Study Concerning the Level of Pollution with Heavy Metalls of Forestry Species from Cluj – Napoca Town

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Abstract. The possibility of monitoring the degree of heavy metal pollution in most crowded Cluj-Napoca town areas using different forestry species as biomonitors located around 4 monitoring stations was studied. Acer platanoides, Acer pseudoplatanus, Aesculus hippocastanum, Betula pendula, Juglans regia, Picea pungens var. Glauca, Picea abies, Pinus nigra, Tilia cordata, Robinia pseudoacacia, and Thuja occidentalis were the analyzed species. Microwave digestion of leaf and/or needles tissues and subsequent use of atomic absorption spectrometry was the analytical methodology used for the determination of heavy metals (Cu, Pb, Zn, and Cd). Only for the concentration of lead in the tree leaves and/or needles bigger values compared to maximum admitted limit were reported. This situation was recorded in three of the four monitoring stations. Aesculus hippocastanum, was the tree specie that accumulates the bigger metallic pollutant quantities, while Betula pendula, the smallest. A moderate negative correlation was reported between copper and lead (r = - 0.506), which is the biggest among the monitored pollutants.

Key words: tree, leaf, needle, biomonitoring

INTRODUCTION

It is well known that forestry species (herbs/grasses and trees/shrubs) may successfully be used as indicators for air pollution monitoring in highly polluted areas where lichens and mosses (usually used as air pollutants biomonitoring agents) are absent (Titseesang, 2008). Due to their bioaccumulative properties, forestry species are suitable biomonitors in the assessment of heavy metal air contamination, in crowded towns with heavy traffic and developed industry (Pourkhabbaz, 2010).

The most exposed parts of the trees located in urban areas to heavy metal pollution are their leaves, but the degree of pollutant retention is often the result of several factors. Among them we can mention: size of metallic pollutant particle, tree leaf surface characteristics, weather conditions (rain, wind direction, humidity, etc.), season (e.g. according to Sawidis, 2010, old leaves collected during the fall were more contaminated than young leaves collected during the spring).

In Europe, the tree species considered as representative biomonitoring agents for metallic pollution in urban areas are: Betula pendula, Fraxinus excelsior, Sorbus aucuparia, Tilia cordata, Ailanthus glandulosa, Celtis occidentalis, Salix alba, Tilia tomentosa, Sambucus nigra, Quercus robur, Fagus sylvatica, Populus nigra sp.Italica Robinia pseudoacacia, Pinus nigra, Aesculus hippocastanum, Acer platanoides, Acer pseudoplatanus, Juglans regia, Picea abies, Robinia pseudoacaci, and Thuja occidentalis (Kovács, 1992c).

This study was carried on with the aim of establishing the possibility of monitoring the degree of heavy metal pollution in most crowded Cluj-Napoca town areas using different...
forestry species as biomonitors, and also, possible correlation between different metallic pollutants presence in analyzed tree species.

MATERIAL AND METHOD

The experiment was developed between 1.04.2011 – 1.06.2011, in Cluj – Napoca town. The air quality data were prelevated from several air quality monitoring stations of different types (CLU-1 ÷ CLU- 4), placed in four locations on Cluj – Napoca town area (one station by location), by the Agency of Environmental Protection Cluj (http://anpm.ro/), as follows:

- CLU-1: traffic type, located in the proximity of the bus station from Aurel Vlaicu St. in front of the blockhouse building 5B;
- CLU-2: urban type, located inside the inner yard of the Nicolae Bălcescu Highschool;
- CLU-3: suburban type, located in Grigorescu District, 1 Decembrie 1981 Boulevard, near RATUC garage;
- CLU-4: industrial type, placed on Dâmboviței St., in Expo Transilvania area (http://www.apmcluj.ro).

The tree species from where leaf and needle samples were harvested are located around the above mentioned monitoring stations and represented by the following species: Acer platanoides, Acer pseudoplatanus, Aesculus hippocastanum, Betula pendula, Juglans regia, Picea pungens var. Glauca, Picea abies, Pinus nigra, Tilia cordata, Robinia pseudoacacia, and Thuja occidentalis. The leaves and needles were harvested from superior, median, and inferior third of the crown of tree groups belonging to the above mentioned specie, two times by week during the entire experimental period. Each group was made up of six trees.

The presence of the following metallic pollutants was studied during the experimental four months period: copper, lead, cadmium, and zinc. The analyses were carried on within the Laboratory of Testing the Water & Noise Level from the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca.

Sample preparation was carried on according to the methods recommended by Chiriac & Răuță, 1980. The leaf and/or needle samples were dried, and smashed with a MKM 6003 Bosch Mill.

Mineralization was carried on with a Berghof microwaves device (Wagner,1998). The heavy metals determination was carried on with a Perkin Elmer AAS equipment.

According to work methodology, recommended by the microwave device producer (http://www.berghof-instruments.de), 300 mg dry matter are placed in digestion flasks, while 2 mL nitric acid and 3 mL oxygened water are added. they are left for 20 mintes in the digestion flasks, which are then are closed and placed in microwave device. Digestion was conducted in three stages, according to the following programme:

- Stage 1: 145°C, 75% power, 5 mintes;
- Stage 2: 185°C, 90% power, 10 mintes;
- Stage 3: 105°C, 40% power, 10 mintes.

A clear transparent solution resulted from mineralization, which was then placed in AAS device in order to qualitative and quantitative identification of aimed heavy metals (Cu, Pb, Cd, Zn). The spectroscopic analyze was performed according to the methodology recommended by L’Vov (2005),
The laboratory experimental data were processed with SATISTICA v. 7.0, programme. Average values, variability coefficients, skewness, kurtosis, and correlation coefficients were calculated.

RESULTS AND DISCUSSIONS

The laboratory analyses emphasize the evolution of the Cu, Pb, Cd, Zn presented as average by experimental period in Cluj – Napoca, in overall, and also as average by experimental period by monitoring stations.

Average values of 3.27 mg/kg, 23.93 mg/kg, 35.10 mg/kg, and 2.41 mg/kg were reported for the copper, lead, zinc, and cadmium concentrations, by entire experimental period and locations (Tab. 1).

In all locations big variability coefficients were recorded, in majority of heavy metals analyzed in order to estimate their pollution potential (Tab. 1). The biggest were reported for copper and zinc (65.62%, and 61.52%, respectively), and the smallest for cadmium (16.40%).

The average values reported by entire experimental period and monitoring stations, for copper, zinc and cadmium concentration in monitored trees leaves and/or needle samples are smaller compared to maximum allowed limits, while in lead, it is bigger compared to maximum admitted limit (20 mg/kg), in overall, by entire experimental period and in three of 4 monitoring stations (Fig. 1).

The smaller average lead concentration measured by entire experimental period was of 9.24 mg/kg and it was reported in monitoring station of traffic type (CLU-1). The maximum allowed concentration was recorded in the suburban type monitoring station (CLU-3), with the average value of 32.68 mg/kg, while values of 23.47 mg/kg and 30.30 mg/kg were reported for the monitoring station of urban type (CLU-2), and industrial type (CLU-4), respectively (Fig. 1).

The maximum average lead concentration by entire experimental period (April – June 2011), in all monitoring locations, was reported in Aesculus hippocastanum, while the minimum in Betula pendula.

Skewness is ranging from - 0.463 to + 2.386, and kurtosis from - 1.071 to + 2.227. This indicates that the data were in normal distribution (Tab. 1), and this allows us to test the correlation between the studied metallic pollutants.

Negative weak correlations (Tab. 2) were found between Zn and Cu, Pb, and Cd, \( r_{Cu-Zn} = -0.172, r_{Pb-Zn} = -0.132, r_{Cd-Zn} = -0.179 \), statistically not significant \((p > 0.05)\). Average correlations were identified between copper, cadmium and lead. If positive average correlation was reported between copper and cadmium \( r = 0.435 \) \((p < 0.05)\), between copper and lead, it is stronger, but negative \( r = -0.506 \) \((p < 0.01)\).
Fig. 1. The picture of the lead concentration during experimental period (01.04.2011 – 30.06.2011) by monitoring stations

Tab. 2. The average values of the monitored heavy metal content (mg/kg) of the analyzed tree leaves and needles

<table>
<thead>
<tr>
<th>Correlated traits</th>
<th>n</th>
<th>R</th>
<th>R^2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu content - Pb content</td>
<td>92</td>
<td>-0.506</td>
<td>0.256</td>
<td>0.007</td>
</tr>
<tr>
<td>Cu content - Zn content</td>
<td>92</td>
<td>-0.172</td>
<td>0.029</td>
<td>0.391</td>
</tr>
<tr>
<td>Cu content - Cd content</td>
<td>92</td>
<td>0.435</td>
<td>0.189</td>
<td>0.023</td>
</tr>
<tr>
<td>Pb content - Zn content</td>
<td>92</td>
<td>-0.132</td>
<td>0.017</td>
<td>0.371</td>
</tr>
<tr>
<td>Pb content - Cd content</td>
<td>92</td>
<td>0.254</td>
<td>0.064</td>
<td>0.081</td>
</tr>
<tr>
<td>Zn content - Cd content</td>
<td>92</td>
<td>-0.179</td>
<td>0.032</td>
<td>0.223</td>
</tr>
</tbody>
</table>

This demonstrates that only between copper and lead pollution of studied tree species located near monitoring stations, may be established a relationship, but of inverse proportionality.

CONCLUSIONS

According to our study, copper, zinc and cadmium pollution in established monitoring points is not a concern, due to overall average values reported by entire experimental period (3.27 mg/kg, 35.10 mg/kg, and 2.41 mg/kg).

The lead concentration in monitored tree leaves and/or needels by entire experimental period, recorded bigger values compared to maximum admitted limit (20 mg/kg), in suburban type monitoring station, CLU-3 (32.68 mg/kg), in urban type station, CLU-2 (23.47 mg/kg), and in industrial type monitoring station, CLU-4 (30.30 mg/kg), demonstrate

The maximum average lead concentration was reported in Aesculus hippocastanum, demonstrating the suitability of this species for biomonitoring use.
The initial data concerning metallic pollutants (Cu, Pb, Zn, Cd) reflect a normal distribution.

The correlation coefficient \( r = -0.506 \) calculated between copper and lead pollution of studied tree species located near monitoring stations, indicates that as copper concentration increases, lead decreases, in proportion of 25.60%.

REFERENCES

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