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*Full Length Research Paper*

# Determination of major and trace elements in ten important folk therapeutic plants of Haripur basin, Pakistan

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**Several Pakistani plants are known to be of potential therapeutic value and are used in traditional herbal medicine system of the country. In this work, ten of the most popular routinely used medicinal plants (*Achyranthes aspera*, *Alternanthera pungens*, *Brassica campestris*, *Cannabis sativa*, *Convolvulus arvensis*, *Hordeum vulgare*, *Justicia adhatoda*, *Parthenium hysterophorus*, *Ricinus communis*, *Withania somnifera*), which are reported in literature and belong to Haripur basin, are studied first time for their trace (Zn, Cu, Cr, Ni, Co, Cd, Pb, Mn and Fe) and major (K, Na, Ca and Mg) elemental composition by atomic absorption spectrophotometer. In addition, some relevant aspects of heavy metal toxicity are also discussed. Although all plants are found to accumulate good quantity of Fe, K, Na, Ca and Mg, however, their trace heavy metal contents are high according to the international safety standards for the consumption of human beings.**

**Key words:** Haripur basin, elemental contents, medicinal herbs, medicinal plants.

## INTRODUCTION

Therapeutic plants have always been valued as a mode of treatment of variety of ailments in folk cultures and have played a very important role in discovering the modern day medicines with novel chemical constituents (Chan, 2003; Haider et al., 2004; Devi et al., 2008; Shirin et al., 2010). Although the efficacy of medicinal plants for curative purposes is often accounted for in terms of their organic constituents like essential oils, vitamins, glycol-sides, etc. Now, it has been established fact that over dose or prolonged ingestion of medicinal plants leads to the chronic accumulation of different elements which causes various health problems (WHO, 1992; Sharma et al., 2009). In this context, elemental contents of the medi-cinal plants are very important and need to be screened for their quality control (Schroeder, 1973; Somer, 1974; Liang et al., 2004; Arceusz et al., 2010).

In recent years, several authors all across the world, reported many studies on the importance of elemental constituents of the herbal drug plants which enhanced the awareness about trace elements in these plants (Wong et al., 1993 in China; Sharma et al., 2009 in India; Sheded et al., 2006 in Egypt; Koe and Sari, 2009, Basgel and Erdemoglu, 2006 in Turkey; Ajasa et al., 2004 in Nigeria; Kanias and Loukis, 1987 in Greece). Most of these studies concluded that essential metals can also produce toxic effects when the metal intake is in high concentrations, whereas non-essential metals are toxic even in very low concentrations for human health.

Phytotherapy is also a common practice in Pakistan (Hayat et al., 2008; Hayat et al., 2009; Ashraf et al., 2010). Overseas reports are scanty with respect to ele-mental constituents of endemic herbal plants of Pakistan.

The present study was carried out in Haripur basin quite rich in medicinal plants (Figure 1). Several ethno-botanical studies (Marwat et al., 2004; Hussain et al., 2008; Abbasi et al., 2009) in the basin have documented

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**Figure 1.** Location map of the Haripur basin (Haro River separates the Haripur basin from Attock basin).

various healing plants with folk recipes. Rapid Industrialization and urbanization, in the area, are threat to the local medicinal flora in context of heavy metals pollution (Salman and Fida, 2009; Sail et al., 2006; Rehman et al., 2007). Therefore, it is important to have a look on good quality control of medicinal herbs in order to protect consumers from contamination. 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 ten most important medicinal herbs of the basin which are reported in literature. Secondly, whether, the use of these plants is safe for consumers according to the world health standards.

## MATERIALS AND METHODS

### Sample collection

Three field trips were arranged through out the Haripur basin (Figure A) in order to collect previously reported medicinally important plants from October 2008 to June 2009. Details of these plants are given in Table 1. The identification and nomenclature of these plants was based on The Flora of Pakistan (Nasir and Ali, 1978). Voucher specimens were deposited in herbarium of University of Peshawar, Peshawar, Pakistan (UOP).

### Sample preparation

Plant samples were washed with deionized water and oven dried at 80°C for 2 days and then subjected to grinding for powder formation.

### Digestion

Two gram powder of each plant sample was dissolved in 10 ml of nitric acid for 12 h and then heated until the reddish brown fumes disappear. 4 ml of perchloric acid was added to the above solution and heated for 5 min then 10 ml of aquaregia was add and heated to small volume and up to marked 250 ml by adding deionized water (Rio et al., 2002).

### Atomic absorption spectrophotometery

Major and trace elemental contents were determined using flame atomic absorption spectroscopy using Perkin Elmer A Analysit 700.

## RESULTS AND DISCUSSION

### Zinc

The content of Zn ranged between 17.38 ppm in *Convolvulus arvensis* and 65.85 ppm in *Hordeum vulgare* (Table 2 and Figure 2). 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, metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984) it is found that only *Achyranthes aspera*, *C. arvensis* and *Withania somnifera* are within this limit while all others plants accumulate Zn above this limit. However, for medicinal plants the WHO (2005) limits not yet been established for Zn. According to Bowen (1966) and Allaway (1968), the range of Zn in agricultural products should be between 15 to 200 ppm.

### Copper

The lowest content of Cu that is7.06 ppm was in *A. aspera* and maximum concentration was estimated as 19.19 ppm in *H. vulgare* (Table 2 and Figure 3). The permissible limit set by FAO/WHO (1984) in edible plants was 3.00 ppm. After comparison, metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984) it is found that all plants accumulate Cu above this limit. However, for medicinal plants the WHO (2005) limits not yet been established for Cu. Although in medicinal plants, permissible limits for Cu set by China and Singapore, were 20 ppm and 150 ppm respectively (WHO, 2005). According to Bowen (1966) and Allaway (1968), the range of Cu in agricultural products should be between 4 to 15 ppm. Reddy and Reddy (1997) reported that the range of Cu contents in the 50 medicinally important leafy material growing in India were 17.6 ppm to 57.3 ppm.

### Chromium

The range of Cr varied between 1.2 ppm in *C. arvensis* and 29.49 ppm in *Cannabis sativa* (Table 2 and Figure 4). Chronic exposure to Cr may result in liver, kidney and

**Table 1.** Common medicinal herbs used in folk remedies by the inhabitants of Haripur Basin, Pakistan.

| Sr. | Plant specie | Local name | Part use | Disease cure | Reference(s) |
|---|---|---|---|---|---|
| 1. | *Achyranthes aspera* L. | Puthkanda | Whole plant | Cough, asthma, kidney stone, anti inflammatory, diuretic | Abbasi, 1999; Marwat et al., 2004; Hussain et al., 2008 |
| 2. | *Alternanthera pungens* Kunth | Kabli | Whole plant | Itching | Marwat et al., 2004 |
| 3. | *Brassica campestris* L. | Sarsoon | Whole plant | Leucorrhoea, menstrual disorder, body weakness, internal pain, skin diseases | Abbasi, 1999 |
| 4. | *Cannabis sativa* L. | Bhang | Leaves | Body inflammation, boils, sedative, relaxant | Abbasi, 1999; Marwat et al., 2004; Hussain et al., 2008 |
| 5. | *Convolvulus arvensis* L. | Liali | Whole plant | Painful joints, skin disorder, constipation | Abbasi, 1999; Marwat et al., 2004; Hussain et al., 2008 |
| 6. | *Hordeum vulgare* L. | Jou | Seeds | Jaundice, hepatitis | Abbasi et al., 2009 |
| 7. | *Justicia adhatoda* L. | Bhekkar | Whole plant | Cough, asthma, bronchitis, stomach inflammation, dysentery, diarrhea, phelgum, jaundice, diabetes, mouth gum, toothache, tuberculosis | Abbasi, 1999; Abbasi et al., 2009 |
| 8. | *Parthenium hysterophorus* L. | Gandi booti | Whole plant | Anti-hysteric, dysentery, anti-amoebic | Marwat et al., 2004 |
| 9. | *Ricinus communis* L. | Arand | Whole plant | Constipation, stomach disorder, swelling, Chambal, against scorpion sting | Abbasi, 1999; Matin et al., 2001; Hussain et al., 2008 |
| 10 | *Withania somnifera* (L.) Dunal | Asghand | Whole plant | Aphrodisiac, diuretic, bronchitis, ulcer | Hussain et al., 2008 |

lung damage (Zayed and Terry, 2003). The permissible limit set by FAO/WHO (1984) in edible plants was 0.02 ppm.

After comparison, metal limit in the studied medicinal plants with those proposed by FAO/WHO (1984) it is found that all plants accumulate Cr above this limit. However, for medicinal plants the WHO (2005) limits not yet been established for Cr. Although in medicinal plans, permissible limits for Cr set by Canada, were 2 ppm in raw medicinal plant material and 0.02 mg/day in finished herbal products (WHO, 2005).

## Nickel

*C. arvensis* accumulate lowest Ni that is, 2.6 ppm and *C. sativa* accumulate maximum that is 15.8 ppm (Table 2 and Figure 5). 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) limits not yet been established for Ni. Ni toxicity in human is not a very common occurrence because its absorption by the body is very low (Onianwa et al., 2000).

## Cobalt

*H. vulgare* have higher Co concentration that is 11.26 ppm than the other, while *A. pungens* recorded the minimum accumulation that is 3.41 ppm (Table 2 and Figure 6). There are no established criteria for Co in medicinal plants. Basgel and Erdemoglu (2006) determined Co concentration ranged between 0.14 ppm to 0.48 ppm in seven herbs in Turkey.

**Table 2.** Concentrations (ppm[a]) of trace and major elements in study plants

| Plant | Zn | Cu | Cr | Ni | Co | Cd | Pb | Mn | Fe | K | Na | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. aspera* | 20.91 ±4.61 | 7.06 ±1.15 | 1.48 ±0.90 | 5.90 ±0.92 | 5.23 ±0.42 | 0.59 ±0.41 | 9.28 ±1.66 | 105.56 ±6.70 | 455.94 ±176.33 | 17786.25 ±1123.11 | 145.59 ±17.24 | 25575.00 ±3535.53 | 6350.63 ±3608.90 |
| *A. pungens* | 37.86 ±2.76 | 9.11 ±3.09 | 17.74 ±1.56 | 7.97 ±1.67 | 3.41 ±0.60 | 1.45 ±0.80 | 9.89 ±2.95 | 40.50 ±5.48 | 739.50 ±32.23 | 12886.50 ±2341.11 | 245.73 ±75.87 | 20192.50 ±2461.85 | 6004.50 ±3213.56 |
| *B. campestris* | 37.56 ±2.34 | 10.78 ±3.49 | 8.19 ±1.08 | 6.64 ±1.98 | 7.55 ±3.57 | 1.20 ±0.28 | 8.78 ±2.33 | 87.01 ±6.32 | 1889.69 ±18.89 | 16243.13 ±3387.66 | 510.29 ±66.56 | 41210.94 ±5411.24 | 3615.47 ±940.94 |
| *C. sativa* | 29.45 ±4.81 | 9.60 ±3.59 | 29.49 ±2.93 | 15.80 ±4.57 | 4.79 ±1.58 | 1.66 ±0.64 | 10.57 ±2.46 | 54.19 ±21.54 | 387.59 ±34.56 | 13057.50 ±6380 | 112.49 ±48.62 | 36737.50 ±11792.69 | 3907.41 ±1596.53 |
| *C. arvensis* | 17.38 ±2.67 | 8.93 ±1.21 | 1.20 ±0.08 | 2.60 ±0.98 | 4.33 ±0.98 | 1.23 ±0.54 | 3.15 ±0.87 | 77.35 ±11.98 | 391.88 ±21.90 | 9435.00 ±123.98 | 122.28 ±16.98 | 13343.75 ±1132.65 | 2241.88 ±221.89 |
| *H. vulgare* | 65.85 ±1.06 | 19.19 ±0.69 | 6.21 ±1.45 | 14.96 ±1.68 | 11.26 ±0.30 | 1.16 ±0.19 | 10.34 ±1.75 | 37.00 ±10.91 | 6796.88 ±508.23 | 18111.25 ±1732.54 | 2174.38 ±21.32 | 18575.00 ±774.28 | 2306.88 ±715.06 |
| *J. adhatoda* | 31.64 ±7.84 | 8.38 ±3.58 | 5.30 ±2.50 | 4.09 ±1.47 | 6.50 ±1.50 | 0.99 ±0.29 | 5.12 ±2.05 | 32.64 ±18.33 | 409.38 ±36.90 | 17644.58 ±1130.81 | 197.30 ±236.13 | 39643.75 ±3533.39 | 4820.21 ±2458.81 |
| *P. hysterophorus* | 28.92 ±9.18 | 12.98 ±4.17 | 6.07 ±2.12 | 6.54 ±2.41 | 4.93 ±1.65 | 1.19 ±0.50 | 8.24 ±3.12 | 35.36 ±5.50 | 688.13 ±103.19 | 14417.00 ±4455.67 | 317.54 ±56.85 | 28990.42 ±10396.63 | 2810.92 ±1247.30 |
| *R. communis* | 31.55 ±4.20 | 15.62 ±2.24 | 14.26 ±1.28 | 8.10 ±2.92 | 4.70 ±0.95 | 1.58 ±0.07 | 10.63 ±2.44 | 64.60 ±4.28 | 317.71 ±34.27 | 15175.83 ±2480.18 | 146.88 ±7.12 | 34472.92 ±3897.94 | 4418.96 ±2603.04 |
| *W. somnifera* | 22.33 ±3.63 | 8.33 ±1.93 | 8.34 ±2.89 | 5.66 ±2.62 | 3.59 ±0.61 | 1.33 ±0.64 | 7.93 ±3.29 | 34.14 ±5.87 | 181.63 ±60.14 | 12926.00 ±7737.84 | 121.25 ±29.35 | 21248.75 ±1010.14 | 4536.75 ±1042.13 |

[a]Average concentration of element ± standard deviation (n=5) (mg/kg).

## Cadmium

In studied plants, Cd concentration ranged between 0.59 ppm in *A. aspera* and 1.66 ppm in *C. sativa* (Table 2 and Figure 7). 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, 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 *Ricinus communis* exhibited higher Pb concentration that is, 10.63 ppm and *C. arvensis* possess minimum concentration of Pb that is, 3.15 ppm (Table 2 and Figure 8). The permissible limit set by FAO/ WHO (1984) in edible plants was 0.43 ppm. How-ever, for medicinal plants limit was 10 ppm set by China, Malaysia, Thailand and WHO. Similarly,

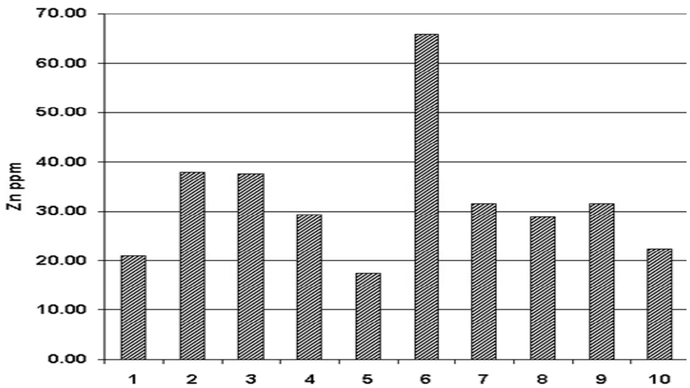


**Figure 2.** Concentration of Zinc in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

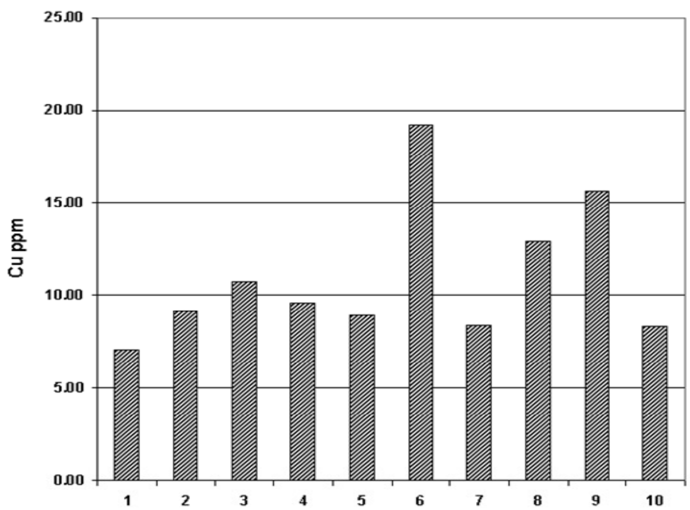


**Figure 3.** Concentration of Copper in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

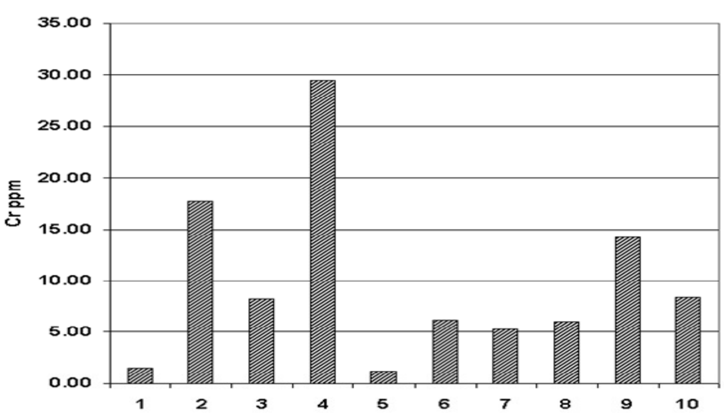


**Figure 4.** Concentration of Chromium in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

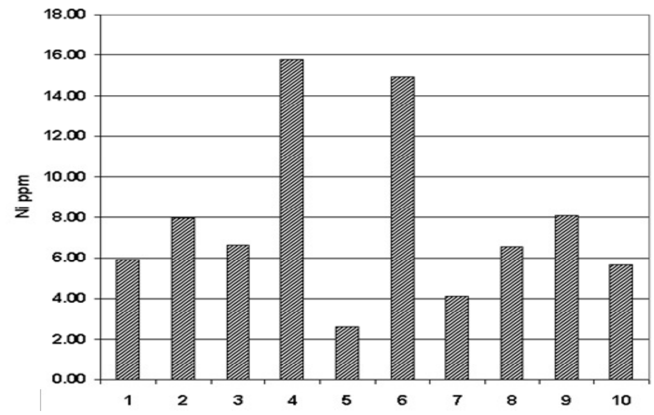


**Figure 5.** Concentration of Nitrogen in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

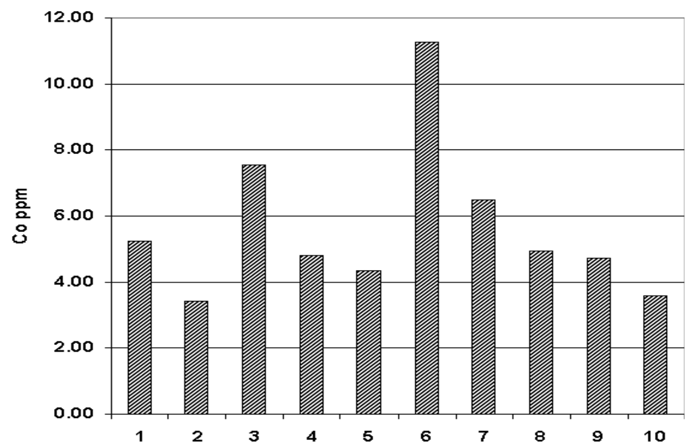


**Figure 6.** Concentration of Cobalt in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

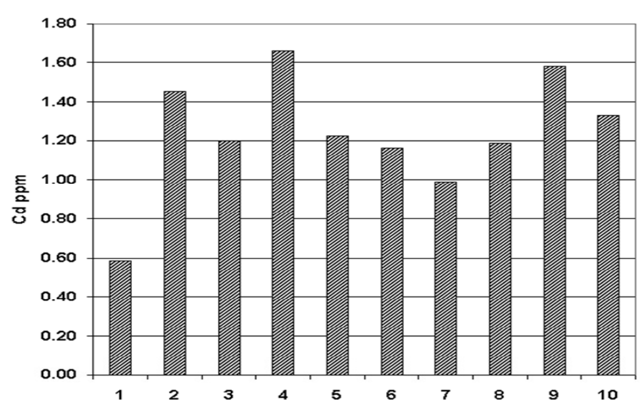


**Figure 7.** Concentration of Cadmium in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

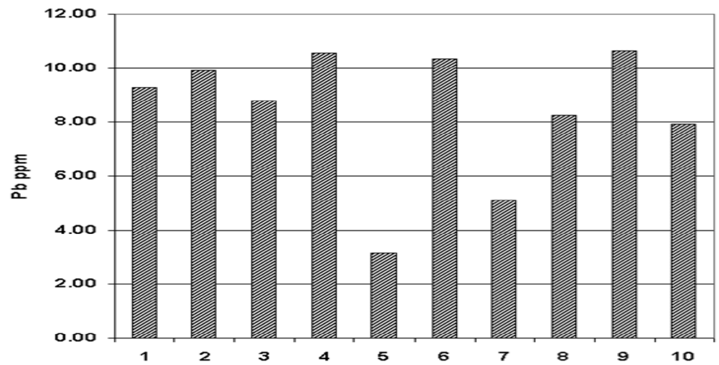


**Figure 8.** Concentration of Lead in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

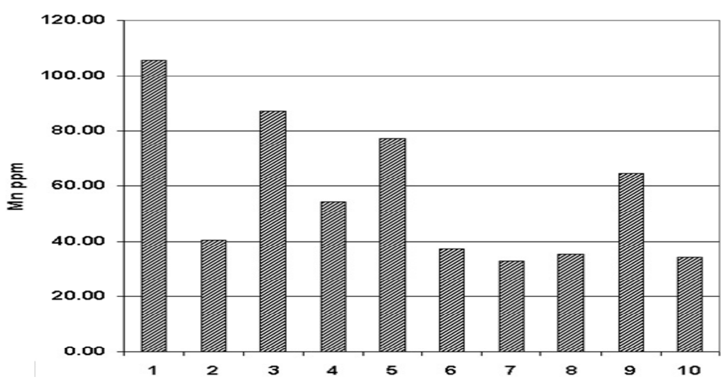


**Figure 9.** Concentration of Manganese in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

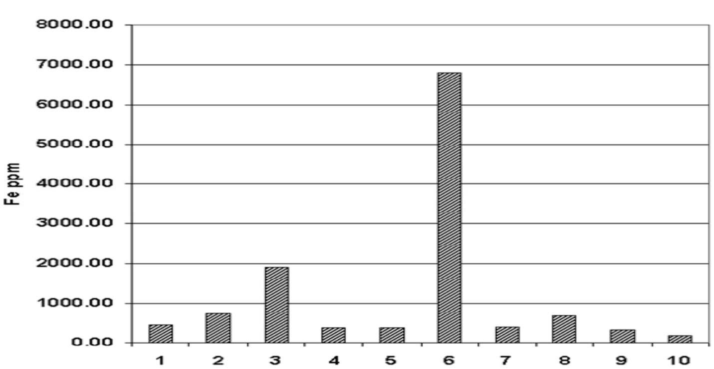


**Figure 10.** Concentration of Iron in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

permissible limits in medicinal plans, for Cd set by Canada, were 10 ppm in raw medicinal plant material and 0.02 mg/day in finished herbal products (WHO, 2005). After comparison, metal limits in the studied medicinal

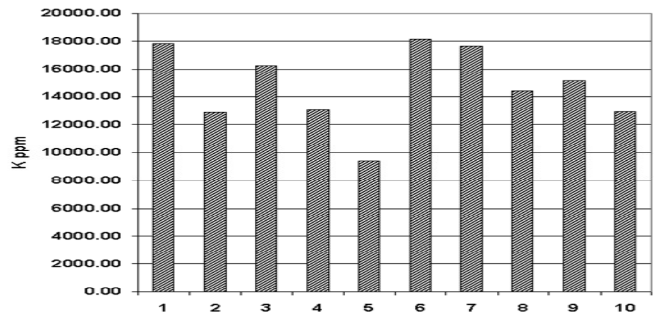


**Figure 11.** Concentration of Potassium in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

plants with those proposed by WHO (2005) it was found that *R. communis*, *H. vulgare* and *C. sativa* 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). Recently, Hadi and Bano (2009) reported *P. hysterophorus* for the remediation of Pb contaminated soil as it is good accumulator of Pb.

## Manganese

The range of Mn varied with values between 32.64 ppm in *Justicia adhatoda* and 105.56 ppm in *A. aspera* (Table 2 and Figure 9). The permissible limit set by FAO/WHO (1984) in edible plants was 2 ppm. After comparison, 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) reported 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 181.63 ppm in *W. somnifera* and maximum of 6796.88 ppm in *H. vulgare* (Table 2 and Figure 10). 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. 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 ppm 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

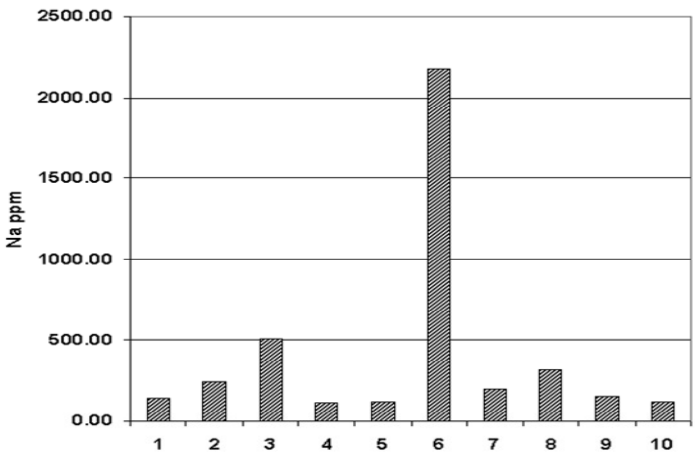


**Figure 12.** Concentration of Sodium in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

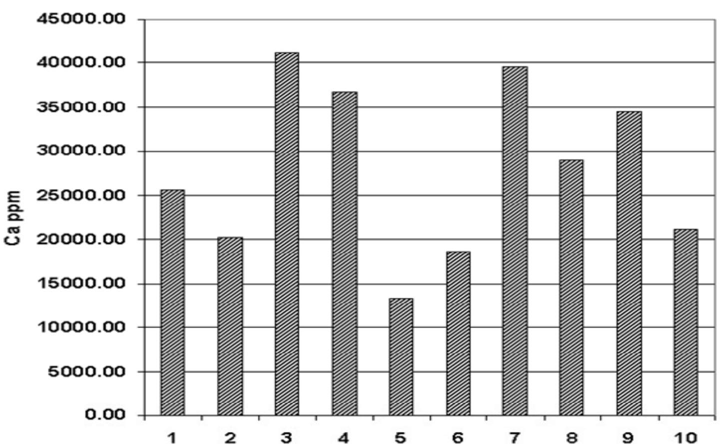


**Figure 13.** Concentration of Calcium in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

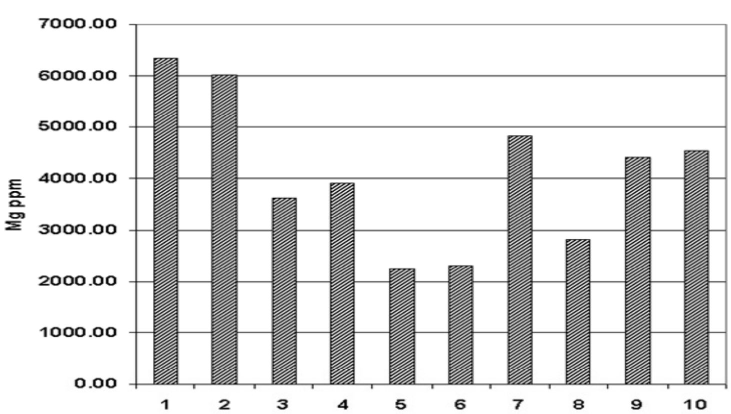


**Figure 14.** Concentration of Magnesium in studied plants collected from different sites of Haripur basin (Numbers 1 to 10 represents the serial no. of plants from Table 1).

and electron transfer in human body (Kaya and Incekara, 2000).

### Potassium

The range of K varied between 9435.00 ppm in *C. arvensis* and 18111.25 ppm in *H. vulgare* (Table 2 and Figure 11). All the studied plant show high K contents and our results coincided with the previous studies on medicinal herbs (Badri and Hamed, 2000; Ozcan and Akbulut, 2007).

### Sodium

The lowest content of Na that is 112.49 ppm was in *C. sativa* and maximum concentration was estimated as 2174.38 ppm in *H. vulgare* (Table 2 and Figure 12). All plants show low accumulation of Na except *H. vulgare*.

### Calcium

*B. campestris* exhibited higher Ca concentration that is13343.75 ppm than the other plants and *C. arvensis* possess minimum concentration of Pb that is 41210.94 ppm than the other plants (Table 2 and Figure 13). High concentrations of Ca are important because of its role in bones, teeth, muscles system and heart functions (Brody, 1994) and studied plants show satisfactory level of Ca accumulation.

### Magnesium

The content of Mg ranged between 2241.88 ppm in *C. arvensis* and 6350.63 ppm in *A. aspera* (Table 2 and Figure 14). The results indicated that the studied herbal plants showed a high content of Mg and this is agreeable with the previous findings (Chizzola and Franz, 1996; Lavilla et al., 1999; Ajasa et al., 2004).

## Conclusion

This study reveled that investigated medicinal plants are good source of Na, K, Ca, Mg and Fe. However, in some cases they carry very high content of toxic metals whose main reason is the industrial pollution and irrigation by polluted waste water (Salman and Fida, 2009; Sail et al., 2006; Rehman et al., 2007). Therefore, special care must be taken during the administration of routinely used medicinal plants. It is also important to have good quality control practices for herbal medicines screening in order to protect consumers from toxicity.

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