Journal of Medicinal Plants Research Vol. 4(21), pp. 2256-2263, 4 November, 2010
Available online at http://www.academicjournals.org/JMPR
DOI: 10.5897/JMPR10.460
ISSN 1996-0875 ©2010 Academic Journals

Full Length Research Paper

A study on elemental contents of medicinally important species of *Artemisia* L. (Asteraceae) found in Pakistan

Muhammad Ashraf[1] and Muhammad Qasim Hayat[1,2]* and Abdul Samad Mumtaz[2]

[1]NUST Centre of Virology and Immunology, National University of Science and Technology, H-12, Islamabad, Pakistan.
[2]Department of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan.

Accepted 7 September, 2010

Genus *Artemisia* is cosmopolitan in distribution and its several species are being used in folk therapeutic treatments worldwide. In this study, elemental compositions of seventeen indigenous species *(A. scoparia, A. absinthium, A. indica, A. santolinifolia, A. maritime, A. vulgaris, A. japonica, A. nilagirica, A. herba-alba, A. annua, A. brevifolia, A. moorcroftiana, A. dracunculus, A. roxburghiana and A. dubia)* that are commonly used against ailments in Pakistan were studied for the first time through atomic absorption spectrophotometry methods. In this study we observed nine trace elements namely Zn, Cu, Cr, Ni, Co, Cd, Pb, Mn, Fe and four major elements that are K, Na, Ca and Mg in these species. Further it is observed that in few sepses the concentration of heavy metals are found over and above the normal concentration levels than the international safety standards prescribed for medicinal plants. This study also discusses the impacts of heavy metal toxicity in humans.

Key words: Artemisia, elemental analysis, medicinal herbs, medicinal plants, heavy metal poisoning.

INTRODUCTION

The cosmopolitan genus *Artemisia* L. (Anthemideae: Asteraceae) comprises about 500 species (this number varies depending upon the authors: McArthur, 1979; Mabberley, 1990; Ling, 1982, 1991a, b, 1994, 1995a, b; Bremer and Humphries, 1993; Oberprieler, 2001; Valles and McArthur, 2001; Valles and Garnatge, 2005). Many species are economically important as food, forage, ornamentals or soil stabilizers in disturbed habitats. Some taxa are toxic or allergenic and others are invasive weeds which can adversely affect the harvests (Pareto, 1985; Tan et al., 1998). In addition, several studies have been done all across the world to unveil its medicinal importance (Table 1).

The effectiveness of medicinal plants for therapeutic reason is often accounted for by their organic constituents like flavonoides, alkaloids, essential oils, vitamins, glycosides, etc., and little attention has been paid to their inorganic constituents (Desideri et al., 2010). Excess doses or prolonged intake of medicinal plants can lead to accumulation of trace elements which cause various health problems (WHO, 1992; Sharma et al., 2009). In this context, elemental contents of the medicinal plants are very important and herbal preparations need to be screened for toxic trace elements (Schroeder, 1965; Somer, 1974; Liang et al., 2004; Arceusz et al., 2010).

Recently several studies on the elemental constituents of medicinal plants have enhanced the awareness of trace elements in products (Caldas and Machado, 2004 in Brazil; Wong et al., 1993 in China; Sharma et al., 2009 in India; Sheded et al., 2006 in Egypt; Jabeen et al., 2010 in Pakistan; Koe and Sari, 2009, Basgel and Erdemoglu, 2006 in Turkey; Ajasa et al., 2004 in Nigeria; Kanias and Loukis, 1987 in Greece). These studies show that essential metals can also result in toxic effects when the metal ingestion is in high amounts, whereas non-essential trace metals are toxic even in very low concentrations for human health.

*Corresponding author. E-mail: mqasimhayat@hotmail.com. Tel: +92-333-5232392

Table 1. Medicinally important species of *Artemisia*.

Species	Disease cure	Reference (s)
A. scoparia	Skin burns, Ear pain	Neghahban et al., 2004; Hayat et al., 2009c
A. absinthium	Helminths	Qurashi et al., 2006; Hayat et al., 2009c,d
A. indica	Malaria	Bunyapraphatsara, 1986; Farnsworth, 1992
A. santolinifolia	Helminths	Ahmed et al., 2006; Hayat et al., 2009c
A. maritima	Malaria, Abdominal pain, Helminths	Valecha et al., 1994; Aziz, 1996
A. vulgaris	Fever and Moxa	Khan et al., 2003; Anderson, 1988
A. japonica	Malaria	Valecha et al., 1994; Hayat et al., 2009c,d
A. nilagirica	Malaria	Valecha et al., 1994
A. herba-alba	Diabetes	Iriadam et al., 2006; Hayat et al., 2009c
A. annua	Malaria, breast cancer	Duke et al., 1994; Singh and Lai, 2001
A. brevifolia	Helminths	Iqbal et al., 2004; Gilani et al., 2003
A. moorcroftiana	Malaria	Hayat et al., 2009d
A. dracunculus	Intestinal infections	Aglarova et al., 2008; Hayat et al., 2009c
A. roxburghiana	Diabetes, Helminths	Hussain et al., 2004; Hayat et al., 2009c,d
A. dubia	Leprosy, hysteria asthma, scabies, ulcer	Anisuzzaman et al., 2007; Sapkota, 2008

Use of plants from the genus *Artemisia* is fairly common in herbal medicine in different parts of the world, and its use goes back beyond recorded history (Hayat 2009c; Ashraf et al., 2010), but published reports are scanty with respect to their elemental constituents. Only A. elegantissima has a published analysis (Kaneez et al., 1998). The primary aim of this study is to establish the trace (Zn, Cu, Cr, Ni, Co, Cd, Pb, Mn and Fe) and major (K, Na, Ca and Mg) elemental levels in 17 of the most medicinally important *Artemisia* species which are reported in literature. This will establish whether the use of these Artemisia species is safe for the consumers according to the world health standards (Bowen, 1966; FAO/WHO, 1984; NRC, 1984; WHO, 1992; WHO, 2005).

MATERIALS AND METHODS

Sample collection

Field trips were arranged through out the Pakistan in order to collect *Artemisia* species in previously reported localities by Ghafoor (2002) and Sterwart (1972) from January 2007 to December 2009. The identification and nomenclature of these plants was based on The Flora of Pakistan (Ghafoor, 2002). Detail of voucher specimens is presented in our previous studies (Hayat et al., 2009a, b).

Sample preparation

Plant samples belongs to 17 *Artemisia* species were washed with deionized water and oven dried at 80°C for 2 days, and then subjected to crushing and grinding for fine powder formation.

Digestion

Two gram powder of each plant sample was dissolved in 10 ml of nitric acid for over night and then heated until the reddish brown fumes disappeared. 4 ml of perchloric acid was mixed to the above solution and heated for 5 min then 10 ml of aquaregia was added and heated to small volume and up to marked 250 ml by adding deionized water (Jabeen et al., 2010).

Atomic absorption spectrophotometery

Major and trace elemental concentrations were determined using flame atomic absorption spectroscopy using Perkin Elmer AAnalysit 700 system at National Center of Excellence in Geology, University of Peshawar, Pakistan. The instrument was calibrated with specified standards in which *Artemisia* sample were ranged. After every ten sample run the credibility of instrument is again checked. Five independent runs are carried out for all the elements of the every sampled plant.

RESULTS AND DISCUSSION

Potassium

Potassium ions are the most abundant cation in the human body (Osorio, 1999). The array of K values varies between 11458 ppm in *A. stenocephala* and 18375 ppm in *A. tournifotiana* (Table 2 and Figure 2-B). All the examined species gave evidence for high K contents and our findings matched with the earlier studies on healing plants (Badri and Hamed, 2000; Ozcan and Akbulut, 2007; Jabeen et al., 2010).

Sodium

A healthy human body contains 90 to 130 g of Na (Robert, 2006). The lowest concentration of Na that is 1005 ppm was found in *A. japonica* and maximum

Table 2. Average concentration (ppm) (n=5) along with standard deviation of the elements in studied *Artemisia* species.

Species	Pb	Cu	Zn	Cr	Cd	Mn	Fe	Ni	Co	Na	K	Ca	Mg
A. scoparia	13.200±0.23	09.525±1.64	35.730±0.90	10.250±0.09	0.950±0.75	47.500±0.95	0018.730±0.84	11.300±0.21	0.400±0.35	1078.100±0.28	18238.00±0.34	6480.000±0.37	0760.000±0.34
A. absinthium	00.525±0.14	11.600±1.47	30.300±0.13	07.875±0.50	0.380±0.03	27.500±0.93	0935.630±0.14	07.380±0.44	0.230±0.79	1391.900±0.75	14438.00±0.28	5462.500±0.11	1480.000±0.82
A. kurramensis	08.850±0.82	08.975±0.31	38.650±0.06	09.800±0.75	0.530±0.06	39.230±0.14	0695.000±0.55	05.950±0.83	2.030±0.11	1187.500±0.83	17513.00±0.33	8695.000±0.30	2246.300±0.50
A. stanosephala	00.150±0.35	07.300±0.36	23.430±1.03	03.425±0.26	0.530±0.43	62.380±0.82	0504.380±0.23	03.000±0.90	1.250±0.93	1083.800±0.49	11458.00±5.02	5615.000±0.34	0742.500±0.88
A. maritima	00.100±0.28	12.500±1.84	19.600±0.73	01.325±0.44	0.400±0.69	23.350±0.23	0501.250±0.49	02.050±0.29	1.080±0.68	1010.000±0.59	14338.00±0.49	1025.000±0.41	0157.500±0.74
A. vulgaris	25.800±1.95	13.600±0.46	31.700±0.70	05.375±0.41	0.500±0.79	41.650±0.05	0393.130±0.67	00.000±0.14	2.050±0.27	1118.800±0.52	15325.00±0.67	7177.500±0.67	0910.000±0.12
A. japonica	01.750±0.20	07.275±0.82	18.680±0.74	07.375±0.83	0.350±0.33	16.180±0.36	0264.380±0.74	05.530±0.71	0.750±0.72	1005.000±2.14	17313.00±0.09	0577.500±0.12	0260.000±0.60
A. herba-alba	09.700±0.74	10.050±0.62	19.830±0.75	09.400±0.25	5.250±0.63	39.630±0.20	0936.250±0.84	03.730±0.43	2.830±0.12	2368.800±0.08	14150.00±0.74	1850.000±0.91	0475.000±0.71
A. annua	03.950±2.63	13.330±0.76	32.380±0.49	06.225±0.86	0.980±0.84	42.500±0.36	0336.880±0.94	05.050±0.74	0.780±0.96	1329.400±0.98	17463.00±0.94	5172.500±0.83	1357.500±0.31
A. brevifolia	10.400±0.35	21.730±0.69	24.400±0.60	15.780±0.67	0.900±0.42	75.250±0.40	3126.900±0.36	05.550±0.25	3.650±0.05	1201.900±7.49	15450.00±0.45	0800.000±0.31	0077.500±0.81
A. tournifotiana	08.700±0.60	13.300±2.70	29.350±0.13	06.975±0.22	1.000±0.84	51.800±0.38	0560.000±0.89	06.430±0.58	1.000±0.18	1519.400±0.88	18375.00±0.21	10503.00±0.76	1665.000±0.50
A. persica	08.700±3.59	88.700±0.89	25.900±2.41	09.050±0.93	0.930±0.35	40.430±0.69	0765.000±0.45	05.280±0.27	1.980±0.45	1105.000±0.48	15663.11±0.23	0755.000±0.54	0302.500±0.98
A. biannus	12.180±0.63	09.900±0.98	13.730±0.90	03.400±0.74	1.400±0.18	35.250±0.70	1056.300±0.42	00.100±0.84	2.080±0.11	1067.500±3.92	15875.00±0.42	0897.500±0.60	2072.500±0.47
A. roxburghiana	13.050±0.67	18.080±1.13	20.680±0.41	03.850±0.65	0.780±0.75	40.300±0.80	0415.000±0.78	03.280±0.56	0.330±0.70	1030.000±0.05	14913.00±0.78	8778.800±0.41	1420.000±0.21
A. dubia	11.030±2.62	14.300±0.51	33.850±0.93	08.150±0.35	1.200±0.44	55.950±0.58	0595.630±0.40	06.830±0.39	1.380±0.37	1158.800±0.69	17313.00±0.10	10693.00±0.18	1733.800±0.91
A. incisa	09.550±0.39	10.050±0.53	13.850±0.74	03.300±0.23	0.650±0.17	44.650±0.44	0346.880±0.48	01.430±0.03	0.280±0.21	1107.500±0.66	15800.00±0.55	3235.000±0.35	2927.500±0.14
A. turanica	06.925±0.43	26.930±0.97	20.230±0.73	28.280±0.87	0.050±0.49	69.530±0.71	3048.100±0.29	08.930±0.16	1.850±0.15	1873.100±0.22	13913.00±0.45	0715.000±0.40	0055.000±0.45

content of Na was projected as 2368.8 ppm in *Artemisia herba-alba* (Table 2 and Figure 1-H). All species show moderate accumulation of Na except *A. herba-alba* and *Artemisia turanica*.

Calcium

One of the most resourceful and common signalling agent in the human body are calcium ions (Berridge et al., 1998). *Artemisia dubia* showed the higher Ca content that is 10693 ppm as compared to the other species and *A. japonica* results the minimum concentration that is 577.5 ppm (Table 2 and Figure 2-D). High concentration of Ca is considered important in medicinal plants because of its role in bones, teeth, muscles system and heart functions (Brody, 1994). Studied plants showed satisfactory level of Ca accumulation in genus *Artemisia*.

Magnesium

Mg is the fourth most abundant element in the human body and is essential to good health (WHO, 2009). The content of Mg ranged between 55.00 ppm in *Artemisia turanicum* and 2927.50 ppm in*. Artemisia incisa* (Table 2 and Figure 2-E). This result signified that the examined herbal plants showed a high content of Mg (except *Artemisia brevifolia* and *Artemisia turanica*) which is in an agreement with the previous findings (Chizzola and Franz, 1996; Lavilla et al., 1999; Ajasa et al., 2004).

Zinc

The content of Zn ranged between 13.73 ppm in *Artemisia kurramensis* and 38.65 ppm in *Artemisia biennis* (Table 2 and Figure 1-B). The maximum tolerable zinc level has been set at 500 ppm for cattle and 300 ppm for sheep (National Research Council, 1984). The permissible limit set by FAO/WHO (1984) in edible plants was 27.4 ppm. After comparison with the metal limits those proposed by FAO/WHO (1984) it is found that only *Artemisia stenocephala*, *Abronia maritima*, *A. japonica*, *A. herba-alba*, *A. brevifolia* (*S. brevifolium*), *Artemisia persica*, *Artemisia biennis*,

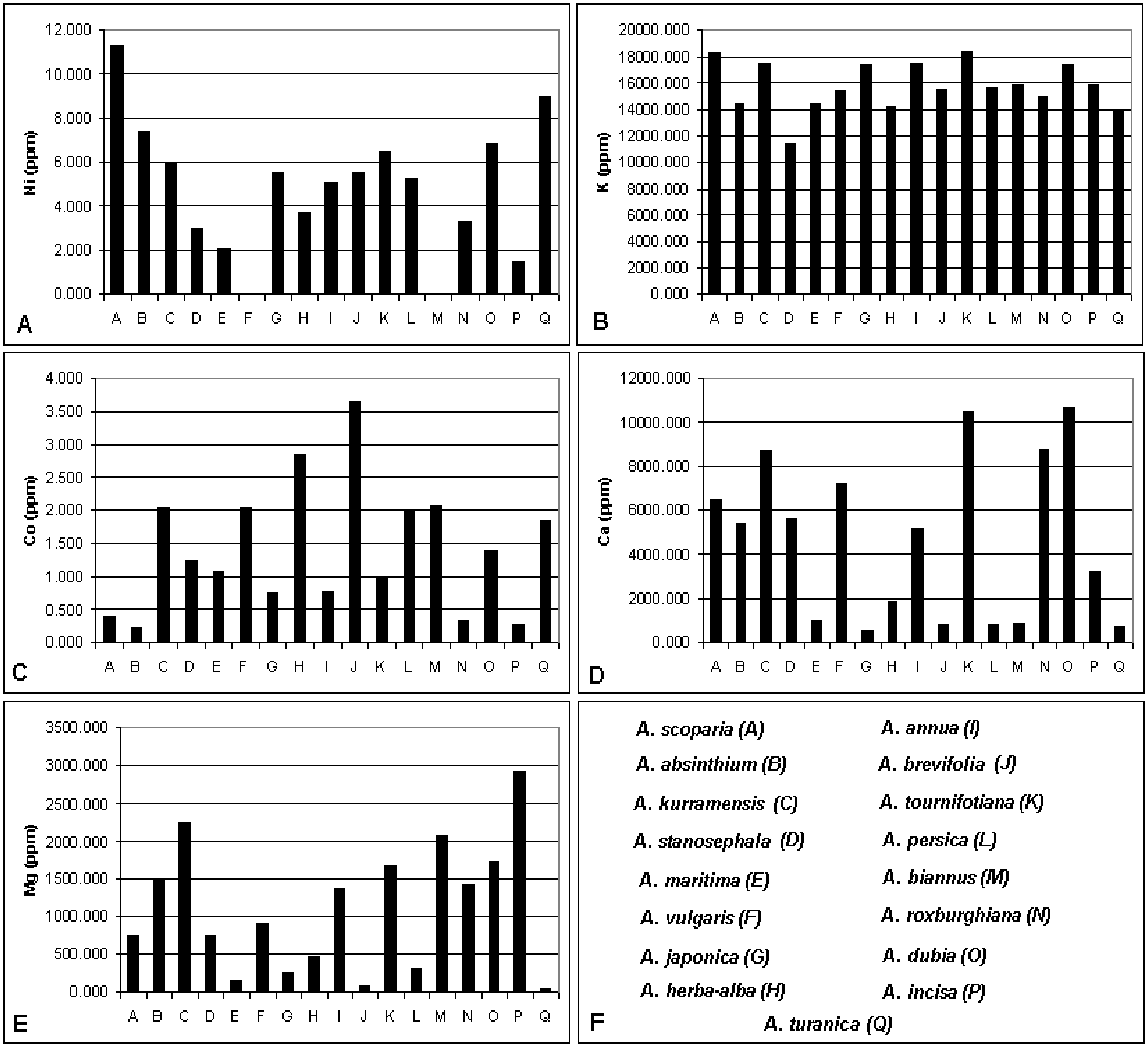

Figure 2. Concentration levels of elements in *Artemisia*.

A. roxburghiana, *A. incisa* and *A. turanica* (*S. turanicum*) are within this limit while all others *Artemisia* accumulate Zn above this limit. However, for medicinal plants the WHO (2005) limits have not yet been established for Zn. According to Bowen (1966) and Allaway (1968) estimates, the range of Zn in agricultural products should be between 15 to 200 ppm.

Copper

The lowest content of Cu that is 7.275 ppm was in *A. japonica* and the maximum concentration was estimated as 88.700 ppm in *A. persica* (Table 2 and Figure 1-C). The permissible limit set by FAO/WHO (1984) in edible plants was 3.00 ppm. After comparison of the metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984), it was found that all plants accumulate Cu above this limit. However, for medicinal plants, the WHO (2005) limits had not yet been established for Cu. Although in medicinal plants, permissible limits for Cu set by China and Singapore, were 20 and 150 ppm respectively (WHO, 2005). According to Bowen findings (1966) and Allaway (1968) explanations, the range of Cu

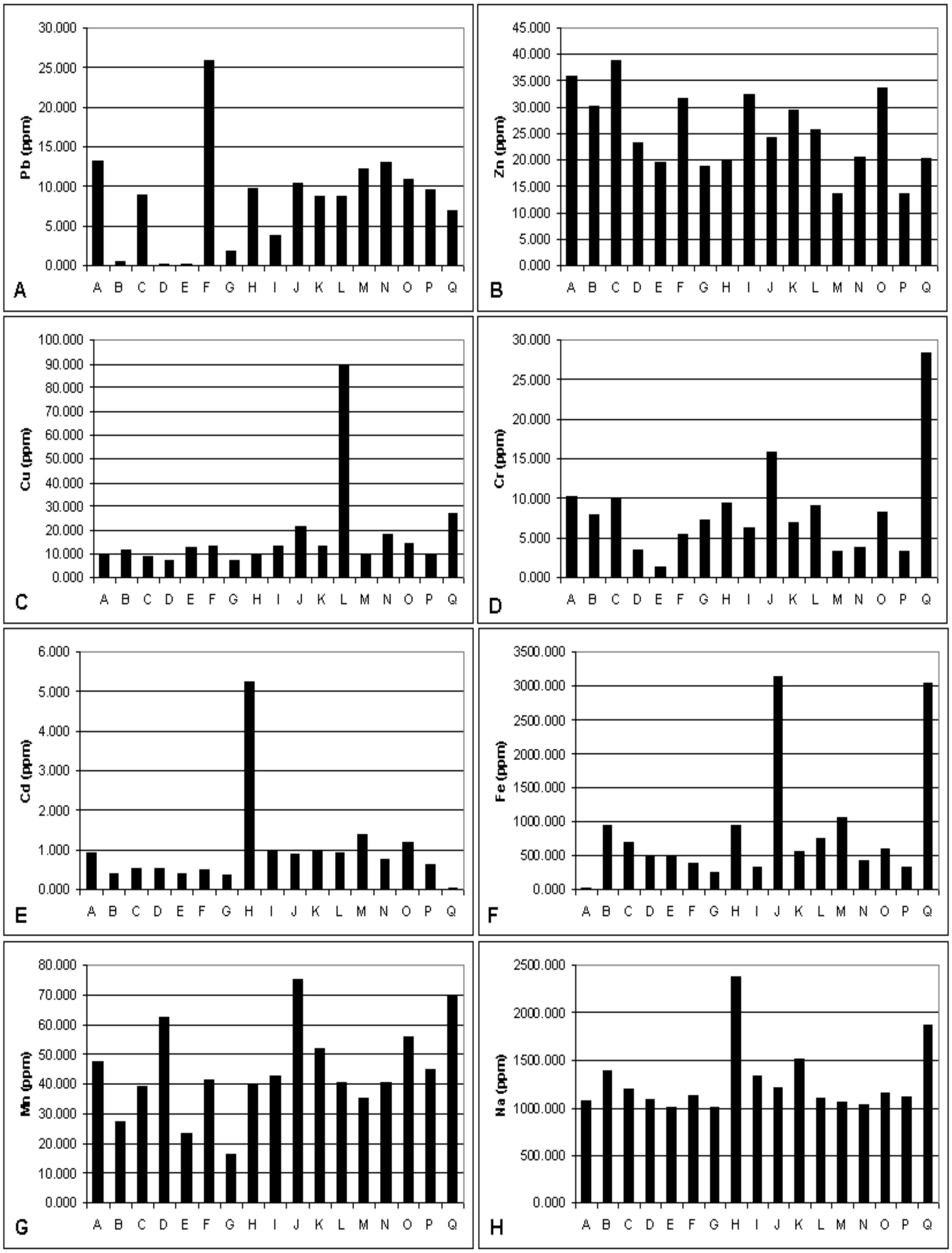

Figure 1. Concentration levels of elements in *Artemisia*. Alphabets A to Q represents the studied species (see Figure 2)

in agricultural products should be between 4 to 15 ppm. Reddy and Reddy (1997) pointed out that the range of Cu contents in the 50 medicinally important leafy material growing in India were 17.6 to 57.3 ppm.

Chromium

The range of Cr varied between 1.325 ppm in *A. maritima* and 28.280 ppm in *S. turanicum* (Table 2 and Figure 1-D).

Chronic exposure to Cr may result in liver, kidney and lung damage (Zayed and Terry, 2003). The permissible limit set by FAO/WHO (1984) in edible plants was 0.02 ppm. After comparison of the metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984), it was found that all plants accumulate Cr above this limit. However, in medicinal plants, the WHO (2005) limits had not yet been established for Cr. Although in medicinal plans, permissible limits for Cr were set by the Canada which was 2 ppm in raw medicinal plant material and 0.02 mg/day in finished herbal products (WHO, 2005).

Nickel

Artemisia vulgaris accumulated lowest Ni that is 0.001 ppm and *Artemisia scoparia* maximum that is 11.300 ppm (Table 2 and Figure 2-A). The permissible limit set by FAO/WHO (1984) in edible plants was 1.63 ppm. After comparison, metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984) it is found that all plants accumulate Ni above this limit. However, for medicinal plants the WHO (2005) levels and limits are not yet been established for Ni. Ni toxicity in human is not very common occurrence because its absorption by the body is very low (Onianwa et al., 2000).

Cobalt

A. brevifolia had higher Co concentration that is 3.650 ppm than the other, while *Artemisia absinthium* recorded the minimum accumulation that is 0.230 ppm (Table 2 and Figure 1C). There are no established criteria for Co in medicinal plants. Basgel and Erdemoglu (2006) determined Co concentration ranged between 0.14 to 0.48 ppm in seven herbs in Turkey.

Cadmium

In studied plants, Cd concentration ranged between 0.050 ppm in *A. turanicum* and 5.250 ppm in *A. herba-alba* (Table 2 and Figure 1-E). The permissible limit set by FAO/WHO (1984) in edible plants was 0.21 ppm. However, for medicinal plants the permissible limit for Cd set by WHO (2005), China and Thailand was 0.3 ppm. Similarly, permissible limits in medicinal plants for Cd set by Canada were 0.3 ppm in raw medicinal plant material and 0.006 mg/day in finished herbal products (WHO, 2005). After comparison, metal limits in the studied medicinal plants with those proposed by FAO/WHO (1984) and WHO (2005) it was found that all studied plants accumulate Cd above this limit. Cd causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and immune system (Heyes, 1997).

Lead

Among the investigated medicinal plants *A. vulgaris* exhibited higher Pb concentration that is 25.800 ppm and *A. maritima* possess minimum concentration of Pb that is 0.100 ppm (Table 2 and Figure 1-A). The permissible limit set by FAO/WHO (1984) in edible plants was 0.43 ppm. However, for medicinal plants the limit was 10 ppm set by China, Malaysia, Thailand and WHO. Similarly, per-missible limits in raw medicinal plans materials, for Pb set by Canada, were 10 ppm in and 0.02 mg/day in finished herbal products (WHO, 2005). After evaluation, the metal limits in the studied medicinal plants with those proposed by WHO (2005) it was found that *A. scoparia*, *A. vulgaris*, *A. brevifolia*, *A. biannus*, *A. roxburghiana* and *A. dubia* accumulate Pb above these limits. Pb causes both acute and chronic poisoning, and also poses adverse effects on kidney, liver, vascular and immune system (Heyes, 1997).

Manganese

The range of Mn varied with values between 16.180 ppm in *A. japonica* and 75.250 ppm in *A. brevifolia* (Table 2 and Figure 1-G). The permissible limit set by FAO/WHO (1984) in edible plants was 2 ppm. After comparison of the metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984), it is found that all plants accumulate Mn above this limit.

However, for medicinal plants the WHO (2005) limits not yet been established for Mn. Sheded et al. (2006) investigated that the range of Mn in their study was between 44.6 to 339 ppm in selective medicinal plants of Egypt.

Iron

The range of Fe in the studied plants was high with a minimum of 18.730 ppm in *A. scoparia* and maximum of 3126.900 ppm in *A. brevifolia* (Table 2 and Figure 1-F). The maximum tolerable level for cattle was suggested as 1000 ppm by National Research Council (1984). The permissible limit set by FAO/WHO (1984) in edible plants was 20 ppm. After comparison, metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984) it is found that all plants accumulate Fe above this limit except *A. scoparia*.

However, for medicinal plants the WHO (2005) limits not yet been established for Fe. Sheded et al. (2006) reported that the range of Fe in their study was between 261 to 1239 ppm in selective medicinal plants of Egypt. Fe is necessary for the formation of haemoglobin and also plays an important role in oxygen and electron transport in human body systems (Kaya and Incekara, 2000).

Conclusions

This study concluded that investigated *Artemisia* species accumulates significant amount of Na, K, Ca, Mg and Fe. However, in few cases they carry a high amount of toxic metals which can cause metal poisoning in humans. The possible reasons to accumulate hazardous metals in *Artemisia* may include the growing of *Artemisia* in contaminated soils such as near roadways or mining and industrial areas or irrigated by toxic water. The other reasons were may be that the studied plants were hyperaccumulators even their soil contain the lower elemental level (McLaughlin, 1999; Pip, 1991). Therefore, special care must be taken during the administration of *Artemisia* species as a remedy. It is also necessary to have a look on good quality control methods and research practices for *Artemisia* based herbal medicines screening in order to protect humans from heavy metal toxicity.

ACKNOWLEDGEMENTS

We are thankful to Higher Education Commission (HEC), Pakistan for their financial support through out research on genus *Artemisia*. We acknowledge Prof. Dr. Muhammad Tahir Shah, National Center of Excellence in Geology, University of Peshawar, Peshawar Pakistan for technical facilities to do elemental analysis. We are also grateful to Dr. Katherine Kidner, Royal Botanical Garden Edinburgh/University of Edinburgh, Scotland UK for her help in the manuscript preparation.

REFERENCES

Ahmed S, Ali A, Beg H, Dasti AA (2006). Ethnobotanical studies on some medicinal plants of Booni valley, District Chitral Pakistan. Pak. J. Weed Sci. Res., 12: 183-190.

Ajasa MA, Bello OM, Ibrahim OM, Ogunwande AI, Olawore ON (2004). Heavy trace metals and macronutrients status in herbal plats of Nigeria. Food Chem., 85: 67-71.

Allaway WH, (1968). Agronomic controls over environmental cycling of trace elements. Adv. Agron., 20: 235-274.

Anderson JW (1988). Medicinal plants in Pakistan in Unani Materia Medica. Hamdarad Medicus, 31: 61-83.

Anisuzzaman M, Rahman AHMM, Harun-or-Rashid M, Naderuzzaman ATM, Islam AKMR, 2007. An ethnobotanical study of Madhupur, Tangail. J. of Appl. Sci. Res., 3: 519-530.

Arceusz A, Radecka I, Wesolowski M (2010). Identification of diversity in elements content in medicinal plants belonging to different plant families. Food Chem., 120: 52-58.

Ashraf M, Hayat MQ, Jabeen S, Shaheen N, Khan MA, Yasmin G (2010). *Artemisia* L. Species Recognized by the Local Community of Northern Areas of Pakistan as Folk Therapeutic Plants. J. Med. Plants Res., 4, 112-119.

Aziz A (1996). Indigenous knowledge of plant uses and ethnobotany of Chitral with particular reference to medicinal plants. Proceed. Ethnobot. Workshop, Nat. Agric. Res. Center, Islamabad.

Badri MA, Hamed AI (2000). Nutrient value of plants in an extremely arid environment (Wadi Allaqi biosphere reserve, Egypt). J. Arid Environ., 44: 347-356.

Basgel S, Erdemoglu SB (2006). Determination of mineral and trace elements in some medicinal herbs and their infusions consumed in Turkey. Sci. Total Environ., 359: 82-89.

Berridge MJ, Bootman MD, Lipp P (1998). Calcium - a life and death signal. Nature, 395: 645-648

Bowen HJM (1966). Trace Elements in Biochemistry. New York; Academic Press.

Bremer K, Humphries C.J (1993). Generic Monograph of the Asteraceae-Anthemideae. Bull.Nat. Hist. Mus., London (Bot.), 23: 71-177.

Brody T (1994). Nutritional Biochemistry. San Diego, CA: Academic Press.

Bunyapraphatsara N (1986). Thai Medicinal Plants Used in Primary Health Care System. Vol. 2. Medicinal Plant Information Center: Mahidol University, pp. 32.

Caldas ED, Machado LL (2004). Cadmium, mercury and lead in medicinal herbs in Brazil. Food Chem. Toxicol., 42: 599-603.

Chauhan RS, Kitchlu S, Ram G, Kaul MK, Tava A (2010). Chemical composition of capillene of *Artemisia dracunculus* L. from North-West Himalaya, India. Ind. Crop. Prod., 31: 546-549.

Chizzola R, Franz C (1996). Metallic trace elements in medicinal and aromatic plants from Austria. J. Appl. Biol., 70: 52-56.

Desideri D, Meli MA, Roselli C (2010). Determination of essential and non-essential elements in some medicinal plants by polarized X ray fluorescence spectrometer (EDPXRF). Microchem. J., 95: 174-180.

Duke MV, Paul RN, Elsohly G, Sturtz G, Duke SO (1994). *Localization* of artemisinin and attemisitene in foliar tissues of glanded and glandless biotypes of *Artemisia annua*. Int. J. Plant Sci. ,155: 365-372.

FAO/WHO (1984). Contaminants. In Codex Alimentarius, Vol. XVII, Edition 1. FAO/WHO, Codex Alimentarius Commision, Rome.

Farnsworth NR, Bunyapraphatsara N (1992). Thai medicinal plants recommended for primary health care system. Medicinal Plant Information Center: Mahidol University, pp. 48.

Ghafoor A (2002). Asteraceae (I)-Anthemideae In: Ali SI, Qaiser M (eds.), Flora of Pakistan, Missouri botanical garden, St. Louis, Missouri, U.S.A. 207: 93-161.

Gilani SS, Abbas SQ, Shinwari ZK, Hussain F, Nargis K (2003). Ethnobotanical studies of Kurram Agency, Pakistan through rural community participation. Pak. J. Biol. Sci., 6: 1368-1375.

Hayat MQ, Ashraf M, Khan MA, Yasmin G, Shaheen N, Jabeen S (2009a). Diversity of foliar trichomes and their systematic implications in the genus *Artemisia* (Asteraceae). Int. J. Agric. Biol., 11: 542-546.

Hayat MQ, Ashraf M, Khan MA, Yasmin G, Shaheen N, Jabeen S (2009b). Phylogenetic relationships in *Artemisia* spp. (Asteraceae) based on distribution of foliar trichomes. Int. J. Agric. Biol., 11: 553-558.

Hayat MQ, Khan MA, Ashraf M, Jabeen S, (2009c). Ethnobotany of the Genus *Artemisia* L. (Asteraceae) in Pakistan. Ethnobot. Res. Appl., 7: 147-162.

Heyes RB (1997). The Carcinogenicity of metals in humans. Cancer Causes Control, 8: 371-385.

Hussain Z, Waheed A, Qurashi RA, Burdi DK, Verspohl EJ, Khan N, Hassan M (2004). The effects of medicinal plants of Islamabad and Murree region of Pakistan on insulin secretion from INS-1 Cells. Phytother. Res., 18, 73-77.

Iqbal Z, Lateef M, Ashraf M, Jabbar A (2004). Anthelmintic activity of *Artemisia brevifolia* in sheep. J. Ethnopharmacol., 93: 265-268.

Iradam M, Musa D, Gumusan H, Baba F (2006). Effects of two Turkish medicinal plants *Artemisia herba-alba* and *Teucrium polium* on blood glucose levels and other biochemical parameters in rabbits. J. Cell Mol. Biol., 5: 19-24.

Jabeen S, Shah MT, Khan S, Hayat MQ (2010). Determination of major and trace elements in ten important folk therapeutic plants of Haripur basin, Pakistan. J. Med. Plants Res., 4: 559-566.

Kaneez FA, Qadirruddin M, Kalhoro MA, Khaula S, Badar Y (1998). Determination of major trace elements in *Artemisia elegantissima* and *Rhazaya stricta* and their uses. Pak. J. Sci. Ind. Res., 45: 291-293.

Kanias GD, Loukis A (1987). Determination and correlation of active consitituents and trace elements in the medicinal plants *Thymus capitatus* Hffm. and Link, Frezenius Z. Anal. Chem., 327: 355-357.

Kaya I, Incekara N (2000). Contents of some wild plants species consumed as food in Aegean region. J. Turkish Weed Sci., 3: 56-64.

Khan A, Gilani SS, Hussain F, Durrani MJ (2003). Ethnobotany of Gokand valley, District Bunner, Pakistan. Pak. J. Bot., 6: 363-369.

Koe H, Sari H (2009). Trace metal contents of some medicinal, aromatic plants and soil samples in the Mediterranean region, Turkish J. Appl. Chem. Res., 8: 52-57.

Lavilla I, Filagueiras AV, Bendicho C (1999). Comparison digestion method for determination of trace and minor metals in plant samples. J. Agric.Food Chem., 47: 291-293.

Liang J, Wang QQ, Huang BL (2004). Concentration of hazardous heavy metals in environmental samples collected in Xiaman, China as determined by vapor generation non-dispersive atomic fluorescence spectrometry. Analy. Sci., 20: 85.

Ling YR (1991a). The old world *Seriphidium* (Compostae). Bull. Bot. Lab. N. E. Forest. Inst. Herbin, 11: 1-40.

Ling YR (1991b). The old world *Artemisia* (Compostae). Bull. Bot. Lab. N. E. Forest. Inst. Herbin, 12: 1-10.

Ling YR (1994). The genera *Artemisia* L. and *Seriphidium* (Bess.) Poljak. in the world. Compostae Newslett., 25: 39-45.

Ling YR (1995a). The new world *Artemisia* L. In: Hind DJN, Jeffrey C, Pope GV, (eds.), Advances in Compostae Systematics. Royal Botanical Garden, Kew, UK, pp. 255-281.

Ling, Y.R., (1995b). The new world *Seriphidium* (Besser) Fourr. L. In: Hind DJN, Jeffrey C, Pope GV, (eds.), Advances in Compostae Systematics. Royal Botanical Garden, Kew, UK, pp. 283-291.

Ling YR, (1982). On the systematics of genus *Artemisia* L. and the relationship with its allies. Bull.Bot. Lab. N. E. Forest. Inst. Herbin, 2: 1-60.

Mabberley DJ (1990). The Plant-Book. 2nd Edition, Cambridge University Press, Cambridge.

McArthur ED (1979). Sagebrush systematics and evolution. In: Sagebrush Ecosystem Symposium. Logan: Utah State University, pp. 14-22.

McLaughlin MJ, Parker DR, Clark JM (1999). Metals and micronutrients – food safety issue. Field Crop. Res., 60: 143-163.

National Research Council (NRC) (1984). Nutrient requirement for Beef Cattle, 6th rev. ed. Nutrient requirement of domestic animals, Vol. 4. National Academy of Science, Wahington, pp. 421-427.

Negahban M, Moharramipour S, Sefidkon F (2007). Fumigant toxicity of essential oil form *Artemisia sieberi* Besser against three stored-product insects. J. Stored Prod. Res., 43: 123-128.

Oberprieler C (2001). Phylogenetic relationships in *Anthemis* L. (Compositae, Anthemideae) based on nrDNA ITS and cpDNA trnL/trnF IGS sequence variation. Plant Syst. Evol., 255, 145-170.

Onianwa PC, Lawal JA, Ogunkeye AA, Orejimi BM (2000). Cadmium and nickel composition of Nigerian foods. J. Food Composit. Anal., 13: 961–969.

Osorio FV, Linas SL (1999). Disorders of potassium metabolism. In: Schrier RW (ed.) Atlas Dis.Kidney, 1: 3.1–3.18.

Ozcan MM, Akbulut M (2007). Estimation of minerals, nitrates and nitrite contents of medicinal and aromatic plants used as spices, condiments and herbal tea. Food Chem., 106: 852-858.

Pareto G (1985). Artemisie. Ricerca ed applicazione. Quaderni Agricoli, Supplementary, 2: 1-261.

PiP E (1991). Cadmium, copper and lead in soils and garden produces near a metal smelter at Flin Flon, Manitoba. Bull. Environ. Contamination and Toxicol., 46: 790-796.

Qurashi RA, Ghufran MA, Sultana KN, Ashraf M, Knan AG (2006). Ethnobotanical studies of medicinal plants of Gilgit District and surrounding areas. Ethnobot. Res. Appl., 5: 115-122.

Reddy PR, Reddy SJ (1997). Elemental concentrations in medicinally important leafy materials. Chemosphere 34: 2193-2212.

Robert PH (2006). Role of Dietary Sodium in Osteoporosis. J. American College of Nutr., 25: 271S–276S.

Sapkota PP (2008). Ethno-ecological observation of Magar of Bukini, Baglung, Western, Nepal. Dhulagiri J. Sociol. Anthropol., 2: 227-252.

Schroeder H (1965). Influence of Chromium Cadmium and lead on rat aortic lipids and circulating cholesterol. Am. J. Physiol., 209: 433-437.

Sharma KR, Agrawal M, Marshall MF (2009). Heavy metals in vegetables collected from production and market sites of a tropical urban area of India. Food chem. Toxicol., 47: 583-591.

Sheded GM, Pulford ID, Hamed IA (2006). Presence of major and trace elements in seven medicinal plants growing in the South-Eastern Desert, Egyptian J. Arid Environ., 66: 210-217.

Singh N, Lai H (2001). Selective toxicity of dihydroartemisinin and holotransferin towards human breast cancer cells. Life Sci. 70, 49-56.

Somer E (1983). The toxic potential of trace metals in foods: A review. J. Food Sci., 39: 215-217.

Sterwart RR (1972). An annotated catalogue of the vascular plants of West Pakistan and Kashmir, In: Ali SI, Nasir M (eds.), Flora of West Pakistan, Fakhri Printing Press Karachi, Pakistan, 207: 93-161.

Tan RX, Zheng WF, Tang HQ (1998). Biologically active substances from the genus *Artemisia*. Planta Medica, 64: 295-302.

Valecha N, Biswas S, Badoni V, Bhandari KS, Sati OP (1994). Antimalarial activity of *Artemisia japonica*, *Artemisia maritima* and *Artemisia nilegarica*. Indian J. Pharmacol., 26: 144-146.

Valles J, Garnatje T (2005). *Artemisia* and its allies: genome organization and evolution and their biosystametic, taxonomical and phylogenetic implications in Artemisiinae and related subtribes (Asteraceae, Anthemideae). In: Sharma, A., (Ed.), Plant Genome: *Biodiversity and Evolution*, Vol. 1B, Phanerogams. Science Publishers, Enfield, New Hampshire, pp. 255-285.

Valles J, McArthur ED (2001). *Artemisia* systematics and phylogeny: cytogenetic and molecular in sights. In proceedings: McArthur ED, Fairbanks DJ (eds.), Shrubland ecosystem genetics and biodiversity; 2000 June 13-15 Provo, UT Ogden: US department of agriculture forest service, Rocky Mountain Res. Station, pp. 67-74.

WHO (1992). Cadmium, Environmental health criteria, Vol. 134, World Health Organization, Geneva.

WHO (2005). Quality Control Methods for Medicinal Plant Materials, Revised, World Health Organization, Geneva.

WHO (2009). Calcium and Magnacium in drinking-water, Public health significance. World Health Organization, Geneva.

Wong MK, Tan P, Wee YC (1993). Heavy metals in some of Chinese herbal plants. Biol. Trace Element Res., 36: 135-142.

Zayed AM, Terry N (2003). Chromium in the environment: factors affecting biological remediation. Plant Soil, 249: 139-156.