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MANGANESE CONCENTRATION IN PLANTS OF THE PROTECTED NATURAL RESOURCE, KOSMAJ, IN SERBIA

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Abstract – This study was focused on determining the manganese (Mn) concentration in vegetative organs of 10 plant species (8 woody and 2 herbaceous), from four sites in the protected natural resource Kosmaj. The concentration of Mn was analyzed at the beginning of the vegetation period, during a two-year period (2012-2013). The results indicate a wide range of Mn concentrations, depending on site and plant species.

Key words: protected natural resource; manganese; contamination; manganese; woody plants; herbaceous plants; heavy metal

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INTRODUCTION

Since environmental pollution by chemical substances represents one of the most important individual degradable factors of the ecosystem, knowledge about the accumulation and toxic effect of heavy metals in plants is extremely important, because this is a possible way of their entering in the food chain (Kastori, 1997; Memon et al., 2001). The degree of heavy metals accumulation in plant tissue is determined by numerous biotic and abiotic factors, of which the genotype specificity is one of the dominant (Pajević et al., 2008; Nikolić et al., 2008). High concentrations of heavy metals in plants result in numerous anatomical, morphological and physiological changes. The accumulation of heavy metals in plant tissue indicate the important role of specific plant species as (bio)indicators of environmental pollution (Ten-Houten, 1983; Prasad and Freitas, 2003; Stanković, 2008; Stanković et al., 2011). Mn toxicity is a worldwide problem in areas with acid soils (Millaeo et al., 2010). Potentially, each plant species can serve as a bioindicator of environmental conditions. Some plant species can accumulate very large quantities of heavy metals, especially in the leaves (Baker and Brooks, 1989).

Monitoring of heavy metals is important because the damaging effects of all heavy metals on an annual level exceed the overall damaging effects of radioactive and organic waste generated each year (Nriagu, 1979; Pacyna et al., 1989).

There are numerous attempts to use plants in the monitoring of environmental pollution, but the problems are the critical thresholds for individual heavy metals, plant resistance to their presence, cumulative and possible synergetic influence, as well as many other aspects that are little known (Stanković et al., 2008; Stanković et al., 2009).

As a special activator of enzymes in the plants, Mn is an important trace element. It acts as a biocatalyst in the formation of chlorophyll, enhances the formation of starch and sugars in plants. By distribution, Mn is the tenth element in the lithosphere, contained in a number of minerals (manganite, braunite, pyrolusite) and soils, mostly from MnO_2. Only 0.1-1% (200-3000 ppm) of the total Mn in the soil is available to plants (Krstić et al., 2011).

The scientific knowledge of this issue is heterogeneous, and monitoring the heavy metal content in plant tissue will contribute to an improved understanding of their harmful influence on the environment.

MATERIALS AND METHODS

Samples were collected at the beginning of the growing season during a two-year period (2012-2013) at four sites in the protected natural resource, Kosmaj: 1) Tresije Monastery; 2) Hajdučica, a peak of Kosmaj; 3) the monument on Kosmaj; 4) the Pošta restaurant.

Leaf samples (1-2 kg) were taken from 10 plant species: *Tilia cordata*, *Quercus cerris*, *Quercus conferta*, *Quercus petraea*, *Prunus avium*, *Fagus sylvatica*, *Pinus nigra*, *Acer campestre*, *Urtica dioica* and *Taraxacum officinale*.

The sampled plant material was classified and dried at 105°C. Heavy metal concentrations were determined after dry burning at 450°C in treatment with HCl. The content of heavy metals was determined by atomic absorption spectroscopy (AAS), using the apparatus "Thermo series M". The analyses were performed in the laboratories of the Faculty of Forestry, University of Belgrade and Faculty of Natural Sciences, University of Novi Sad.

Differences between mean values of Mn concentrations were tested by single factor analysis of variance (one-way ANOVA). Mean values of Mn concentration were separated into homogenous groups using Duncan's range test with a significance level of $p<0.05$. Statistical analyses were performed in Statistica 7 (StatSoft Inc. USA).

RESULTS

Single factor analysis of variance confirmed significant differences in Mn concentration, between plants species at all sites. At site 1 (Fig. 1), the concentration of Mn ranged from 28.97 mg/kg in *Tilia cordata* to 972.60 mg/kg in *Fagus sylvatica* leaves, with an average value for all species of 264.40 mg/kg. All species are in separated homogenous groups. At site 2 (Fig. 2), Mn concentration ranged from 23.52 mg/kg in *Pinus nigra* to 515.79 mg/g in *Quercus petraea* leaves, with an average value for all species of 152.42 mg/kg. All species are separated in seven homogenous groups. *Pinus nigra*, *Tilia cordata* and *Prunus avium* are in the homogenous group with the lowest Mn concentration (group G). *Fagus sylvatica* and *Urtica dioica* are in the same homogenous group (group F) while all other species are in separated groups. At site 3 (Fig. 3), Mn concentration ranged from 41.48 mg/g in *Pinus nigra* to 434.52 mg/kg in *Quercus petraea* leaves, with an average value for all species of 125.68 mg/kg. All species are separated in eight homogenous groups. *Pinus nigra* and *Prunus avium* are in the homogenous group with the lowest Mn concentration (group H). *Taraxacum officinale* and *Acer campestre* are in the same homogenous group (group F) while all other species are in separated groups. At site 4 (Fig. 4), Mn concentration ranged from 24.96 mg/g in *Prunus avium* to 721.99 mg/kg in *Fagus sylvatica* leaves, with an average value for all species of 193.16 mg/kg. All species are in separated homogenous groups.

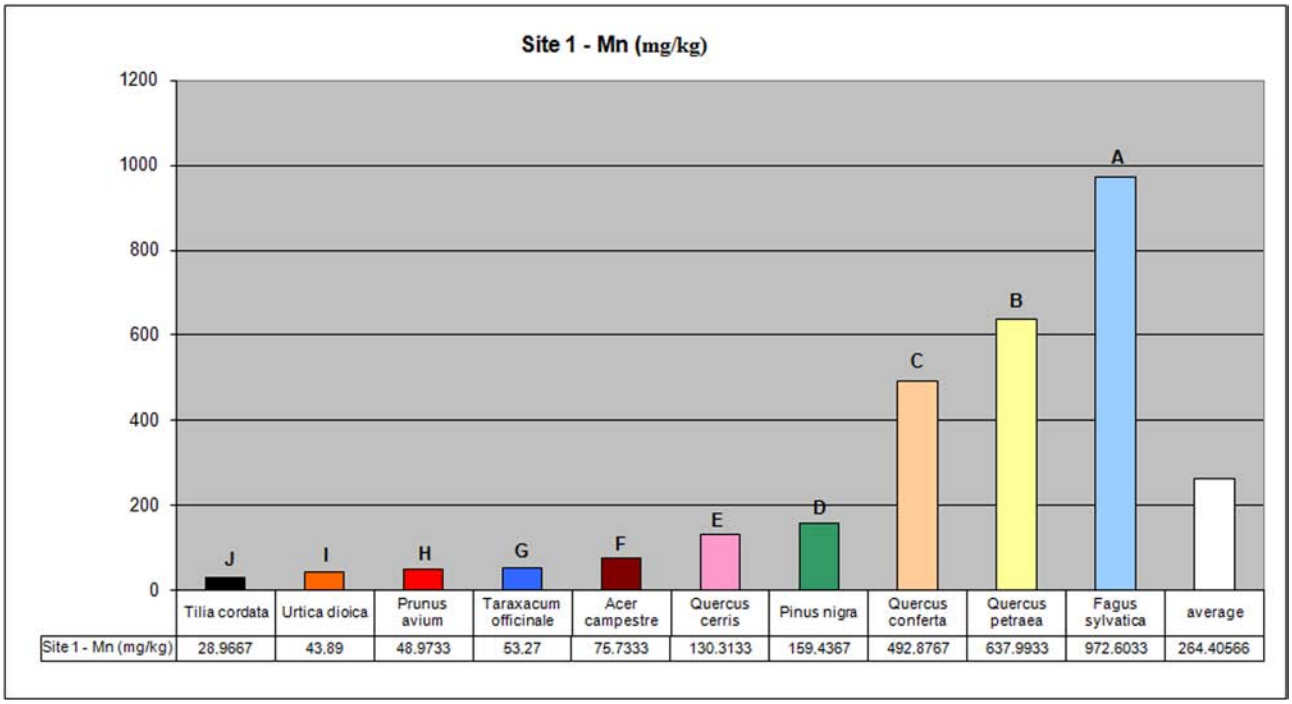

Fig. 1. Mn concentration in plant species at site 1 – Monastery Tresije

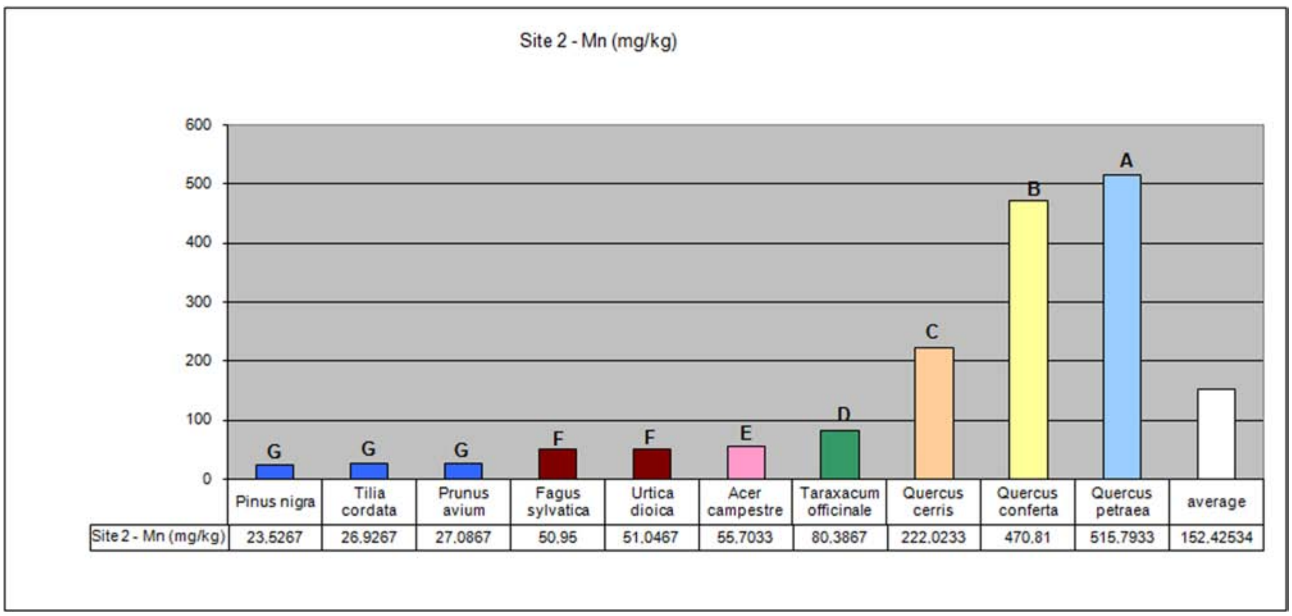

Fig. 2. Mn concentration in plant species at site 2 – Hajdučica, peak of Kosmaj

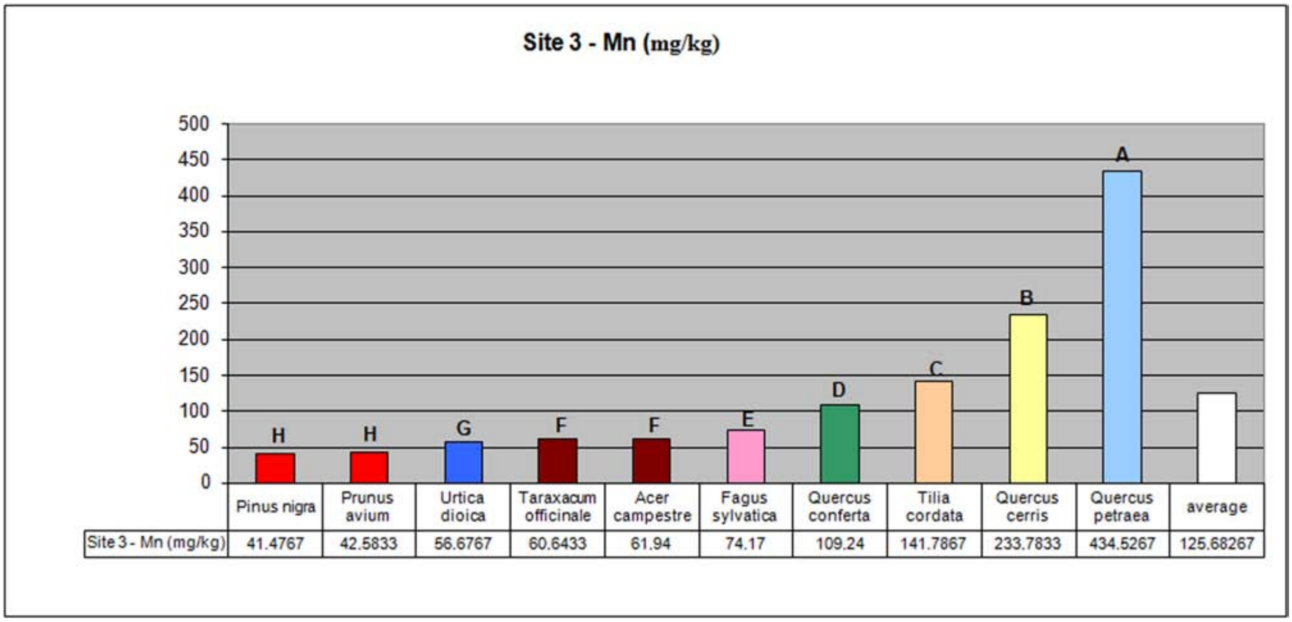

Fig. 3. Mn concentration in plant species at site 3 – monument at Kosmaj

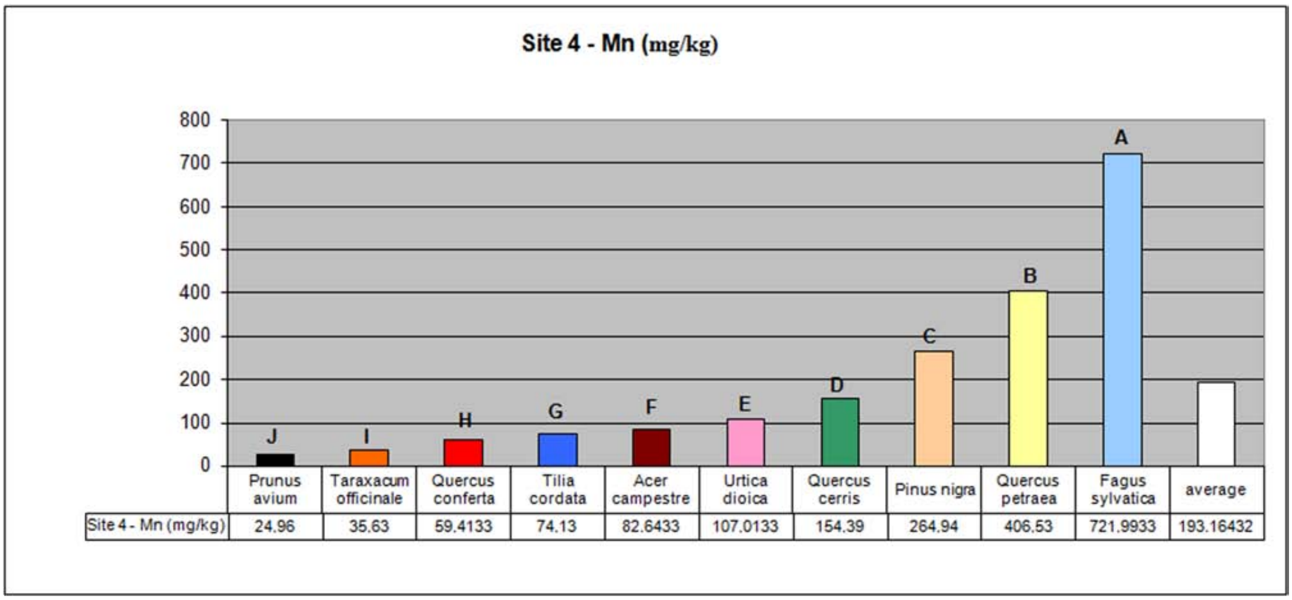

Fig. 4. Mn concentration in plant species at site 4 – close to restaurant Pošta

DISCUSSION

The Mn concentration in leaves at the same site is strongly dependent on species. *Quercus petraea* and *Fagus sylvatica* are the species with highest concentrations, alternating at different sites. Generally, all three species of *Quercus* show concentrations above average, except *Quercus cerris* at site 1 and *Quercus conferta* at site 4. Herbaceous species at all four sites show Mn concentrations below average. Recorded concentrations of Mn concentration in leaves of *Fagus sylvatica*, *Prunus avium*, *Pinus nigra* and *Quercus* species are much lower than concentrations reported by Kula et al., (2012) but comparable with Bergmann (1988) and Classification Values for European Foliage Data. The highest average Mn concentrations in leaves of all species are at site 1. In addition to strong species effect, the influence of site on Mn concentrations in leaves of the same species is evident; indicating that the full potential of particular species as bioindicators depends on the spatial distribution of its individuals. Furthermore, Mn concentrations show high inter-tree variability in *Fagus sylvatica* (Duquesnay et al., 2000).

Different Mn concentrations dependant on species or site are consistent with previously reported results that leaf element concentrations are influenced by taxonomy and the environment (Zhang et al., 2012).

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REFERENCES

Baker, A.J.M. and *R. Brooks* (1989). Terrestrial higher plants which hyperaccumulate metallic elements-A review of their distribution, ecology and phytochemistry, *Biorecovery*. **1**, 81-126.

Bergmann, W. (1988): Ernährungsstörungen bei Kulturpflanzen. (Entstehung, visuelle und analytische Diagnose). Second edt., Jena:VEB Gustav Fischer Verlag, 762.

Duquesnay, A., Dupouey J. L., Clement A., Ulrich E. and *F. Le-Tacon* (2000). Spatial and temporal variability of foliar mineral concentration in beech (*Fagus sylvatica*) stands in northeastern France. *Tree Physiology* **20**, 13-22.

Kastori, R. (1997). Heavy metals in the environment. Feuilleton, Institute of Field and Vegetable Crops, Novi Sad. 195-247

Krstić, B., Oljača, R. and *D. Stanković* (2011). Physiology of woody plants. University of Banja Luka, Faculty of Forestry, 1-352.

Kula, E., Hrdlička, P., Hedbavny, J. and *P. Švec* (2012). Differentiated content of manganese in selected forest trees and plants in the undergrowth. *Beskydy,* **5** (1), 19-26

Memon, A., Aktoprakligil, D., Özdemir, A. and *A. Vertii Tubitak* (2001). Heavy metal accumulation and detoxification mechanisms in plants. *Turk. J. Bot*. **25**, 111-121.

Millaleo, R., Reyes- Diaz, M., Ivanov, A.G., Mora, M.L. and *M. Alberdi* (2010). Manganese as essential and toxic element for plants: transport, accumulation and resistance mechanisms. *Journal of soil science and plant nutrition*, **10,** (4), 470-481.

Nikolić, N., Kojić, D., Pilipović, A., Pajević, S., Krstić, B., Borisev, M. and *S. Orlović* (2008). Responses of hybrid poplar to cadmium stress: Photosynthetic characteristics, cadmium and proline accumulation and antioxidant enzyme activity. *Acta Biologica Cracoviensia, Series Botanica* **502**, 95-103.

Nriagu, J.O. (1979). Global inventory of natural and anthropogenic emissions of trace metals to the atmosphere. *Nature* **279**, 409-411.

Pacyna, J. and *J. Munch* (1989). "European Inventory of Trace Metal Emissions to the Atmosphere", *Heavy Metal Emissions* , **Vol. 1**, 24-26.

Pajević, S., Borišev, M., Rončević, S., Vukov, D. and *R. Igić* (2008). Heavy metal accumulation of Danube river aquatic plants – indication of chemical contamination. *Ctr. Eur. J. Biol.* **3**, 285-294.

Prasad M. N. V. and *H. M. Freitas* (2003). Metal hyperaccumulation in plants – biodiversity prospecting for phytoremediation technology. *El. J. Biotech.*, **6** (3), 286-290.

Stanković, D. (2008). Plants and traffic. Monograph. Foundation Andrejević, Belgrade, 1-98.

Stanković, D., Šijačić-Nikolić, M., Krstić, B. and *V. Vilotić* (2009). Heavy metals in the leaves of tree species *Paulownia elongata* S.Y.Hu in the region of the city of Belgrade. *Biotechnology & Biotechnological Equipment, Diagnosis*, **23**, (3), 1330-1336.

Stanković, D., Krstić, B., Igić, R., Trivan, G., Petrović, N. and *Dj. Jović* (2011). Concentration of pollutants in the air, soil and plants in the area of National Park "Fruska gora" – Serbia. *Fresenius Environmental Bulletin*, Psp. Germany **20** (1), 44-50.

Stanković, D., Krstić. B. and *N. Nikolić* (2008). Effect of traffic on the soil contamination with polycyclic aromatic hydrocarbons (PAHs) *J. Biotech. Biotech. Equip.* **22** (2), 736-741.

Ten Houten, J. G. (1983). Biological indicators of air pollution. *Environ. Monitor. Ass.* **3** (3-4), 257-261.

Zhang, S.B., Zhang, J.L., Slik, J. W. F. and *K.F. Cao* (2012). Leaf element concentrations of terrestrial plants across China are influenced by taxonomy and the environment. *Global Ecol. Biogeo.* **21**, 809-818.