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Profile of Heavy Metals in Selected Medicinal Plants Used for the Treatment of Diabetes, Malaria and Pneumonia in Kisii Region, Southwest Kenya

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Abstract: Medicinal herbs are sources of chemical substances that have different biological activities including those useful in the treatment of human and animal diseases. Amongst the indigenous herbs used as phytomedicines for the treatment of diabetes, malaria and pneumonia in Kisii region, Southwest Kenya are *Carissa spinarum, Urtica dioica, Warburgia ugandensis, Senna didymobotrya, Physalis Peruvian, Bidens pilosa, Leonotis nepetifolia* and *Toddalia asiatica.* A study was carried out on these herbs in the year 2011 to 2012. The objective was to determine the essential and non-essential heavy metals present in the herbs and their levels. Leaf samples of these plants were obtained from Kisii region, washed, air-dried and milled. The samples were digested by wet digestion method and analysed by atomic absorption spectrometry. The essential and non-essential heavy metals in the plant extracts were quantified. As a guideline, FAO/WHO defined the permissible limits (ppm) of the various heavy metals in the consumed medicinal herbs for different countries as: chromium (2), manganese (44.6 to 339), iron (261 to 1239), cobalt (0.14 to 0.48), nickel (1.63), copper (20 to 150), zinc (27.4), cadmium (0.3), mercury (0.1) and lead (10). Results obtained in the present study showed that extracts of the medicinal herbs investigated contain heavy metals namely iron, chromium, copper, zinc, cobalt, manganese and nickel that are considered essential elements; and lead, cadmium and mercury which are non-essential. The concentration (ppm) of heavy metals in the plant extracts was found to be as follows: chromium (0.567 to 2.035), manganese (3.254 to 17.33), iron (0.967 to 6.067), cobalt (0.967 to 6.067), nickel (0.589 to 1.60), copper (0.305 to 1.44), zinc (0.989 to 1.833), cadmium (0.035 to 0.206), mercury (0.0024 to 0.00838) and lead (0.25 to 0.407). From the comparison of the results with the defined permissible limits, it was concluded that the levels of heavy metals present in the herbs fall in the permissible range for consumed medicinal herbs as defined for different countries.

Key words: Heavy Metals · Profile · Selected Herbal Plants

INTRODUCTION

Herbs may be contaminated with heavy metals during growing in the field, processing and handling. It is important to have quality medicinal herbs in order to protect consumers from contamination WHO [1-3] and Jabeen *et al*. [4]. Herbs which are contaminated can be toxic and produce undesirable side effects [5, 6]. Heavy metals are those in their standard state and have a specific gravity of more than about 5 g cm^{-3}. Some of the heavy metals are essential in very low concentrations for the survival of all forms of life. Trace heavy metals are important in daily diets, because of their essential nutritious value and possible harmful effects [7]. Heavy metals such as iron, chromium, copper, zinc, cobalt, manganese and nickel are essential metals since they play an important role in biological systems; whereas mercury, lead and cadmium are non- essential metals which can be toxic even in trace amounts. The heavy metals namely lead, cadmium, chromium and arsenic are widely considered as potential contaminants in our environment [8]. The Contamination of medicinal herbs by heavy metals can be attributed to environmental pollution and can pose clinically relevant dangers for the health of the user and therefore should be limited [9-14].

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It has been reported that whatever is taken as herbs could cause metabolic disturbance subject to the allowed upper and lower limits of trace metals [15]. After collection and transformation of herbs into dosage form, the heavy metals confined in plants finally enter the human body and may disturb the normal functions of central nervous system, liver, lungs, heart, kidney and brain, leading to hypertension, abdominal pain, skin eruptions, intestinal ulcer and different types of cancers [15]. Both the deficiency and excess of essential micronutrients and trace of toxic metals may cause serious effects on human health [15]. The concentration of essential and non-essential heavy metals in medicinal herbs beyond permissible limit is a matter of great concern to public safety all over the world [16]. The problem is more serious in Kenya, because medicinal herbs which form the raw materials for the finished products of herbal treatment are neither controlled nor properly regulated by quality assurance parameters. The World Health Organization (WHO) recommends that medicinal plants which form the raw materials for the finished products may be checked for the presence of heavy metals. It was reported by Khan *et al.,* [15] that the maximum permissible limits of toxic metals like arsenic, cadmium and lead in consumed medicinal herbs are 1.0, 0.3 and 10 ppm, respectively. Plants may absorb heavy metals from soil, water or air. The ability of plants to selectively accumulate essential element varies in different species and is subjected to certain geochemical characteristics depending on the type of soil, Khan *et al.* [15]. In the Kisii region, Southwest Kenya, the leave decoction of *Carissa spinarum, Urtica dioica, Warburgia ugandensis, Senna didymobotrya, Physalis peruviana, Bidens pilosa, Leonotis nepetifolia* and *Toddalia asiatica*, are used for the treatment of diabetes, malaria and pneumonia [17].

The objective of the study was to determine the essential and non-essential heavy metals present in the herbs and their levels.

MATERIALS AND METHODS

Sample Collection and Preparation: In this study the leaves of the *Carissa spinarum, Urtica dioica, Warburgia ugandensis, Sennadidymobotrya, Physalis peruviana, Bidens pilosa, Leonotis nepetifolia* and *Toddalia asiatica* were collected from Kisii region, southwest Kenya. The verification of the herbal species was done by the Botanist; Egerton University. The leaves of the authenticated herbal plants were then collected from their site in Kisii region and air-dried for twelve weeks to obtain constant weight. The dried sample was cut into smaller pieces and then ground into fine particles with a grinder at the Department of Food Science and Technology, Faculty of Science, Jomo Kenyatta University of Agriculture and Technology. The powdered sample was bagged in black plastic bags and stored in an air-tight container for further work.

Wet Digestion Procedure: One gram of herbal samples was digested with 5 ml of 16 M HNO_3 in the covered beakers to near dryness. It was necessary, another 5 ml portion of 16 M HNO_3 was further added each time until the sample solutions became clear. Five millilitres of 12 M HCl were then added to ensure complete digestion. After cooling to room temperature, the digested solutions were diluted to 100 ml with deionized water for lead, cadmium and chromium. The samples were analyzed using atomic absorption spectrometry (AAS) for, iron, chromium, copper, zinc, cobalt, manganese, nickel, lead, cadmium and mercury. The procedures used are described by Okalebo [18].

Calibration of Equipment: For the elements under investigation, the following sensitivity and detection limits were established respectively for the used AAS apparatus. Cr 0.5 and 2.5 ppm, Mn 0.5 and 5.0 ppm, Fe 0.5 and 2.5 ppm, Ni 2.0 and 10.0 ppm, Co 0.5 and 5.0 ppm, Cu 0.5 and 2.5.0 ppm, Zn 0.5 and 5.0 ppm, Cd 0.2 and 1.0 ppm, Hg 0.02 and 0.08 ppm, Pb 0.5 and 2.5 ppm.

Preparation of Blank Solutions: The blank solutions were undergoing the same digestion procedure as that of the samples.

Preparation of Standard Solutions: The stock solution for Fe, Cr, Cu, Zn, Co, Mn, Ni, Pb, Cd and Hg were made from a metal salt of Analar grade (purity 99.9%). The metal salt was dissolved in dilute hydrochloric acid and diluted to the 1 litre mark using distilled water. The required concentrations were prepared by serial dilution of the stock solution.

Atomic Absorption Spectrometry (AAS) Procedure for Herbal Sample Analysis: Herbal sample analysis was carried out using atomic absorption spectrometry interfaced with computer. The samples and standards at different intervals were aspirated into an air acetylene flame and the concentration recorded in the computer.

Data Collection: The levels of heavy metals present in the extracts were expressed as mean of heavy metal concentration (ppm) ± S.D of three replicates. Calibration functions for each element was determined. Concentrations of each heavy metal in the medicinal herbs were calculated from the calibration functions.

Data Analysis: The null hypothesis being tested in the study is that there are no significant heavy metals present in the selected traditional herbs used in Kisii region to treat diabetes, malaria and pneumonia diseases. The mean and the S.D of each herbal extract were used to compute the calculated t-value. Differences between the critical t-value and calculated values of the heavy metal concentrations of the herbal extracts were computed. For all the eight herbal species, the null hypothesis was retained because the calculated t-value was less than the critical t-value at $p = 0.05$.

RESULTS AND DISCUSSION

The results analysis of the levels of heavy metal present in the selected herbs is discussed in this section and the concentration of Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Hg and Pb in the herbs is presented in (Table 1).

Chromium: The highest concentration of Chromium was found in *Physalis peruviana* 2.035 ppm, followed by *Warburgia ugandensis* 1.517 ppm, *Leonotis nepetifolia* 1.183 ppm, *Bidens Pilosa* 0.983 ppm, *Senna didymobotrya* 0.70 ppm, *Carissa spinarum* 0.733 ppm, *Toddalia asiatica* 0.583 ppm and *Urtica dioica* 0.567 ppm in that order (Table 1). For medicinal plants the WHO [3] limits for Chromium have not yet been established. Hwever, permissible limits for Chromium set by Canada were 2 ppm in raw medicinal plant material and 0.02 mg/day in finished herbal products WHO [4]. Comparison of metal levels in the medicinal plants investigated with those proposed by FAO/WHO [1] showed that the herbs have Chromium concentrations equivalent to the limits permissible in edible plants. It was observed that the herb *Physalis peruviana* with the concentration 2.035 ppm has equivalent concentration to the permissible limits for Chromium set by Canada. Also, the other selected seven herbs have concentration within permissible limits for Chromium as set by Canada [4]. Chronic exposure to chromium may result in liver, kidney and lung damage Khan *et al.,* [15]. It was also reported by Khan *et al.,*[15] that the toxic effects of Chromium intake causes skin rash, nose irritations, bleeds, upset stomach, kidney and liver damage, nasal itch and lungs cancer. However, chromium deficiency is characterized by disturbance in glucose, lipids and protein metabolism.

Manganese: Results showed that Manganese concentration is high in all herbs studied. The highest concentration of Manganese was found in *Carissa spinarum* 17.33 ppm, followed by *Warburgia ugandensis* 15.01 ppm, *Bidens Pilosa* 11.15 ppm, *Urtica dioica* 0.567 ppm, *Physalis peruviana* 6.061 ppm, *Toddalia asiatica* 6.010 ppm, *Leonotis nepetifolia* 5.761 ppm and *Senna didymobotrya* 3.254 ppm (Table 1). It was observed that *Senna didymobotrya* has comparatively lowest concentration of Manganese at 3.254 ppm. However, for medicinal herbs the WHO [3] limits not yet been established for Manganese. It was reported by Jabeen *et al*. [4] that the range of Manganese in selective medicinal herbs of Egypt in the study carried out was between

Table 1: Heavy Metal levels in herbal Plants

	Heavy metals Metal Concentration (ppm). (mean ±S.D)									
Plant species	Cr	Mn	Fe	Co	Ni	Cu	Zn	Cd	Hg	Pb
Carissa spinarum	0.73±0.2	17.3± 0.2	3.87±0.9	3.87±0.8	0.59±0.4	1.04±0.2	1.51±0.1	0.035±0.1	0.0024±0	0.25±0.1
Urtica dioica	0.567±0.1	7.25±0.1	4.03±0.3	4.03±0.6	1.16±0.3	0.83±0.03	1.67±0.1	0.21±0.	0.00453±0.1	0.27±0
Warburgia ugandensis	1.517±0.8	15.01±0.1	0.97±0.2	0.97±0.3	0.83±0.1	0.31±0	1.14±0	0.04±0	0.00265±0.9	0.38±0.1
Senna didymobotrya	0.75±0.2	3.25±0.6	4.07±0.5	4.07±0.2	0.84±0.1	0.96±0.3	1.16±0	0.04±0	0.00289±0.5	0.33±0.1
Physalis peruviana	2.035±0.7	6.06±0.1	3.17±0.2	3.17±0.1	1.03±0.8	1.44±0	0.99±0.1	0.06±0	0.00572±0.2	0.41±0.3
Bidens pilosa	0.983±0.8	11.15±0.2	2.9±0.4	2.9±0.4	1.6±0.2	1.33±0.3	1.83±0.2	0.10±0	0.00651±0.2	0.32±0.2
Leonotis nepetifolia	1.18±0.1	5.76±0.1	6.07±0.7	6.07±0.7	1.06±0.6	0.93±0	1.15±0.1	0.06±0	0.00838±0.5	0.17±0.1
Toddalia asiatica	0.58±0.3	6.01±0.1	3.4±0.4	3.4±0.7	0.84±0.8	1.06±0.1	0.74±0.1	0.10±0	0.00683±0.4	0.15±0.1

44.6 to 339 ppm. The concentration of all the selected eight herbs is in the range of 3.254 to 17.33 (ppm), indicating that the concentration of the eight studied herbs is within normal level for the element in selective medicinal herbs of Egypt. Deficiency of Manganese in human causes myocardial infection and other cardiovascular diseases, also disorder of bony cartilaginous growth in infants and children and may lead to immunodeficiency disorder and rheumatic arthritis in adults, Khan *et al.* [15].

Iron: The results revealed that highest concentration of iron in the herbs studied was found in *Leonotis nepetifolia* 6.067 ppm, followed by *Senna didymobotrya* 4.067 ppm, *Urtica dioica* 4.033ppm, *Carissa spinarum* 3.867ppm, *Toddalia asiatica* 3.4ppm, *Physalis peruviana* 3.167ppm, *Bidens Pilosa* 2.9ppm and *Warburgia ugandensis* 0.967ppm. The range of iron in the studied herbs was lowest in *Warburgia ugandensis* 0.967ppm and highest in *Leonotis nepetifolia* 6.067ppm (Table 1). The permissible limit set by FAO/WHO [1] in edible plants was 20 ppm. After comparison, metal limit in the studied medicinal herbs with those proposed by FAO/WHO [1] it was found that all herbs have iron below this limit. However, for medicinal plants the WHO limits not yet been established for iron. It was reported by Jabeen *et al*. [4] that the range of iron in selective medicinal herbs of Egypt in the study carried out was between 261 ppm to 1239 ppm. However, the concentration of the selected eight studied herbs is within normal range for the element in selective medicinal herbs of Egypt. Iron is an essential element for human beings and animals and is an essential component of haemoglobin. It facilitates the oxidation of carbohydrates, protein and fat to control body weight, which is very important factor in diabetes Ullah *et al.,* [9]. Iron is necessary for the formation of haemoglobin and also plays an important role in oxygen and electron transfer in human body Ullah *et al.* [9]. Low iron content causes gastrointestinal infection, nose bleeding and myocardial infection Ullah *et al.* [9].

Nickel: Results obtained showed that maximum concentration of nickel was found in *Bidens Pilosa* 1.6ppm, followed by *Urtica dioica* 1.156ppm, *Leonotis nepetifolia* 1.056 ppm, *Physalis peruviana* 1.033 ppm, *Senna didymobotrya* 0.844 ppm, *Toddalia asiatica* 0.844ppm, *Warburgia ugandensis* 0.833ppm and *Carissa spinarum* 0.589 ppm. It was observed that *Carissa spinarum* has lowest nickel of 0.589 ppm and *Bidens Pilosa* has highest nickel of 1.6ppm (Table 1). It was reported by Jabeen *et al*. [4] that the permissible limit set by FAO/WHO [1] in edible plants was 1.63 ppm. After comparison, metal limit in the studied medicinal herbs with those proposed by FAO/WHO [1] it was found that selected seven herbs have nickel below the limit of edible plants, but *Bidens Pilosa* has nickel at equivalent permissible limit of edible plants. However, for medicinal plants the WHO limits not yet been established for nickel. The nickel toxicity in human is not a very common occurrence because its absorption by the body is very low Jabeen *et al*. [4]. The most common ailment arising from nickel is an allergic dermatitis known as nickel itch, which usually occurs when skin is moist, further more nickel has been identified as a suspected carcinogen and adversely affects lungs and nasal cavities. Although nickel is required in minute quantity for body as it is mostly present in the pancreas and hence plays an important role in the production of insulin. Its deficiency results in the disorder of liver Khan *et al.* [15].

Cobalt: The concentration level of cobalt in the selected medicinal herbs was found highest in *Leonotis nepetifolia* 6.067ppm, followed by *Senna didymobotrya* 4.067 ppm, *Urtica dioica* 4.033ppm, *Carissa spinarum* 3.867ppm, *Toddalia asiatica* 3.4ppm, *Physalis peruviana* 3.167ppm, *Bidens Pilosa* 2.9ppm and *Warburgia ugandensis* 0.967ppm. *Leonotis nepetifolia* has higher cobalt concentration of 6.067 ppm while *Warburgia ugandensis* recorded the minimum accumulation of 0.967 ppm (Table 1). There are no regulatory limits by WHO/FAO for cobalt content in herbal plants and preparations. It was reported by Jabeen *et al.,* [4] that the study carried out in seven herbs in Turkey determined cobalt concentration ranged between 0.14 ppm to 0.48 ppm. However, the selected herbs from Kisii region Southwest Kenya have high cobalt concentration ranges between 0.967 ppm to 6.067 ppm than that recorded by seven herbs in Turkey. At low concentrations cobalt play prominent role in the formation of cyanocobalmin – vitamin B 12, an essential vitamin in man Ullah *et al.,* [9].

Copper: The highest concentration of copper was found in *Physalis peruviana* 1.44 ppm, followed by *Bidens Pilosa* 1.328 ppm, *Toddalia asiatica* 1.058 ppm, *Carissa spinarum 1*.039 ppm, *Senna didymobotrya* 0.959 ppm, *Leonotis nepetifolia* 0.933 ppm, *Urtica dioica* 0.827ppm and *Warburgia ugandensis* 0.305 ppm (Table 1). The lowest concentration of copper observed was 0.305 ppm in *Warburgia ugandensis* and highest concentration was recorded as 1.44 ppm in *Physalis peruviana* (Table 1).

It was reported by Jabeen *et al*., [4] that the permissible limit set by FAO/WHO [1] in edible plants was 3.00 ppm. After comparison, metal limit in the studied medicinal herbs with those proposed by FAO/WHO, it is found that all the selected herbs from Kisii region Southwest Kenya have copper below the permissible limit set by FAO/WHO in edible plants. However, for medicinal herbs the WHO [3] limits not yet been established for copper. Although in medicinal plants, permissible limits for copper set by China and Singapore, were 20 ppm and 150 ppm respectively (WHO) [3]. The selected eight herbs were found to have permissible limits for copper below that set by China and Singapore. It was reported by Jabeen *et al*. [4] that the range of copper contents in the 50 medicinally important leafy materials growing in India was 17.6 ppm to 57.3 ppm. The high levels of copper may cause metal fumes fever with flue like symptoms, hair and skin decolouration, dermatitis, irritation of the upper respiratory tract, metallic taste in the mouth and nausea. Copper deficiency results in anaemia and congenital inability Ullah *et al.* [9].

Zinc: Results obtained show that high concentration of zinc was found in *Bidens Pilosa* 1.833ppm followed by *Urtica dioica* 1.661 ppm, *Carissa spinarum* 1.513 ppm, *Senna didymobotrya* 1.160 ppm, *Leonotis nepetifolia* 1.148 ppm, *Warburgia ugandensis* 1.139 ppm, *Physalis peruviana* 0.989 ppm and *Toddalia asiatica* 0.736 ppm (Table 1). It was reported by Jabeen *et al*. [4] that the permissible limit set by FAO/WHO) in edible plants was 27.4 ppm. The zinc concentration in the selected eight herbs analysed ranges between 0.736 ppm to 1.833 ppm compared to 27.4 ppm permissible limit set by FAO/WHO [1] in edible plants. Therefore the zinc concentration in the eight herbs is below permissible limit set by FAO/WHO [1] in edible plants. Zinc is an essential trace element and plays an important role in various cell processes including normal growth, brain development, behavioural response, bone formation and wound healing. Zinc deficient diabetics fail to improve their power of sensitivity and cause loss of sense of touch and smell Jabeen *et al*. [4]. Dietary limit of Zn is 100 ppm as reported by Jabeen *et al*. [4].

Cadmium: Results obtained show that high concentration of cadmium was found in *Urtica dioica* 0.206 ppm, followed by *Toddalia asiatica* 0.104 ppm, *Bidens Pilosa* 0.1008 ppm, *Physalis peruviana* 0.063 ppm, *Leonotis nepetifolia* 0.061 ppm, *Warburgia ugandensis* 0.041 ppm, *Senna didymobotrya* 1.160 ppm and *Carissa spinarum* 0.035 ppm (Table 1). It was reported by Jabeen *et al*. [4] that the permissible limit set by FAO/WHO [1] in edible plants was 0.21 ppm. However, for medicinal herbs the permissible limit for cadmium set by WHO, China and Thailand was 0.3 ppm. Similarly, permissible limits in medicinal plants for cadmium set by Canada were 0.3 ppm in raw medicinal plant material and 0.006 mg/day in finished herbal products WHO [3]. After comparison, metal limits in the studied eight medicinal herbs with those proposed by FAO/WHO [3] it was found that all studied eight herbs have cadmium below the permissible limit set by WHO, Canada, China and Thailand. Cadmium causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and immune system Jabeen *et al*. [4].

Mercury: Results obtained indicate that the highest concentration of mercury was found in *Leonotis nepetifolia* 0.00838ppm, followed by *Toddalia asiatica* 0.006833ppm, *Physalis peruviana* 0.00572ppm, *Bidens Pilosa* 0.006507ppm, *Urtica dioica* 0.004533ppm, *Senna didymobotrya* 0.002887ppm, *Warburgia ugandensis* 0.002653ppm and *Carissa spinarum* 0.0024ppm (Table 1). The lowest concentration of mercury observed was 0.0024 ppm in *Carissa spinarum* and highest concentration was recorded as 0.00838ppm in *Leonotis nepetifolia* (Table 1). It was reported by Jabeen *et al*. [4] that the permissible limit set by FAO/WHO [(1] in edible plants was 0.02 ppm and in medicinal herbs was 0.1 ppm. After comparison, metal limit in the studied medicinal herbs with those proposed by FAO/WHO [1] it is found that selected eight herbs have mercury below permissible limit set by FAO/WHO [1] in herbal medicine. Exposures to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys and developing foetus. The effects on brain functioning result in irritability, shyness, tremors, changes in vision or hearing and memory problems. Exposure to methyl mercury is worse for young children than for adults, because more of it passes into children's brains where it interferes with normal development, Vaikosen and Alade. [19].

Lead: Results obtained show that highest concentration of lead was found in *Physalis Peruviana* 0.407ppm, followed by *Warburgia ugandensis* 0.380 ppm, *Senna didymobotrya* 0.326ppm, *Bidens Pilosa* 0.315ppm, *Urtica dioica* 0.267ppm, *Carissa spinarum* 0.25 ppm, *Leonotis nepetifolia* 0.166ppm and *Toddalia asiatica* 0.148ppm. The herb *Physalis Peruviana* exhibited higher lead concentration of 0.407ppm and *Toddalia asiatica* possess minimum concentration of lead 0.148ppm (Table 1). It was reported by Jabeen *et al*., [4] that the permissible limit set by FAO/ WHO [1] in edible plants was 0.43ppm. The WHO [3] prescribed limit for lead contents in herbal medicine is 10 ppm while the dietary intake limit for lead is 3 mg/week. However, for medicinal herbs limit was 10 ppm set by China, Malaysia, Thailand and WHO. Similarly plants with those proposed by WHO [3] it was found that all the selected eight herbs have Lead below permissible limit set by China, Malaysia, Thailand and FAO/ WHO. Lead causes both acute and chronic poisoning and also poses adverse effects on kidney, liver, vascular and immune system Jabeen *et al*. [4]. Lead is non-essential trace elements having functions neither in human's body nor in plants. They induce various toxic effects in humans at low doses. The typical symptoms of lead poisoning are colic, anemia, headache, convulsions and chronic nephritis of the kidneys, brain damage and central nervous system disorders, Khan *et al.* [15].

CONCLUSIONS

The extracts of medicinal herbs investigated contain heavy metals namely iron, chromium, copper, zinc, cobalt, manganese and nickel that are considered essential elements; and lead, cadmium and mercury which are non-essential. The concentration (ppm) of heavy metals in the plant extracts was found to be as follows: chromium (0.567 to 2.035), manganese (3.254 to 17.33), iron (0.967 to 6.067), cobalt (0.967 to 6.067), nickel (0.589 to 1.60), copper (0.305 to 1.44), zinc (0.989 to 1.833), cadmium (0.035 to 0.206), mercury (0.0024 to 0.00838) and lead (0.25 to 0.407). From the comparison of the results with the defined permissible concentration limits, it was concluded that the levels of heavy metals present in the herbs fall in the permissible range for consumed medicinal herbs, described for different countries.

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