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THE INFLUENCE OF HEAVY METALS ON THE URBAN FLORA

UTICAJ TEŠKIH METALA NA URBANU FLORU

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ABSTRACT

In this study, the first aim was to find out the measures of lead (Pb), cupper (Cu), iron (Fe) and zinc (Zn) as the heavy metal pollution in Sarajevo, Bosnia and Herzegovina. The second aim was to test if chicory, Cichorium intybus, can be used as a biomonitor of heavy metal pollution. Eighteen sites (urban and suburban) in Sarajevo were investigated during the summer period in 2010. Concentrations of Pb, Cu, Fe and Zn were determined in aerial parts (leaves and stem) and roots of *C. intybus* and also in soils collected from a wide range of sites with different degrees of metal pollution.

As a result of measurements, the highest value of Pb, Cu and Fe accumulations have been observed in roots while the highest value of Zn in leaves. Although there was no proper results of Pb, the highest value was detected as 60.13 $mgkg^{-1}$ dry weight in the Museum garden. The highest values of Cu accumulation were observed as 80.35 $mgkg^{-1}$ dry weight in roots in Bentbasha and as 30.55 $mgkg^{-1}$ dry weight in aerial parts in Pofalic. The highest values of Fe accumulation have been reached as 5244.28 $mgkg^{-1}$ dry weight in roots and 1677.81 $mgkg^{-1}$ dry

weight in aerial parts in Skenderije. On the other hand, the highest values of Zn were detected as 188.72 $mgkg^{-1}$ dry weight in aerial parts in Bentbasha and as 98.80 $mgkg^{-1}$ dry weight in roots in Museum. *C. intybus* was found to be a useful biomonitor in the determination of the influence of heavy metals.

Key words: *heavy metals*, Cichorium intybus, *contamination*, *ecotoxicity*

SAŽETAK

U ovoj studiji, prvi cilj je bio saznati mjere olova (Pb), bakra (Cu), željeza (Fe) i cinka (Zn), kao teških metala zagađivača u Sarajevu, Bosna i Hercegovina. Drugi je cilj bio provjeriti može li se cikorija, *Cichorium intybus* koristiti kao biomonitor zagađenja teškim metalima. Osamnaest mjesta (gradskih i prigradskih) u Sarajevu je istraživano tokom ljetnog razdoblja u 2010. Koncentracije Pb, Cu, Fe i Zn određene su u nadzemnim dijelovima (lišće i drška) i korijenu *C. intybus* te u zemlji sakupljenoj iz širokog spektra mjesta s različitim stepenima zagađenosti metalima.

Kao rezultat mjerenja, najveća vrijednost Pb, Cu i Fe nakupine pronađena je u korijenu, dok je najviša vrijednost Zn u lišću. Iako nije bilo odgovarajućeg rezultata za Pb, najveća pronađena vrijednost je 60,13 mgkg-1 suhe mase u vrtu muzeja. Najveće pronađene vrijednosti Cu akumulacije su 80.35 mgkg-1 suhe mase u korijenima na Bentbaši i 30.55 mgkg-1 suhe mase u nadzemnim dijelovima na Pofalićima. Najveće pronađene vrijednosti Fe akumulacije su 5244.28 mgkg-1 suhe mase u korijenima i 1677.81 mgkg-1 suhe mase u nadzemnim dijelovima na Skenderiji. S druge strane, najviše otkrivene vrijednosti Zn su 188,72 mgkg-1 suhe mase u nadzemnim dijelovima na Bentbaši i 98,80 mgkg-1 suhe mase u korijenima u muzeju. Utvrđeno je da se *C. intybus* može iskoristiti kao biomonitor u određivanju koncentracije teških metala.

Ključne riječi: *teški metali*, Cichorium intybus, *kontaminacija*, *ekotoksičnost*

INTRODUCTION

Heavy metals are one of the most serious environmental problems. Heavy metals represents major pollutants in the air that sediment in the soil and they are all included in bio-geochemical cycles. For that is the way heavy metals, plants and animals and humans, and to enter into all other environmental cycles (Tyler, 1981; Koeppe, 1981; Rose 1981; Tam et al. 1987; Paveley & Davies. 1988; Kartal et al. 1993; ; Markert, 1993; Wittig 1993; Ross, 1994; Al-Shayeb et al. 1995; Aksoy & Öztürk 1996; Aksoy et al. 1999).

Names

Common chicory is a worldwide plant. It is also known as succory, blue sailors, and coffee weed. Moreover, it is also called cornflower.

Scientific classification

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Asterales
Family:	Asteraceae
Tribe:	Cichorieae
Genus:	*Cichorium*
Species:	*C. intybus*

Binomial name: *Cichorium intybus*

Description

Cichorium intybus, also known as Common chicory, is a bushy perennial herbaceous plant. It has blue, lavender, or sometimes white flowers. It lives as a wild plant on roadsides in many countries of its native Europe, North America and Australia. Various varieties are cultivated for salad leaves, chicons (blanched buds), or for roots (var. sativum), which are baked, ground, and used as a coffee substitute and additive. It is also grown as a forage crop for livestock.

„Chicory" is also the common name in the US for curly endive (*Cichorium endivia*); these two closely related species are often confused.

When flowering, chicory has a tough, grooved, and more or less hairy stem, from 30 to 100 centimeters tall. The leaves are stalked, lanceolate and unlobed. The flower heads are 2 to 4 centimetres wide, and bright blue. There are two rows of involucral bracts – the inner are longer and erect, the outer are shorter and spreading. It flowers from July until October.

The achenes have no pappus (feathery hairs), but do have toothed scales on top.

Wild chicory leaves are usually bitter. Their bitterness is appreciated in certain cuisines, such as in the Liguria and Puglia regions of Italy and also in Catalonia, in Greece and in Turkey. In Ligurian cuisine the wild chicory leaves are an ingredient of preboggion and in Greek cuisine of horta; in the

Puglian region wild chicory leaves are combined with fava bean puree in the traditional local dish Fave e Cicorie Selvatiche.

By cooking and discarding the water the bitterness is reduced, after which the chicory leaves may be sauteed with garlic, anchovies and other ingredients. In this form the resulting greens might be combined with pasta or to accompany meat dishes.

Chicory may be cultivated for its leaves, usually eaten raw as salad leaves. Cultivated chicory is generally divided into three types of which there are many varieties:

Radicchio usually has variegated red or red and green leaves. Some only refer to the white-veined red leaved type as radicchio. Also known as red endive and red chicory. It has a bitter and spicy taste, which mellows when it is grilled or roasted. It can also be used to add color and zest to salads. Sugarloaf looks rather like cos lettuce, with tightly packed leaves.

One of the cheapest and reliable methods is to use biological materials in the determination of environmental pollution as indicators. Different types of botanical materials such as fungi, lichens, tree bark, tree rings and leaves have been used to detect the deposition, accumulation and distribution of heavy metal pollution. Lower plants, especially mosses and lichens, in view of their higher capacity for metal accumulation are probably the organisms most frequently used for monitoring metal pollution in urban environments. On the other hand the last few decades there has been an increase in the use of higher plant leaves as biomonitor of heavy metal pollution in the terrestrial environment. The comparison of washed and unwashed samples of leaves gave a reasonably high measure of the total aerial fallout of heavy metal in the studied area.

MATERIALS AND METHODS

Study Areas

In this study, Sarajevo City center and around are studied. Eighteen localities are investigated for heavy metal pollution. These locations are (**Figure 1**):

L1: Tranzit ul.Avde Smailovića
L2: Tranzit -Vraca
L3: Tranzit-Soukbunar džamija
L4: Tranzit- Bistrik
L5: Bakije
L6: Bistrik-Crkva
L7: Bentbaša
L8: Ćumurija
L9: Babina Bašta
L10: Skenderija
L11: Holiday Inn
L12: Dvorište muzeja
L13: Pofalići
L14: Pofalići PMF dvorište
L15: Grbavička
L16: Otoka
L17: Stup
L18: Ilidža

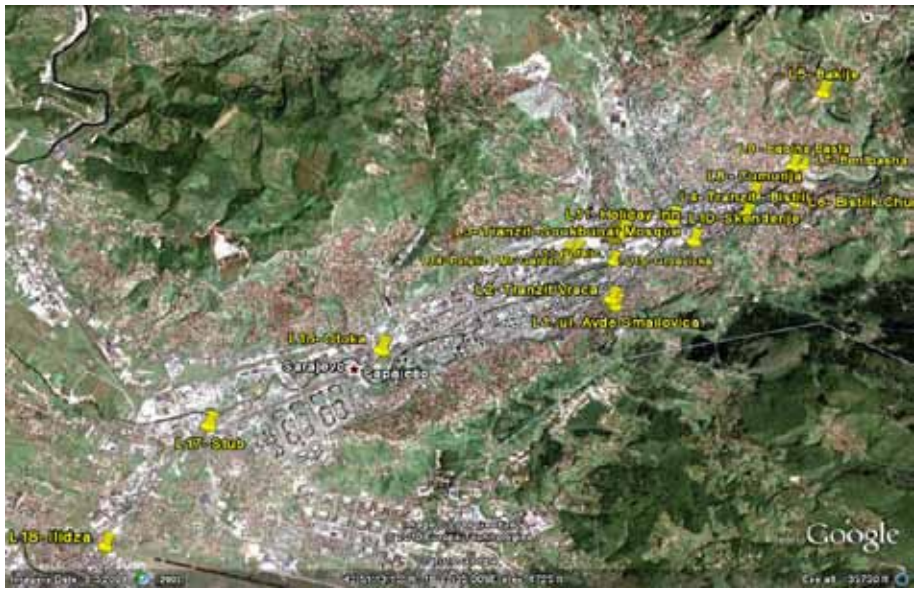

Figure 1. Distribution of locations
Slika 1. Raspored lokaliteta

Method

Heavy metals such as lead (Pb), copper (Cu), iron (Fe) and zinc (Zn) were investigated in the samples of soil, roots of chicory and aerial parts of chicory. The analyses were done by Federal Institute of Agriculture in Sarajevo. Concentrations of lead, copper, iron and zinc were measured in terms of mg/kg in eighteen localities.

1. Sample Collection and Identification: The soil, roots and aerial parts of chicory were handpicked carefully into plastic bags at the each locality. All samples were labeled with respect to their localities.

2. Sample Processing: In the laboratory, all samples were exposed to air dry for 5 days. Then the dried samples were grounded to have fine powder.

3. Sample Analysis by ICP-AES (Inductively Coupled Plasma – Atomic Emission Spectrometry): After sample processing, the last step was analytical procedures of ICP-AES analysis. Perkin Elmer Plasma 400 ICP-AES operating in sequential mode was used for all analyses. Atomic spectrometer is very useful for element analysis because every element has its own characteristic set of energy level. By the use of atomic spectrometer, the set of emission wavelengths were measured.

Table 1. Results
Tabela 1. Rezultati

Location of Sample	Lead (Pb)			Copper (Cu)			Iron (Fe)			Zinc (Zn)		
	Lead (Pb) – Soil (mg/kg)	Lead (Pb) – Roots (mg/kg)	Lead (Pb) – Aerial Parts (mg/kg)	Copper (Cu) – Soil (mg/kg)	Copper (Cu) – Roots (mg/kg)	Copper (Cu) – Aerial Parts (mg/kg)	Iron (Fe) – Soil (mg/kg)	Iron (Fe) – Roots (mg/kg)	Iron (Fe) – Aerial Parts (mg/kg)	Zinc (Zn) – Soil (mg/kg)	Zinc (Zn) – Roots (mg/kg)	Zinc (Zn) – Aerial Parts (mg/kg)
L1 Tranzit ul. Avde Smailovića	**100.68**	**Not Detected**	**Not Detected**	**15.09**	12.71	4.9	11285.63	2692.88	964.46	68.83	24.53	32.75
L2 Tranzit – Vraca	96.33	Not Detected	Not Detected	30.73	18.05	13.44	16300.60	1359.96	528.46	106.37	33.73	87.88
L3 Tranzit – Soukbunar džamija	65.07	Not Detected	Not Detected	42.91	18	12.22	15800.21	1010.84	431.2	98.31	39.8	90.1
L4 Tranzit–Bistrik	100.81	Not Detected	Not Detected	24.92	16.05	11.88	7059.55	1400.10	697.1	106.91	81.51	144.17
L5 Bakije	81.5	Not Detected	Not Detected	92.21	19.78	10.2	20311.80	1401.32	530.11	118.22	44.85	88.41
L6 Bistrik – Crkva	73.42	Not Detected	Not Detected	81.5	20.94	12.56	18111.21	1200.62	437.71	100.28	73.5	113.3
L7 Bentbaša	143.12	19.04	Not Detected	160.3	80.35	16.35	4770.73	1369.95	502.53	353.17	58.07	188.72
L8 Ćumurija	81.5	Not Detected	Not Detected	48.5	8.61	8.21	16500.00	488.31	340	92.32	16.1	64.18
L9 Babina Bašta	127.73	Not Detected	Not Detected	29.02	9.5	3.7	4619.94	400.31	203.56	138.2	30.82	40.57
L10 Skenderija	60.58	Not Detected	Not Detected	31.41	27.95	18.3	15006.50	5244.28	1677.81	93.85	63.62	72
L11 Holiday Inn	110.67	Not Detected	Not Detected	182.31	29.55	16.33	28500.00	1581.00	930.1	200.1	38.82	99.22
L12 Dvorište muzeja	547.66	60.13	Not Detected	195.64	53.1	22.28	15849.09	1469.57	406.84	434.87	98.8	119.37
L13 Pofalići	208.81	Not Detected	Not Detected	315.65	34.15	30.55	42138.53	1744.85	1557.00	234	34.15	44.7
L14 Pofalići PMF dvorište	128.54	Not Detected	Not Detected	48.9	19.58	11.49	15929.03	382.62	142.6	269.1	58.33	74.72
L15 Grbavička	64.67	Not Detected	Not Detected	45.92	19.47	6	10940.29	4247.71	145.14	117.04	25.16	33.15
L16 Otoka	58.73	Not Detected	Not Detected	44.5	18.5	9.33	32309.49	1586.20	680.3	94.58	22.33	38.22
L17 Stup	81.34	Not Detected	Not Detected	38.2	25.88	13.32	18600.70	1280.50	538.71	92.3	65.28	110.21
L18 Ilidža	141.09	Not Detected	Not Detected	46.74	22.6	15.3	11503.51	1921.50	900.5	206.87	28.38	78.8

Table 2. Comparison of heavy metal concentrations (mg kg-1 dry wt) considered toxic or contaminated, taken from the literature (adapted from Ross, 1994), with values from this study.
Tabela 2. Uporedne koncentracije teških metala (mg/kg suhe mase) koji se smatraju toksičnim ili kontaminirajućim, preuzete iz literature (prilagođeno prema Ross, 2994) s vrijednostima iz ove studije

Element	Concentrations in soil	Concentration in	Present results	
	Considered toxic	contaminated plants	Soil	Plants
Pb	100-400	30-300	58.73-547.66	NA – 60.13
Zn	70-400	100-400	92.30-434.87	16.1 – 188.72
Cu	60-125	20-100	15.09-315.65	3.7 – 80.35

DISCUSSION AND CONCLUSION

The concentrations of heavy metals (Pb, Cu, Fe and Zn) found in soil, roots and aerial parts of *C. intybus in* different sites that are presented in the **Table 1**. The heavy metal concentrations in different localities show differences.

It is clear that the concentrations of heavy metals in soil were significantly higher than that of in roots and aerial parts of plants. Therefore, the concentrations of heavy metals in the soils support *C. intybus* in the same areas.

It can be said that the high Pb, Cu, Fe and Zn content in roadside and urban soils and plant samples is mostly due to the density of the traffic which is considered as one of the major sources of heavy metal contamination.

It can be inferred that with an increase in the amount of heavy metals in soil due to percolation, the uptake of heavy metals by *C. intybus* also increases. So it can be concluded that C. intybus can be used as biomonitor of heavy metal pollution.

As a result this study shows that an immediate action is required to provide sustainable traffic, to use ecological methods to have a sustainable development in the area.

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