Journal of Environmental Protection and Ecology 2, No 2, 456–461 (2001)

Ecology

TRACE ELEMENT CONTAMINATION OF TREE LEAVES IN AN URBAN AREA

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Abstract. The concentrations of Pb, Cu and Zn were determined for horse chestnut (*Aesculus hipposastanum* L.) and for Turkish hazel (*Coryllus colurna* L.) leaves in a heavy traffic Belgrade urban area during the vegetation periods of 1996 and 1997. The soil samples were taken at the beginning of the periods and analyzed using atomic absorption method. Chemical analyses of leaves were done by an electrochemical method (DPASV). High Pb content, at toxicity level, was found in leaves. Measured Cu, Zn, and Cd were below the "reference plant" values. Concentrations of all trace elements in leaves increased along the vegetative periods; the slope of Pb and Zn was higher than Cu. Plant-to-soil concentration ratios (CR) were determined.

Keywords: trace metals, urban pollution, soil pollution, pollutant accumulation in plants.

AIMS AND BACKGROUND

Human impact on the environment has changed the atmospheric concentrations of air pollutants during the last century. Trace metals as As, Cd, Cu, Pb and Zn have been transmitted to the biosphere through the atmosphere[1]. The most of trace metals in natural ecosystems originate from the atmospheric deposition. As widely accepted, vegetation has been considered as an important sink for the airborne particle pollutants. Several studies have pointed out the importance of atmospheric input in the biogeochemical cycling of trace metals[2]. Positive relations have been found between atmospheric trace metal deposition and trace metal concentrations in agricultural plants, grasses[3], forest and other vegetation[4]. In urban areas, traffic is the major source of pollutants such as Pb, Zn and Cu in comparison to suburban area[5]. Plant leaves may be used as an important indicator of air pollution[2,6].

The research on trace metal contamination of vegetation requires the use of standard methodological procedures[2,7]. Therefore, full awareness should be present in environmental research regarding certain steps in the methodology. One of the most important is the representative sampling of plant material[8,9]. There is a sig-

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nificant difference between washed and unwashed leaves[10]. Also, faults in analytical procedures contribute to misleading results[8,11]. The aim of this work was to set the reliable methodological approach in sampling and analytical procedures to investigate the trace metal accumulation in plant leaves, using some urban tree leaves.

EXPERIMENTAL

Leaf sampling was done monthly during the vegetation periods, on the trees facing a heavy traffic street, distant about 5 m the street. Leaves were collected from a horse chestnut and a Turkish hazel tree at 2 m height.

For chemical analyses, leaves were cut to fit in clean polycarbonate Petri dishes and so transported to a clean-room (class 100) laboratory. Leaves were washed off in double distilled water (40 ml, kept for 1 h, changing leaf sides every 30 min), on an ultrasonic bath and analyses included elements in this fraction and in leaves after ashing (as recommended by Azcue and Mudroch, 1994). Leaves were dried at 105°C to constant dry weight. Ashing was carried out for 6 h at 450-500°C. The ash was dissolved in 10M HNO_3 and analysed using an electrochemical method, differential pulse anodic stripping voltammetry (DPASV), (ECP 140). Trace elements (Pb, Cd, Cu and Zn) were analysed on the single leaf level.

Soil was sampled at the beginning of the vegetation periods, from the top layer (0 – 15 cm), at three different sites: 2 m distant from the street, under the trees, in an open space between trees and about 20 m away from the street, all situated in the Belgrade Botanical garden. After wet acid digestion, trace elements of soil samples were analysed by the method of atomic absorption (Perkin-Elmer 373). Trace elements were determined in the total sample and in the clay fraction (> 2 nm) as well. Soil pH and Eh were also determined by X-ray analysis, exchangeable cations and also the content of C and humus.

RESULTS AND DISCUSSION

The analysed trace metals Pb, Cu and Zn accumulated in horse chestnut and in Turkish hazel leaves during the vegetation period of 1996, as shown in Fig. 1, *a* and *b*. The values for Cd were at the level of 0.01 and up to 0.06 $\mu g\ g^{-1}$, which was the highest and measured only for Turkish hazel in June. Therefore, in all other samples, Cd concentrations were below 0.05 mg kg^{-1} of dry weight, which was the value reported for the "reference plant" [11]. As widely accepted, while accumulation of trace metals on leaf surfaces reflect their atmospheric concentrations, accumulation in leaves does not simply correspond to trace metal soil concentrations.

Generally, it seemed that the higher accumulation of Zn, Cu and Pb occurred in Turkish hazel than in horse chestnut leaves at the end of the vegetative period. However, this was not confirmed by *t*-statistics, which showed no significant differ-

ence in trace element content between the two species. Except for the Pb concentrations in leaves, which were at the toxicity level (6.8-16.5 μg g^{-1} d.w.) and "reference plant" value is 1, other values for trace metals were below the "reference plant" values (r. p.): Cu were in the range of 3.6 – 6.9 (r. p. 10) and Zn were 18.1 – 22.0 (r. p. 50).

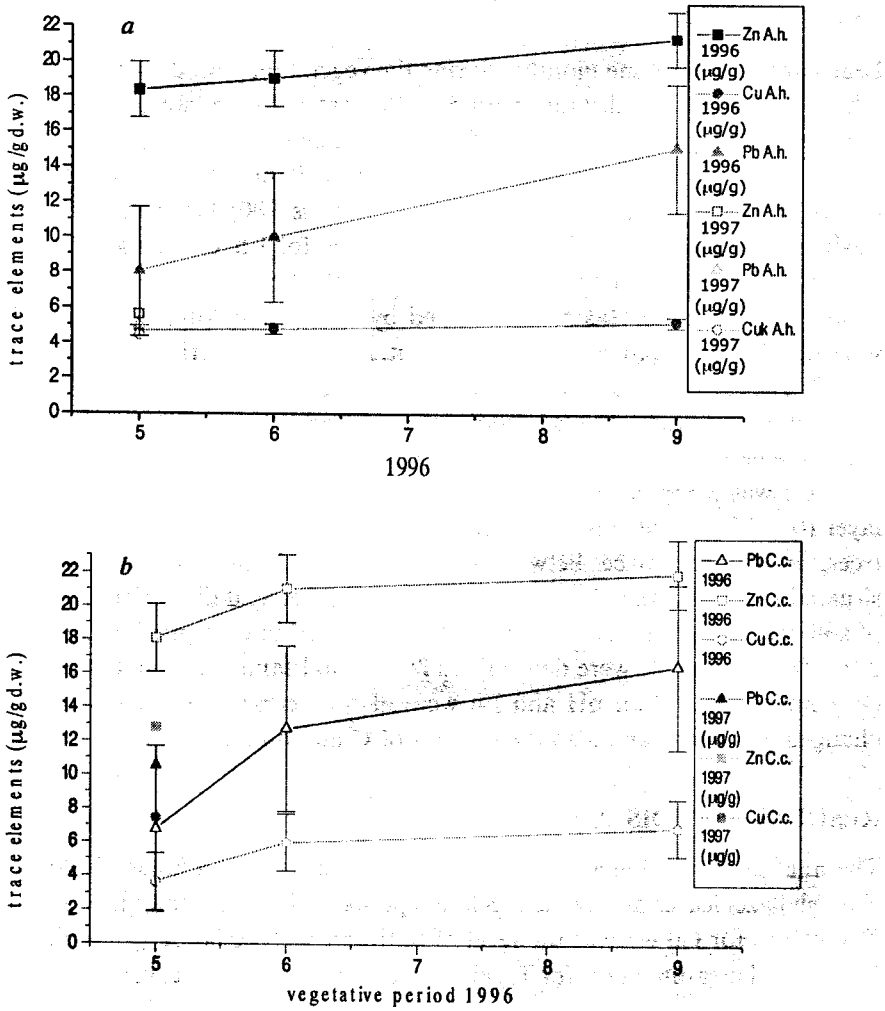

Fig. 1. Trace metal content (μg/g) in leaves of *Aesculus hippocastanum* L. (*a*) and in *Coryllus colurna* L. (*b*) during the vegetation period of 1996. Also, the starting concentrations in May 1997 are indicated

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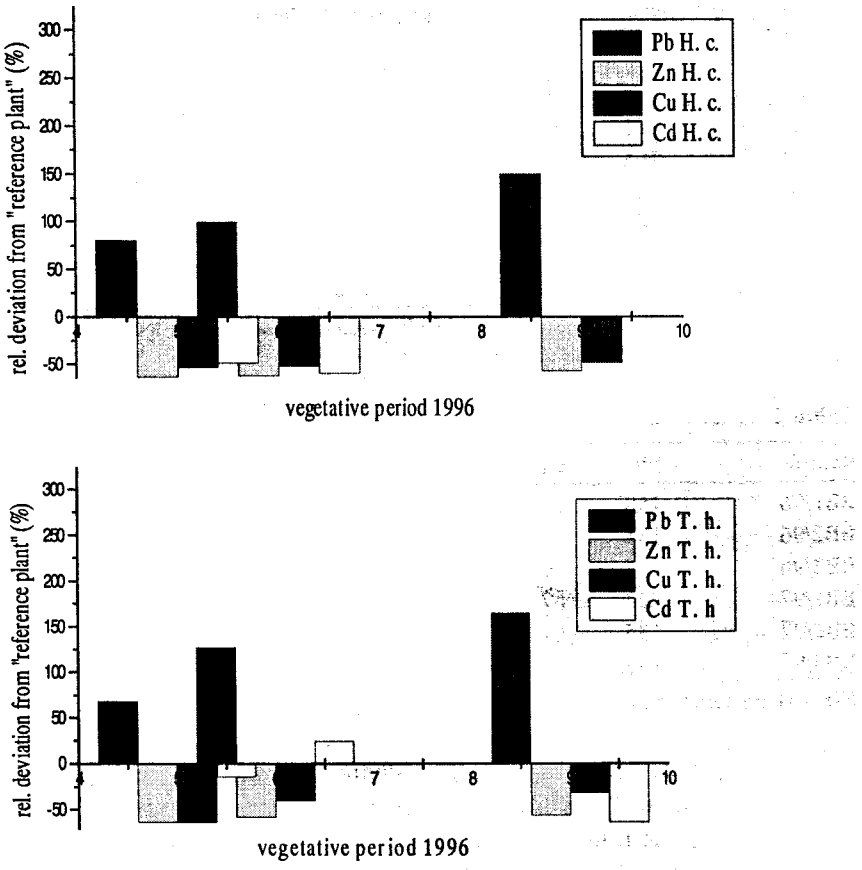

Fig. 2. Chemical fingerprints of *Aesculus hippocastanum* L. (H. c.) and *Coryllus colurna* L. after normalization against "reference plant"[6]

The reference system has often been in practice recently for data evaluation. By normalizing against the values of reference plant and depicting the positive and negative deviations of the individual plant species from the standard values of the reference plant as percentages on a graph it was possible to produce the so-called "chemical fingerprints"[11]. This system enables a comparison between different species and vegetation types, such as mosses, herbaceous plants and trees. The representative sampling and appropriate methodology for chemical analyses are necessary for such comparisons.

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Table 1. Trace elements concentrations (μg/g) in the total top (0-15 cm) soil sample in June of 1996 and 1997

Samples	Pb	Cu	Cr	Zn	Ni	Co	Li	V
BB1/96	81	34	81	80	119	14	0.32	2.0
BB2/96	104	32	96	120	158	21	0.38	1.7
BB3/96	58	28	98	45	166	24	0.68	2.4
BB1/97	147	36	104	255	29	*	0.25	0.8
BB2/97	143	36	91	83	35	*	0.27	1.2
BB3/97	115	36	86	130	41	*	0.29	1.2

BB1 – under the tree, and BB2 – open space between the trees, 2 m distant from the heavy traffic street; BB3 – open space 20 m distant from the street.

Table 2. Trace elements concentrations in clay fraction

Samples	Pb	Cu	Cr	Zn	Ni	Co	Li	V
BB1/96	158	75	131	340	65	*	0.42	1.4
BB2/96	151	77	131	340	65	*	0.42	1.2
BB3/96	105	49	125	283	70	*	0.41	1.2
BB1/97	222	67	157	397	82	*	0.52	1.3
BB2/97	135	67	131	479	82	*	0.52	1.6
BB3/97	143	52	152	347	53	*	0.52	1.4

Other characteristisc as in Table 1.

Soil trace element concentrations change during the year[12]. Therefore, comparison of plant leaf to soil trace element concentration ratios (CR) was calculated for the same time in the vegetative period (June). For Zn, Cu and Pb, this ratio was higher for Turkish hazel than for horse chestnut (Table 3.). However, as mentioned earlier, using *t*-statistics, higher trace element accumulation was not confirmed as significant at this level.

Table 3. The ratio of plant leaves to soil concentration in June 1996

Species	Plant leaves / soil (μg/g)		
	Zn	Cu	Pb
A. hippocastanum	0.233	0.154	0.123
T. hazel	0.257	0.193	0.157

CONCLUSIONS

Measurements of Pb, Cu, Zn and Cd in urban tree leaves of *Aesculus hippocastanum* L. and *Coryllus colurna* L. have shown high Pb concentrations at the phytotoxicity level. Other trace elements were at normal levels. This was well illustrated by the "chemical fingerprints" made upon the "reference plant". This way of data

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evaluation enables the comparison of concentrations between different species and different sites. In our experiment, there was no significant difference in trace element accumulation between the investigated species in spite of a tendency for higher accumulation in *C. colurna* (Table 3).

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Received 24 November 2000
Revised 25 April 2001