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Some Toxic and Essential Metals in Medicinal Plants Growing in R. Macedonia

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Abstract: Plants are used in different ways, among those as medicine and monitoring of metals in the plants is of great importance for protecting the public from the hazard of possible toxic effects and also for information about the nutrition value of the plants. Contents of some toxic and essential metals were determined in four medicinal plants [*Urtica dioica L.* (*Urticaceae*), *Robinia pseudoacacia L.* (*Fabaceae), Taraxacum officinale* (*Asteraceae*) and *Matricaria recutita* (*Asteraceae*)] from Plackovica Mountain, R. Macedonia, with atomic emission spectrometry with inductively coupled plasma (ICP-AES). Metal content was in descending order of Fe>Al>Sr>Zn>Cu>Cr, while Pb, Ni and Cd were present in minor amounts. From toxicological point of view, none of investigated plants would be harmful for the user by taking the plant material in the traditional manner for phytotherapeutically purposes.

Key words: Medicinal plants · Toxic metals · Essential metals · Republic of Macedonia

INTRODUCTION

The chemical constituents in plants, including metal ions, are partially responsible for their medicinal and nutritional properties as well as the toxic ones. As trace elements they are important metabolic products for the plant cells and also play an important role in the plant metabolism and biosynthesis as cofactors for enzymes [1]. Plants can accumulate metals in both the root and the above-ground organs and transfer heavy metal pollutants from soils into the food chain [2]. This accumulation is one of the most serious environmental concerns of the present day, not only because of the phytotoxicity of many of these metals, but also because of the potential harmful effects that toxic metals could have on animals and human health. In protecting the public from hazards of these metals, the monitoring of heavy metals in medicinal and edible plants is therefore of great importance. Some metals are also essential nutrients (zinc, iron, copper, chromium and cobalt) and only become toxic at high concentrations, while others (lead, mercury and cadmium) have no known beneficial properties and are exclusively toxic [3]. The essentiality of trace elements as well as their biochemical and pathological significance to human and animals are well-known [4-8].

In the present study, the mineral contents of four plants frequently used as traditional medicinal herbs in R. Macedonia are determined. *Urtica dioica L.* (*Urticaceae*), *Robinia pseudoacacia L.* (*Fabaceae)*, *Taraxacum officinale* (*Asteraceae*) and *Matricaria recutita* (*Asteraceae*) are herbs commonly used by local people to prepare infusions and use them for phytotherapeutical purposes. The importance of the plants studied, their use, possible medicinal effect and other relevant facts has been reported by a number of authors [9-16].

The aim of this study is to determine the amounts of certain essential and toxic metals (Cd, Cu, Pb, Ni, Zn, Al, Fe, Cr, Sr) in the plants described above that are frequently used by the population in R. Macedonia, in order to find out if they contain metals in amounts that could be toxic in the normal doses used for medical purposes.

MATERIALS AND METHODS

Sampling Area: Urtica dioica L. (*Urticaceae*), Robinia pseudoacacia L. (*Fabaceae)*, Taraxacum officinale (*Asteraceae*) and Matricaria recutita (*Asteraceae*) were all collected during May 2009. The plants were identified at

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Table 1: Plant, plant organ analyzed and sample location

	Location:Plackovica Mount		
	Coordinates		
Plant, plant organ investigated	N	E	Altitude above sea-level
Urtica dioica leaves	41°47'11.58''	22°20'06.49''	740 m
Taraxacum officinale leaves	41°47'11.85''	22°20'08.01''	745 m
Robinia pseudoacacia flowers	41°48'16.51''	22°17'13.67''	383 m
Matricaria recutita flowers	41°48'13.42''	22°17'10.80''	382 m

Fig. 1: Location of the sampling area

the Department of Pharmacognosy on Faculty of Pharmacy, Skopje, R. Macedonia, where specimens of all the plants are deposited in the herbarium. Samples were taken from Plackovica Mountain, located in the eastern part of R. Macedonia, on 380-750 m altitude above sea-level (Fig. 1). Plants sampled and their locations are given in Table 1.

Sample Collection and Preparation: About 200 g (fresh weight) of each plant were collected as follows: *R. pseudo-acacia*: flowers from the middle section of the main leafy area of the plant from each directions; *T. officinale*: similar sized well developed rosette leaves; *U. dioica*: similar sized leaves cut with non-metal knife; *M. recutita*: flowers;

All plant samples, not rinsed, were air dried, milled in a micro-hammer (without metal parts in it) and stored in clean paper bags.

Analytical Techniques: For all preparation of the standards and sample, demineralized water and high purity reagents (Tracepur and *p.a.*) were used. Standards of selected metals were set by dilution of stock-standards which were prepared using analytical grade salts of metals (Merck) with HNO_3 and results were corrected for reagent blanks.

From fine crushed tissues of each item 0.5 g were weighed and placed into PTFE vessels with 5 ml HNO_3 (69% Merck, Tracepur) and 2 ml H_2O_2 (30%, m/V; Merck), mixture was left at room temperature for 1 h and then

Table 2: Procedure used for the digestion of plant samples

Step	Temperature/° C	Time/min	Power/W
1	180	10 (ramp time)	800
2	180	15 (hold time)	800

mineralized by microwave (MARS CEM XP 1500) with the two step procedure at 180°C given in Table 2. Digests were filtered on filter paper (Munktell), quantitatively transferred in 25 ml calibrated flasks, diluted with demineralized water and analysed by ICP-AES (Varian 715-ES) for selected metals. The following wavelengths were chosen for metal analysis: Cd (226.50 nm), Cu (324.71 nm), Pb (220.35 nm), Ni (231.60 nm), Zn (213.86 nm), Al (396.15 nm), Fe (238.20 nm), Cr (267.72 nm) and Sr (407.77 nm). All results were calculated on a dry weight basis (mg kg^{-1} dw). Samples were made in triplicate. The analyses were performed immediately after preparation of samples.

RESULTS AND DISCUSSION

The results for the content of the investigated heavy metal in different plant organs of four plant species are given in Fig 2.

A total of nine elements (Cd, Cu, Pb, Ni, Zn, Al, Fe, Cr, Sr) were analyzed from the powdered medicinal plants and metal contents were in descending order of Fe>Al>Sr>Zn>Cu>Cr, while Pb, Ni and Cd were detected only in half of the samples and in the others were under the limit of detection.

The levels of iron were very high in some plants, e.g., 881.46±0.75 mg kg^{-1} in *T. officinale* leaves and the lowest Fe content was detected in *R. pseudoacacia* flowers 85.69±0.43 mg kg^{-1}. Koc and Sari, 2009 [17] detected content of iron in different plants between 117.6-619.7 mg kg^{-1} in their study. Maiga *et al.*, 2005 [18] detected the highest level of iron in their investigated

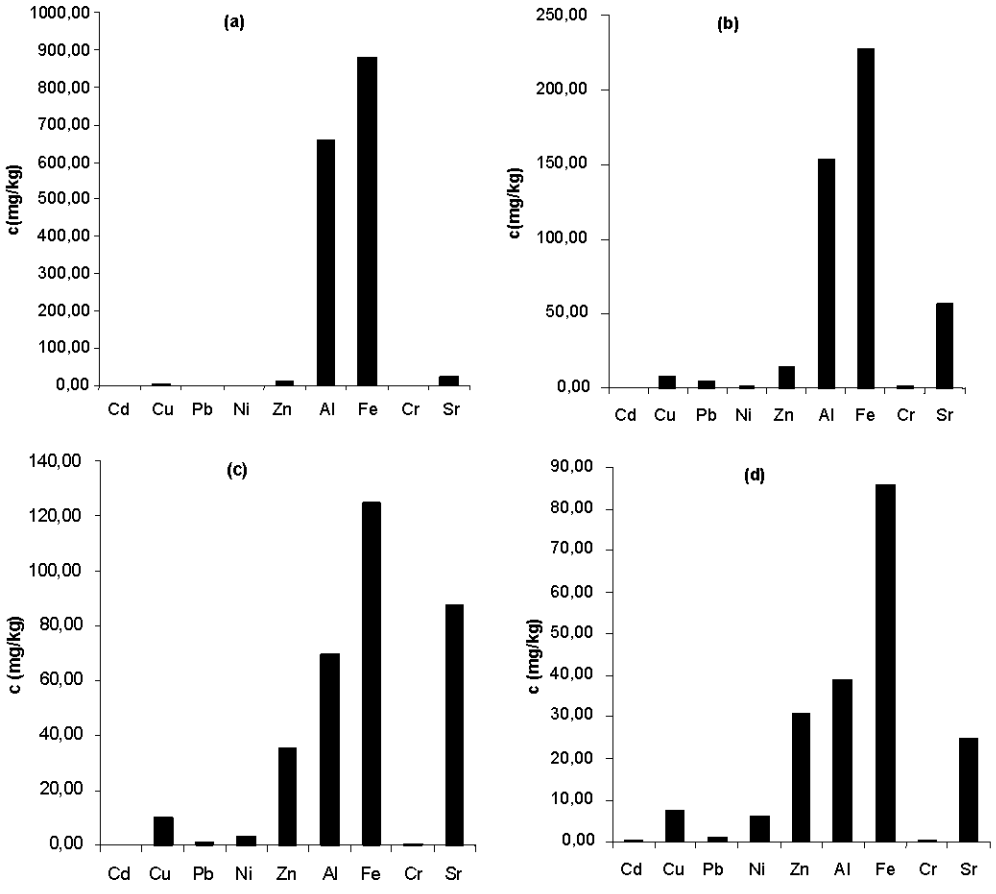

Fig. 2: Content of selected metals (mg kg^{-1}) in different medicinal plants: (a) *Taraxacum officinale* leaves; (b) *Urtica dioica* leaves (c) *Matricaria recutita* flowers; and (d) *Robinia pseudoacacia* flowers; sampled from Plackovica Mount, R. Macedonia

plants of 1500 mg kg^{-1}. The tolerable upper limit of iron is 45 mg per day [19].

Aluminium contents were high and ranged from 655.46±0.82 mg kg^{-1} (*T. officinale*) to 38.79±0.15 mg kg^{-1} (*R. pseudoacacia*). Özcan and Akbulut, 2007 [20] determined Al values from 57.70-2962.74 mg kg^{-1} in their study in Turkey.

Values for Sr were in the range from 22.30±0.15 mg kg^{-1} (*T. officinale*) to 87.47±0.24 mg kg^{-1} (*M. recutita*). Strontium is a relatively common trace element in the Earth's crust and is easily mobile and therefore is readily taken up by plants. Its common amounts, however, calculated as the mean for different food and feed plants, range from about 10 to 1500 mg kg^{-1} dw [2].

Zn was one of t he elements with highest values in this study, in the range of 10.20±0.14 mg kg^{-1} (*T. officinale*) to 35.34±0.26 mg kg^{-1} (*M. recutita*). Maiga *et al.*, 2005 [18] found Zn levels in plants between 9.2±1.3 mg kg^{-1} to 67.1±0.7 mg kg^{-1}, while Ajasa *et al.*, 2004 [21] determined high Zn content of 35.1±0.01 mg kg^{-1} in Nigeria plants. The WHO [22] permissible limit of zinc in foods of 60 mg kg^{-1} is well above our values. The tolerable upper limit of zinc is 40 mg per day [19].

The copper level in this study is from 5.50±0.25 mg kg^{-1} (*T. officinale* leaves); 6.72±0.16 mg kg^{-1} (*U. dioica* leaves); 7.21±0.11 mg kg^{-1} (*R. pseudoacacia*) to the highest 9.74±0.13 mg kg^{-1} detected in *M. recutita* flowers. These levels are below the WHO permissible limits in food, which is 40 mg kg^{-1}.

The level of chromium is between 0.57±0.05 mg kg^{-1} (*M. recutita*) to 1.88±0.12 mg kg^{-1} (*T. officinale* leaves). This values were analogous to results previously published [17, 18, 23] and well below the FDA recommended daily intake of chromium for foods and feeds, which is 0.12 mg g^{-1} [24].

Lead and nickel were both present in low amounts in the plants studied as compared to the other metals in all samples. Their values were under limit of detection for method to maximum 3.86±0.16 mg kg^{-1} (*U. dioica* leaves) for Pb and maximum 5.74±0.12 mg kg^{-1} (*R. pseudoacacia* flowers) for Ni. These values were below the WHO permissible limit in foods, which is 10 mg kg^{-1} for Pb [22] and 5-15 mg kg^{-1} Ni/day in the milk [4].

Cadmium in all samples was under limit of detection for method to maximum determined value of 0.28±0.05 mg kg^{-1}(*R. pseudoacacia* flowers). Generally, it is accepted that the normal limits of Cd content in plants are between 0.2-0.8 mg kg^{-1} and toxic contents of Cd are defined as 5-30 mg kg^{-1} [2]. Provisional tolerable weekly intake recommended by the WHO [22] is 7 ìg Cd/kg body weight/week.

From all plants investigated, *T. officinale* showed highest metal concentrations and it could be of interest as source for iron for humans in the case of too low haemoglobin level for example.

CONCLUSION

It is evident from the data that the medicinal plants in R. Macedonia included in the present study could be a source of essential elements (Fe, Zn, Cu, Ni) as well as heavy toxic metals (Pb, Cd, Sr). In this study, all of the detected values are below the WHO permissible levels and may not constitute a health hazard for consumers, so it can be recommend plants growing in Plackovica Mount as suitable for phytotherapeutical purposes.

Because the elemental contents in the plants depend on many factors (geoclimatic conditions, anthropogenic activities, industries, plant parts used, plant genotype), it becomes essential to ensure the quality of the plant material and monitor the toxic metals if plants are meant for human consumption. The elucidation of element specification in these plants helps interpret the therapeutic actions and may help in designing chemically pure medication.

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