Evaluation of essential and non-essential elemental composition of commonly used medicinal plants from district Peshawar, Khyber Pakhtunkhwa, Pakistan

khan malook (✉ malook.btni@yahoo.com)

University of Peshawar <https://orcid.org/0000-0003-3607-7774>

Ihsan Ul Haque

University of Peshawar

Research Article

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Abstract

This study illustrates a profile of some essential and non-essential elements (Na, K, Mg, Ca, Cu, Zn, Mn, Fe, Pb, Cr, Cd, Co, Al and Sn) in the aerial parts of six medicinal plants i.e *Coriandrum sativum* (P-1), *Mentha spicata* (P-2), *Papaver somniferum* (P-3), *Calotropis gigantean* (P-4), *Withania coagulans* (P-5) and *Fagonia arabica* (P-6) widely consumed in district Peshawar, the capital city of Khyber Pakhtunkhwa, Pakistan. The samples were converted into liquid state *via* wet digestion method and analyzed for elemental composition by using atomic absorption spectrometry. After determining the concentration, hazard quotient (HQ) was calculated for the elements having available maximum permissible limit set by FAO/WHO or any other agency for 50 mg daily intake of the herbal plants by a person of body mass 70 kg. K/Na ratio for the studied plants varied between 14.88:1 and 113.75:1 which was in agreement with the reported permissible range. The amount of Mg, Ca, Cu and Co was within the permissible limit in all the enlisted plants. However, the HQ value for Mg and Ca was greater than the safe limit for some of the plants. The concentration and HQ value of Zn, Mn, Fe, Pb, Cr and Cd was beyond the permissible and unsafe limits for almost all the plants. This study suggests that the plants of this area must be pretreated for lessening the concentration of some elements before consumption.

Introduction

Herbal drugs derived from traditional medicinal plants are used for the treatment of various human ailments across the globe since ages. The unaffordable cost and side effects of allopathic medicines upon prolong usage (Hoareau and DaSilva 1999; Leonti et al. 2013) promoted the interest in phytomedicines as being safer and congenial to the human body (Asiimve et al. 2014). According to the World Health Organization (WHO), in much of the developing world, around 70–90% of human population depend on herbal medicines and natural remedies for primary care (WHO 2011). Medicinal plants are used in various forms. Some of them are used directly while others are used for the preparation of various herbal drugs. Similarly, some of the medicinal plants are also used as raw materials to synthesize other medicines (Hardy 2018).

Medicinal plants are composed of both organic and inorganic constituents (Jyothsna et al. 2020). Inorganic elements play a vital role in the formation of active chemical constituents of medicinal plants and are therefore responsible for their medicinal as well as toxic characteristics (Abugassa et al. 2008). Inorganic elements are very important components in the plants for different psychological activities and production of enzymes within certain permissible limits (Sattar et al. 2012). The dosage of herbal drugs prepared from medicinal plants can also be decided based on their essential elemental content such as Fe, Zn, Cu, Cr etc. However, due to the content of some of the non-essential elements such as Pb, Cd etc. safety also continues to be a major issue with the excessive consumption of these plants (Cindric et al. 2013). Therefore, plants used in therapeutics should be screened for the content of toxic elements. Elemental content of plants is influenced by several factors such as application of fertilizers, vicinity of industries, agricultural activities, ability of herbal plants to accumulate elements, plants environment including water, air and geochemical characteristics of soil (Pytlakowska et al. 2012; Nookabkaew et al.

2006). Therefore, a great diversity can be found in the elemental content of herbal plants from different geographical locations (Arceusz et al. 2010; Aksuner et al. 2012; Zengin et al. 2008).

The aim of the current study was to investigate the elemental composition of six commonly used medicinal plants of district Peshawar which is the capital city of Khyber-Pakhtunkhwa, Pakistan. The plants were selected based on their usage value and frequency of citation. The concentration of elements such as Na, K, Mg, Ca, Cu, Zn, Mn, Fe, Pb, Cr, Cd, Co, Al and Sn was determined in the selected medicinal plants using atomic absorption spectrometry.

Materials And Method

Reagents and solutions

Analytical grade reagents such as HNO_3 and HClO_4 procured from Sigma-Aldrich (Germany) through local supplier were used in the experiments. All the solutions were prepared in double distilled water (DDW).

Samples preparation

Aerial parts of the medicinal plants including *Coriandrum sativum*, *Mentha spicata*, *Papaver somniferum*, *Calotropis gigantean*, *Withania coagulans* and *Fagonia arabica* were used for investigation of their elemental composition. The detail of collected samples is given in table 1. All the plants materials except poppy seeds were collected freshly from the field. Poppy seeds were acquired from the local market. The samples were first washed with tap water to remove dust particles and other removable impurities followed by rinsing with DDW and then drying at 100 °C in an oven. The dried materials were powdered with electric blender. Then, 0.5 gm each of the sample was taken in 100 mL volumetric flask and added 10 mL of concentrated nitric acid. The samples were heated on hotplate until production of red NO_2 fumes ceased. After cooling, 3 mL of 70 % HClO_4 was added to each volumetric flask and heated to evaporate to a small volume. The liquid samples were transferred into 50 mL volumetric flasks and diluted upto the mark with DDW. The final solutions were analyzed for the elements of interest using Atomic Absorption Spectrometry (AAnalyst 700, Perkin Elmer, USA) with relevant hollow cathode lamp.

Table 1 Detail of the selected medicinal plants

No	Botanical Name	English name	Applications	Part used	Sample coding	Medicinal uses
1	<i>Coriandrum sativum</i>	Coriander	Dhaniya	Leaves	P1	Hernia, nausea, bowel spasms, diarrhea
2	<i>Mentha spicata</i>	Mint	Podina	Leaves	P2	indigestion, anxiety, fatigue, cold, flue
3	<i>Papaver somniferum</i>	Poppy	khashkhash	Seeds	P3	Constipation, cough, diarrhea, diabetes
4	<i>Calotropis gigantea</i>	Milkweeds	Aak	Leaves	P4	arthritis, anticancer antidote for snake bite,
5	<i>Withania coagulans</i>	Vegetable rennet	Paneer	Seeds	P5	Constipation, diarrhea cough, Asthma
6	<i>Fagonia arabica</i>	Cretan Prickly Clover	Dhamasa	Branches	P6	anticancer, antiviral, asthma, blood purification

Standard and blank solutions:

For quantitative determination, corresponding standard calibration curve of each element was developed. The working standard solutions for developing standard calibration curves were prepared by diluting known volume of stock solutions (1000 µg. L⁻¹) provided by Perkin Elmer, USA. The blank solution was prepared by the same procedure used for the samples preparation except adding elements of interest.

Quality assurance

Apposite quality assurance procedures and precautions were taken to ensure the consistency of the results. Glassware was cleaned and analytical grade reagents were used. Samples were handled carefully to avoid any external contamination. Standard solutions and blanks were run at regular intervals to monitor reliability and reproducibility in the instrument performance.

Calibration of the equipment

Before starting the sample analysis, the following wavelength, sensitivity, limit of detection (LOD) and limit of quantification (LOQ) were respectively fixed for the equipment as shown in Table 2.

Table 2 Working parameters of atomic absorption spectrophotometer

Element	Wavelength (nm)	Sensitivity ($\mu\text{g.g}^{-1}$)	LOD ($\mu\text{g.g}^{-1}$)	LOQ ($\mu\text{g.g}^{-1}$)
Na	589.0	0.5	0.003	0.009
K	766.5	2.0	0.03	0.009
Mg	285.2	0.3	0.0015	0.004
Ca	422.7	4.0	0.015	0.04
Cu	324.8	4.0	0.015	0.04
Zn	213.9	1.0	0.015	0.04
Mn	279.5	2.5	0.015	0.04
Fe	248.3	6.0	0.005	0.015
Pb	283.3	20.0	0.015	0.04
Cr	357.9	4.0	0.003	0.009
Cd	228.8	1.5	0.008	0.024
Co	240.7	7.0	0.009	0.03
Al	309.3	50.0	0.45	1.4
Sn	286.3	150.0	0.15	0.45

Atomic absorption spectrophotometry (AAS) procedure

Before analyzing the samples, a blank solution was aspirated into air-acetylene or N_2O -acetylene flame to set the instrument signal at zero. N_2O -acetylene flame was used for Al and Sn detection only. Afterward, three working standard solutions of each element of interest were aspirated into the flame to obtain calibration curve. Then, each sample was analyzed and the concentration value was recorded *via* WinLab32 software. Whenever, the concentration of an element in a sample was beyond the highest standard of calibration curve, a known volume of the solution was diluted with DDW to bring the concentration into the working range. The obtained results were then multiplied with dilution factor to obtain results in the original samples.

Recovery analysis

Recovery analysis was done by spiking the samples with standard solution of each metal ion. The percent recovery was calculated according to the given equation 1 and the result is presented in Table 3.

$$\% \text{ Recovery} = \frac{C1 - C2}{C3} \times 100 \quad (1)$$

Where,

C1: Concentration of spiked sample

C2: Concentration of unspiked sample

C3: Concentration of standard solution added

Table 3 % Recovery of the elements from the spiked solutions

Element	% Recovery					
	P1	P2	P3	P4	P5	P6
Na	99.65	100	99.47	98.54	99.68	99.87
K	100.01	100	99.87	98.58	98.69	100
Mg	98.78	99.85	98.16	100.02	100	99.89
Ca	99.87	98.58	99.46	99.68	99.87	98.98
Cu	98.87	100.00	99.68	98.59	99.87	99.68
Zn	100.00	100.2	99.89	99.78	9.16	98.58
Mn	99.87	98.87	99.62	99.78	99.38	98.78
Fe	100.3	99.12	99.87	98.45	99.86	98.96
Pb	99.98	99.81	98.97	98.97	98.78	99.89
Cr	98.35	98.25	100.1	99.89	99.75	99.65
Cd	99.89	99.82	99.36	98.78	99.69	98.25
Co	100.00	99.99	100	99.29	99.98	98.69
Al	99.87	98.56	99.89	99.74	98.58	100
Sn	98.58	98.32	99.56	100.2	99.87	99.88

Conversion of instrument data into mg. kg⁻¹

The instrument data was obtained in mg. L⁻¹ which was converted into mg. kg⁻¹ according to the equation 2;

$$\text{Element (mg. kg}^{-1}\text{)} = \frac{\text{mg. L}^{-1} \text{ in solution} \cdot V \cdot D.F}{\text{Sample weight in grams}} \quad (2)$$

Where; V = Volume of solution, D.F = Dilution factor

Health risk assessment

To carry out the health risk assessment analysis, around two hundred locals were interviewed regarding daily ingestion of the enlisted plants. Unfortunately, majority of the participants were not sure about the daily intake of the mentioned plants. Similarly, in most of the cases, there was enormous difference in the amount of daily intake of the herbal plants. Therefore, it was decided to consider 50 mg daily intake of the dry herbal plant material by a person of 70 kg. From these values, hazard quotient (HQ) was calculated for the element having available maximum permissible limit set by FAO/WHO or any other agency according to the equation 3 (Chary et al. 2008);

$$HQ = W_{\text{plant}} \times \frac{M_{\text{plant}}}{R_f D \times B} \quad (3)$$

HQ < 1 is safe while HQ ≥ 1 is unsafe (Chary et al. 2008).

In the above equation, W_{plant} is the dry weight of the plant material consumed (mg/day) (here 50 mg), C_{plant} is the concentration (mg. kg⁻¹) of the metal in the plant, $R_f D$ is the maximum permissible limit of the element and B is the body weight (kg) (here 70 kg). The results are inserted in the table 4(a-b) along with the concentration of each element.

Results And Discussion

Elemental composition of the above mentioned plants was studied and the results are depicted in table 4 (a-b). The presented results are the mean values of three readings and are based on the dry weight of the samples. From the % recovery study, the reported data has been corrected accordingly. Concentration of the elements in the studied plants has also been presented graphical in Fig.1. The concentration of light metals (Na, K, Mg, Ca), heavy metals (Cu, Zn, Mn, Pb, Cr, Cd, Co) and Fe has been depicted separately due to the greater variation in their amount. The content of Al and Sn was below the detection limit; therefore, their concentration has not been shown in the figure (Fig.1). The detail of elements in each plant is given as;

Sodium (Na) and Potassium (K)

Both sodium and potassium are the major electrolytes predominantly exists in extracellular and intercellular fluids, respectively. Na and K works in conduction of nerve impulses, muscle contraction and acid –base balance (Soetan et al. 2010). In the current study, highest concentration (3644.87 mg. kg⁻¹) of sodium was found in sample P4 while the minimum concentration i.e 72.12 mg.kg⁻¹ was detected in sample P1. Sodium content was also found in P2, P3, P5 and P6 having concentration 118.23 mg. kg⁻¹, 158.10 mg. kg⁻¹, 186.59 mg. kg⁻¹ and 396.74 mg.kg⁻¹, respectively. All the samples have significant quantity of K with maximum amount of 54246.65 mg.kg⁻¹ in P4 and minimum content of 3474.38 mg.kg⁻¹ in P6. The other plants P1, P2, P3 and P5 also contained appreciable amount of K having value 8190.21 mg. kg⁻¹, 7154.50 mg. kg⁻¹, 5216.70 mg.kg⁻¹ and 9820.58 mg. kg⁻¹, respectively. K/Na ratio is used to characterized diuretic activity of medicinal plants (Aziz et al. 2016). The K/Na ratio for the studied plants varied between 14.88:1 and 113.75:1 which are in agreement with the reported values and within the permissible range (Szentmihalyi et al. 1998). K content of the studied medicinal plants is high. Therefore, the enlisted plants must be taken carefully as K can accumulate in human body because of its greater uptake which results in hyperkalemia having symptoms such as cardiac arrest, dilatation of the heart and bowel ulcer (Soetan et al. 2010).

Magnesium (Mg)

Mg plays an important role in several body activities such as enzymatic activities, proper body growth, formation and function of bones and muscles (Murray et al. 2000). Though, there is no established permissible limit for Mg uptake. However, upto 400 mg/day uptake of Mg is considered to be safe for human body (Duruibe et al. 2007). Similarly, as per Food and Nutrition Board recommendation, daily uptake of Mg for female is 300 mg/day and 350 mg/day for male (EGVM 2003). In the studied plants, Mg varied from 600.23 mg. kg⁻¹ in P1 to 5334.54 mg. kg⁻¹ in P4. The amount of Mg in other plants was P2 1302.45 mg. kg⁻¹, P3 4722.58 mg. kg⁻¹, P5 1408.65 mg. kg⁻¹, and P6 1544.74 mg. kg⁻¹. The HQ value of Mg for P3 and P4 was higher than the safe limit. Mg content in leaves of *Withania coagulans* in the current study is higher than the one reported elsewhere (19.22 mg. kg⁻¹) (Hameed and Hussain 2015). This difference may be due to a number of environmental and edaphic factors.

Calcium (Ca)

Ca is an essential element for healthy bones, teeth, blood, muscles and nerves. Ca also overcome the problem of high blood pressure, heart attack, colon cancer and premenstrual syndrome (Vander et al. 2001). Daily upper intake level of Ca in herbs is 2500 mg/day (Lesniewicz et al. 2006). However, higher doses of Ca can result in adverse effects on human body. In this study, the concentration of Ca ranged from 1182.28 mg. kg⁻¹ in P5 to 12880.87 mg. kg⁻¹ in P3. The HQ value of Ca in P1 and P4 was within safe limit. While for P2, P3, P5 and P6, HQ value was greater than the safe limit.

Copper (Cu)

Copper is an essential element for human health as it is a necessary part of several enzymes. Cu plays important role in various physiochemical activities such as elimination of free radicals, development of bone and connective tissues and utilization of iron etc. However, excessive uptake of Cu may cause liver damage, vomiting, diarrhea and dermatitis (Martin and Griswold 2009). In the studied medicinal plants, maximum concentration of Cu was found in P1 and P3 (20.45 and 20.78 mg. kg⁻¹) while the minimum concentration was detected in P6 (9.64 mg. kg⁻¹). Thus, the content of Cu varied in a small range (9 to 20 mg. kg⁻¹). The other medical plants P2, P4 and P5 has Cu content 18.65, 10.94 and 10.57 mg. kg⁻¹ respectively. Singapore has set limit for Cu in medicinal plants at 150 mg. kg⁻¹ (Ullah et al. 2012). The HQ value of Cu was within safe limit for all the studied plants. Thus, according to this study, the Cu content of the plants is within permissible limits and safe for usage.

Zinc (Zn)

Zinc is necessary element of great importance for animals, plants and human beings. A number of metalloenzymes involved in all metabolic activities are Zn based. Zn plays essential role in tissue mending, wound curing, optimum action of insulin, protein synthesis, digestion and an important constituent of plasma (Malhotra 1998). On the other hand, excess amount of Zn also causes several diseases such as jaundice, vomiting, fever and faintness (Hasan 2011; Karahan et al. 2020). As per FAO/WHO recommendations, the maximum permissible limit of Zn in edible plants is 27.4 mg. kg⁻¹ (FAO/WHO 1984). The concentration of Zn in the current study range from 20.82 in P4 to 50.35 mg.kg⁻¹ in P2. The other plants P1, P3, P5 and P6 has 30.54, 44.74, 30.64 and 36.32 mg.kg⁻¹ of Zn respectively. The HQ value of Zn for P2 and P3 was higher than the recommended limit. Other plants P1, P4, P5 and P6 have safe HQ values.

Manganese (Mn)

Mn is also among the essential trace elements and is involved in the activation of many enzymes such as kinases, hydrolases, transferases and decarboxylases (Kulal et al. 2020). The permissible limit of Mn in medicinal plants is 2 mg. kg⁻¹ (FAO/WHO 1984). In the current studied plants, the amount of Mn range from 9.98 in P5 to 86.28 mg. kg⁻¹ in P4. Other plants P1, P2, P3 and P6 has 62.32, 33.53, 43.74 and 20.89 mg. kg⁻¹ of Mn. Thus, all the studied plants have Mn content beyond the permissible limit. Similarly, the HQ value of Mn was also beyond the safe limit for the enlisted plants. Over doses of Mn may results in adverse effects on the brain, lungs and central nerve system (CNS) (Tan et al. 2006).

Iron (Fe)

Iron is an important component of hemoglobin and plays crucial role in the multiple physical functions of tissues including oxygen transport, metabolism, neurological functions, synthesis of DNA and electron transportation (Kaya and Incekara 2000; Grzelak et al. 2020). The permissible limit of iron set by FAO/WHO in edible plants is 20 mg. kg⁻¹ (FAO/WHO 1984). Concentration of iron beyond this limit may cause several health issue such as risk of colon cancer, hemosiderosis due to its accumulation of iron in

liver, lungs, pancreas and other tissues. Fe content of the current plants range from 307.12 mg. kg⁻¹ in P2 to 67.35 mg. kg⁻¹ in P3. Other plants P1, P4, P5 and P6 have 272.85, 201.89, 302.68 and 229.94 mg. kg⁻¹ of iron. Thus, all the studied plants have iron content beyond the normal permissible limit. Similarly, the HQ value of Fe was also beyond the safe limit for the investigated plants

Lead (Pb)

Pb is non-essential element as it has no physiological function in human body and is toxic for both human body and environment even at low concentration (Haider et al. 2004). Pb is dangerous particularly for children before and after birth and should be considered a high risk factor for public health (Baldwin and Marshall 1999). It can cause adverse effects on liver, kidney, immune system, blood pressure and nervous system (Hayes 1997). The permissible limit of Pb in edible plants is 10 mg.kg⁻¹ (WHO 1999). In this study, Pb was detected in all the plants except P2 and P3. The other plants P1, P4, P5 and P6 have 13.48, 32.25, 48.53 and 34.84 mg. kg⁻¹ of Pb. Thus, the detected amount of Pb is higher than the permissible limit. Furthermore, though the calculated HQ value for P1, P2 and P3 was within safe limit however it was beyond the recommended limit for P4, P5 and P6. The higher content of Pb in these plants is an alarming situation. These plants must be properly treated for Pb removal before usage.

Chromium (Cr)

Cr is considered as essential or toxic element for human body depends upon daily intake, oxidation state and biodegradability (Grun et al. 1993). Cr is a trace element and is required for metabolism of cholesterol, fats and glucose (Anderson 1998). The permissible limit of Cr in edible plants is 0.02 mg. kg⁻¹. Chromium consumption beyond permissible limit can cause diarrhea, asthma, allergy and even lung cancer (Moreira et al. 2018). In the enlisted plants, the concentration of Cr range from 9.58 mg.kg⁻¹ in P5 to 24.74 mg. kg⁻¹ in P2. The other plants P1, P3, P4 and P6 have 11.25, 17.35, 14.35 and 11.69 mg. kg⁻¹ of Cr, respectively. Thus, all the investigated plants have Cr concentration beyond the permissible limit. Similarly, the HQ value of Cr was far away from the safe limit.

Cadmium (Cd)

Cd is a nonessential element for human body as it has no specific physiological function. The permissible limit of Cd set by WHO in edible plants is 0.3 mg. kg⁻¹. In case of ingestion in higher quantity, it can accumulate in different parts of human body creating various complications such as liver damaging, affecting normal functioning of kidneys, and osteoporosis (Lin et al. 2015). The concentration of Cd was from 0.0 in P5 & P6 to 20.74 mg. kg⁻¹ in P3. The other plants P1, P2, and P4 have 6.65, 2.12 and 3.52 mg. kg⁻¹ of Cd respectively. Thus, the content in plants from P1, P2 and P4 was beyond the permissible limit. The HQ value of Cd was also outside the safe limit for P1-P4.

Cobalt (Co)

Cobalt is an essential micronutrient and is the main constituent of Cobalamin (Vitamin B12) which has a significant role in human body. In case of medicinal plants there is no established criterion regarding the recommended dosage of Co. However, at higher concentration, Co becomes toxic and can create several human health related issues (Gal et al. 2008). In the current case, the content of Co in P1, P2, P3, P4, P5 and P6 was 2.35, 2.95, 0.0, 5.61, 0.0, and 0.03 mg. kg⁻¹, respectively.

Aluminum (Al) and Tin (Sn)

Both Al and Sn are nonessential elements and were not detected in the enlisted plants.

Table 4-a Concentration (mg. kg⁻¹, mg. kg⁻¹) (mean ± S.D.) and HQ of elements in medicinal plants

Elements	P1	P2	P3
Na	72.12±0.09	118.23±0.07	158.10±0.04
K	8190.21±0.05	7154.50±0.09	5216.70±0.19
Mg	600.23±0.09 HQ = 0.178	1302.45±0.03 HQ = 0.387	4722.58±0.03 HQ = 1.405
Ca	2658.75±0.03 HQ = 0.759	5750.56±0.04 HQ = 1.643	12880.87±0.02 HQ = 3.680
Cu	20.45±0.02, HQ = 0.097	18.65±0.01 HQ = 0.088	20.78±0.01 HQ = 0.098
Zn	30.54±0.01 HQ = 0.79	50.35±0.00 HQ = 1.31	44.74±0.01 HQ = 1.16
Mn	62.32±0.006 HQ= 2.25	33.53±0.01 HQ= 11.97	43.74±0.02 HQ = 15.62
Fe	272.85±0.05 HQ = 9.74	307.12±0.04 HQ = 10.96	67.35±0.05 HQ = 2.40
Pb	13.48±0.30 HQ = 0.96	0.00±0.01 HQ = 0.0	0.00±0.02 HQ = 0.0
Cr	11.25±0.04 HQ = 401.78	24.74±0.01 HQ = 83.57	17.35±0.03 HQ = 619.64
Cd	6.65±0.02 HQ = 15.83	2.12±0.05 HQ = 5.04	20.74±0.02 HQ = 49.38
Co	2.35±0.001	2.95±0.002	0.0±0.001
Al	0.00	0.00	0.00
Sn	0.00	0.00	0.00

Table 4-b Concentration (mg. kg⁻¹, mg. g⁻¹) (mean ± S.D.) and HQ of elements in medicinal plants

Elements	P4	P5	P6
Na	3644.87±0.05	186.59±0.02	396.74±0.03
K	54246.65±0.72	9820.58±0.08	3474.38±0.05
Mg	5334.54±0.05 HQ = 1.587	1408.65±0.02 HQ = 0.419	1544.74±0.005 HQ = 0.459
Ca	12612.25±0.03 HQ = 3.603	1182.28±0.06 HQ = 0.337	11808.37±0.09 HQ = 3.373
Cu	10.94±0.01 HQ = 0.052	10.57±0.08 HQ = 0.050	9.64±0.01 HQ = 0.045
Zn	20.82±0.01 HQ = 0.54	30.64±0.02 HQ = 0.79	36.32±0.04 HQ = 0.94
Mn	86.28±0.05 HQ = 30.814	9.98±0.01 HQ = 3.564	20.89±0.03 HQ = 7.460
Fe	201.89±0.03 HQ = 7.21	302.68±0.05 HQ = 10.81	229.94±0.05 HQ = 8.21
Pb	32.25±0.40 HQ = 2.30	48.53±0.20 HQ = 3.46	34.84±0.22 HQ = 2.48
Cr	14.35±0.04 HQ = 512.5	09.58±0.04 HQ = 342.14	11.69±0.02 HQ = 417.5
Cd	3.52±0.03 HQ = 8.38	00.00±0.02 HQ= 0.0	0.00±0.01 HQ = 0.0
Co	5.61±0.005	0.00±0.003	0.03±0.01
Al	0.00	0.00	0.00
Sn	0.00	0.00	0.00

Conclusion

In the current study, the aerial parts of six medicinal plants of district Peshawar, the capital city of Khyber Pakhtunkhwa, Pakistan were screened for twelve essential and non-essential elements. K/Na ratio for the studied plants varied between 14.88:1 and 113.75:1 which was in agreement within the reported permissible range. The concentration of Mg, Ca, Cu and Co was within the permissible limit set by FAO/WHO. However, the HQ value for Mg and Ca was greater than the safe limit for some of the plants.

The concentration and HQ value of Zn, Mn, Fe, Pb, Cr and Cd was beyond the permissible limit in majority of the investigated plants. It was found that the investigated plants of this area are unsafe and is a potential health risk. Prolong consumption or over dosage of these plants may lead to the enduring accretion of these elements that may cause severe health hazardous effect. Therefore, there is an urgent need to implement a regular monitoring and testing program on the quality of locally available medicinal plants. Similarly, the existence of other toxic metals in the studied and other medicinal plants grown in this region are required to be investigated.

Declarations

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Authors' contributions:

Dr. Khan Malook: Conceptualization, Methodology, Data curation, Writing- Original draft preparation, Investigation.

Ihsan Ul Haque: Software, Visualization, Data Curation.

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Figures

Figure 1

Concentration profile of different elements in the enlisted herbal plants