Martin, 2009). Deficiency of Fe may result in anaemia.

In this study, the concentration levels of Ni in *M. oleifera* leaves was almost the same as the value (2.56 mg/kg) reported in Thailand (Limmatuapira, 2013). However, Nickel (Ni) concentrations in all analysed plant samples in the present study were above the permissible limits of 1.63 mg/kg set by FAO/WHO (1984) in plants (Table 2). Ni is required in minute quantity for body as mostly in the pancreas and hence plays an important role in the production of insulin. Its deficiency results into liver disorder (Pendias and Pendias, 1992). The daily intake of Ni is recommended to be less than 1 mg/day, beyond this it's a toxic (McGrath and Smith, 1990). Surprisingly, for medicinal plants, the WHO limits have not yet been established.

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 sabdariffa*, 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 sabdariffa*, respectively. The mean level of Cu in *M. oleifera* leaves in this study was higher to 1.02 ± 0.08 mg/kg reported in Nigeria (Offor, 2014) but the reported value (6.63 mg/kg) from Sam Phran, Thailand was higher than the levels of Cu in present study (Limmatuapira, 2013). However, for *Hibiscus sabdariffa* the levels were much lower when compared to that reported from Serbia and Nigeria (Mihaljev, 2013; Alexander and Ubandona, 2014). WHO/FAO have not yet established limits for Cu in herbal medicine (Ulla et al. 2012). China and Singapore had set limits for Cu in medicinal plants at 20 mg/kg and 150 mg/kg respectively (Ulla et al. 2012). In the present study, the concentrations of Cu in all medicinal plants were below the limits adopted from China and Singapore.

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 (Gupta, 1975). The observation of anemia in copper deficiency may probably be related to its role in facilitating iron absorption and in the incorporation of iron in hemoglobin. However, copper could be toxic depending on the dose and duration of exposure (Obi *et al.*, 2006) The results of from this paper have shown that copper concentration is not a matter of concern from the toxicity point of view for the observed herb, medicinal plants evaluated contained safe level of copper.

The concentration of Zn in the analysed plant samples ranged 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 sabdariffa*, 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 *M. oleifera* were low compared to the levels reported by Fakankun (2013) in Nigeria which were 15.7 mg/kg and 16.1 mg/kg respectively. Also the concentration level of Zn in *Hibiscus sabdariffa* was low to that reported by Mihaljev (2014) in Serbia and Alexander and Ubandona (2014) in Adama State in Nigeria. The permissible limit for Zn of 50 mg/kg set by FAO/WHO, Therefore, the levels of Zn in all analysed medicinal herbs were below the permissible limits. 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 (Fosmire, 1990).

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 *M. oleifera* leaves and roots respectively. While in *Hibiscus sabdariffa*, the concentration of Pb ranged from 2.32-8.74 mg/kg with mean value of 6.62 ± 0.13 mg/kg. The reported concentration levels of Pb in analysed medicinal plants were below the permissible limits of 10 mg/kg set by FAO/WHO []. Pb exposure may have an adverse effect on the blood, nervous, renal, skeleton muscular, reproductive and cardiovascular systems causing poor muscle coordination (Johnson, 1998).

Cadmium is a nonessential element with uncertain direct functions in both plants and humans (Ano *et al.*, 2008). It is however 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 (Neil, 1993). Cadmium accumulates in human body and damages mainly the kidneys and liver. WHO recommended limit of 0.3 mg/kg (WHO, 1999). Surprisingly Cd in medicinal plants was below detection limit in all plant samples analyzed (Table 2). Higher levels of Cd pose serious toxicological impacts on human health and ingestion via food, especially plant-based foodstuff. The kidney, especially the renal tract, is the critical organ of intoxication after exposure to Cd. Excretion is slow, and renal accumulation of Cd may result in irreversible impairment in the re-absorption capacity of renal tubules (Piscator, 1984).

Table- 3: The average concentration of heavy metals ($\mu\text{g/g} \pm \text{SD}$) in selected medicinal plants

Elements	Concentrations of Heavy Metals in ($\mu\text{g/g} \pm \text{SD}$)		
	S1: <i>Moringa oleifera</i> (leaves) <i>n</i> =5	S2: <i>Moringa oleifera</i> (roots) <i>n</i> =5	S3: <i>Hibiscus sabsdariffa</i> (calyces) (<i>n</i> =7)
Mg	5058.13 $\pm$ 116.80 (4748.79-6346.55)	1400.59 $\pm$ 72.09 (1372.42-1477.53)	4328.86 $\pm$ 132.85 (3232.76 - 4480.26)
K	14541.08 $\pm$ 207.83 (12091.05-17234.11)	20882.24 $\pm$ 254.65 (17600.36-21211.10)	15732.03 $\pm$ 191.27 (10537.02-15919.70)
Mn	73.47 $\pm$ 3.51 (59.81-84.08)	308.46 $\pm$ 10.27 (196.20-317.23)	24.16 $\pm$ 1.00 (12.07-27.09)
Fe	309.57 $\pm$ 8.96 (89.02-553.46)	556.44 $\pm$ 11.77 (246.44-572.81)	716.57 $\pm$ 48.05 (380.56 – 798.43)
Ni	2.25 $\pm$ 0.46 (0.09-4.89)	2.28 $\pm$ 0.88 (0.33-3.08)	1.98 $\pm$ 0.06 (0.98 – 2.15)
Cu	4.35 $\pm$ 0.68 (1.58-6.22)	3.26 $\pm$ 0.50 (1.20-3.79)	0.33 $\pm$ 0.13 (0 - 0.42)
Zn	19.88 $\pm$ 0.22 (8.67-23.54)	25.95 $\pm$ 0.85 (15.51-27.13)	12.67 $\pm$ 0.35 (7.09 – 15.08)
Cd	BDL	BDL	BDL
Pb	0.35 $\pm$ 0.01 (0.01-0.07)	0.77 $\pm$ 0.19 (0.36-1.05)	6.62 $\pm$ 0.13 (2.32-8.74)

Note: The values in bracket represent the range

BDL = Bellow Detection Limits

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. Although there is no available sufficient information on the level of toxic metals like Pb and Cd etc, in medicinal plants from Tanzania, several recent studies in other places in the world have reported that some medicinal plants used in China, Indopaskistan subcontinent, India, Ghana, Nigeria and Cameroon contains high levels of heavy metals and their continuous use might be toxic (Hussain *et al.*, 2006; Shad Ali Khan *et al.*, 2008; Siddique *et al.*, 2010). *M. oleifera* roots generally contains higher levels of metals that the leaves. In all plant samples Mg was higher and followed by K and then Fe. The concentration of Fe was higher in *Hibiscus sabsdariffa* than in *M. oleifera*. The results presented that there is no risk associated with consumption of analysed medicinal plants as far as the FA/WHO and other organisations recommended limits are concerned. However, the concentration of Ni in all plant samples exceeded the permissible limit and Cd was not detected. Cd it is highly toxic even at very low concentrations. Therefore, further

analysis which will include more samples is needed to have a definite statistical conclusion on the safety consumption of the analysed medicinal plants.

Also the study recommends that, closer monitoring during harvesting of those plants should be the matter of concern, also to avoid to collect plant spices from highly polluted areas (i.e. along the highways, near disposals and mine discharges). Also the application of phytoremediation can be used for home/gardened medicinal herbal plants. However herbal formulations of these analysed plant species are also be beneficial sources of appropriate and essential trace elements to humans.

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