University of West Hungary
Faculty of Forestry

Theses of doctoral (PhD) dissertation

Investigation of urban and peri-urban soils in the area of Sopron and Szombathely

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Introduction and aims of the dissertation

In 2011, the University of West Hungary carried out a complex urban ecology project, which investigated the effects of urbanization, industry, agriculture and forestry on the natural environment. Three Hungarian cities (Sopron, Szombathely, Székesfehérvár) have been selected as case study areas, where chemical, hydrological, pedologycal analyses and GIS surveys were made (ALBERT & JANCSÓ, 2012). The main aim of the project was to identify the changes in the environment, which were formed by the different geological and other circumstances, but mostly occurred due to the same human impacts.

The main goal of the dissertation is to introduce the soil conditions of Sopron and Szombathely based on the results of chemical, physical properties and heavy metal concentrations (Co, Cu, Ni, Pb, Zn). Secondary aim was to detect the connections between the investigated soil layers, as well as between the soil conditions and land use. Results can help to identify the local pollutions and their potential causes more easily. There were any complex investigations before like this.

Aims of dissertation:

- Investigation of the soil conditions of the selected cities (Sopron, Szombathely) and analyses the physical and chemical properties;

- Determination of the available concentration of toxic elements (Cd, Co, Cu, Ni, Pb, Zn) and comparison of the results with suggested limits or limits by law;

- Evaluation of heavy metal mobility based on soil properties, which are influencing the amount of toxic elements;

- Comparison of the results of 0-10 cm and 10-20 cm soil layers to each other on each sampling point, statistical analysis of their connections;

- Classification of the soil samples into land use categories, detection of the contamination of land use types;

- Additional investigation of land use categories with extremely high values and sensitive areas with enrichment factors. Assessment of possible harmful effects of toxic metals.

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Materials and methods

The aim of the investigations was to determine the impact of human activities on urban and peri-urban soils. A total of 192 soil samples were collected at depths of 0-10 and 10-20 cm from the area of Sopron and Szombathely. After the analysis of chemical and physical properties, the available heavy metal concentrations were measured using ICP-OES according to the method of Lakanen and Erviö. In additional, the total content of toxic elements (MSZ 21470-50-2006) was investigated in case of extremely high available copper values and sediment samples (from thalweg and dead region). That were collected from the bank of the Rák creek at 6 sampling points to calculate enrichment factors to assess the possible harmful effects of toxic metals in Sopron. The field and laboratory data were processed using a GIS softver (DigiTerraMap). Six elements were selected for analyses (Co, Cd, Ni, Cu, Zn, Pb), which are prominent in urban soils. The results were evaluated based on the limit values by Hungarian law and on the limits suggested by KÁDÁR (1998). Statistical analysis was carried out with Microsoft Office Excel 2003, STATISTICA 11 and R Studio. C2 program was used for the distribution of toxic elements. For studying the relationships between land use categories, cluster analysis was used, applying PAST 2.17c.

Results and discussion

The pH of urban soils was generally slightly alkaline in both cities; therefore the occurrence of toxic elements in high concentrations was not typical. For all investigated sampling points, no significant differences were found between the concentrations of the different soil layers. Values above pollution limit were observed at several sampling points in upper layer, but in fewer cases higher or outstanding values were detected in the lower layer. The Cd, Co and Ni values were lower than the suggested natural background limits. In Szombathely the copper values exceeded the natural background concentrations in several cases; the pollution limit (40 mg Cu/kg) was not reached. But extremely high result were measured on viticulture areas of Sopron (>90 mg Cu/kg), where the copper content is available for the plants in ~75%. Samples taken alongside busy roads, especially in the city center, were contaminated with lead due to the continuous traffic. The Pb concentration decreased slightly towards the suburban areas of the cities. Nevertheless, as the suburban soils were more acidic, even the lower pollution caused by the lower traffic level could be dangerous because of the increase in toxic element mobility. Available zinc exceeded the intervention limit in soils of Szombathely, which were taken from the bank of the Gyöngyös creek. For all heavy metals, the highest pollution level in both layers was found in the soils of parks in Sopron. In urban and peri-urban soils of Szombathely, the weakest correlation was

found in case of Cd between the two layers (R = 0.55) on p <0.05 significance level. In case of two elements, the strongest connection was showed between Cu and Cd (R = 0.76) on p <0.05. Linear connection was found between Cu, Pb and Zn contents. Based on the cluster analysis, the land use categories with similar properties connected as well. Airborne pollutants are absorbed easily in green areas of the city or are washed into the soils of the parks or bank of creeks. The statistical analysis of urban and peri-urban soils of Sopron showed the weakest correlation in case of Zn between the two layers (R = 0.65) on p <0.05 significance level. In case of two elements, the strongest connection was showed between Cu and Pb (R = 0.70) on p <0.05 significance level. Co and Ni contents showed uniform distribution because their presence is evident due to the natural bedrock. Based on the cluster analysis, the land use categories with similar properties also connected as well. Summarized, the airborne pollutants are absorbed easily in green areas of the city or are washed into the soils of parks or bank of creeks. The toxic elements of sediment showed the following tendency: Pb > Zn > Cu > Ni = Co. The EF values were generally higher in dead region than in thalweg except of GYORI point. Lead had the highest EF values between the five metals investigated. The EF values for Pb were generally greater than five which indicates the moderate degree of Pb contamination inside the town. Zn had the second highest EF values among metals studied. Co, Cu and Ni exhibited the lowest in our EF values. The largest heavy metal values were in sampling point GYORI. The EF values for Pb and Zn increased towards city.

Theses

1) The soil pH of the two settlements was mostly slightly alkaline due to anthropogenic influences in the downtown.

2) The soils of the cities are acidic on the suburb and they tend to acidification, therefore these areas are threatened by the growing pollution of toxic elements.

3) There is a strong correlation between the heavy metal concentrations of 0-10 and 10-20 cm soil layers on each sampling points in both cities.

4) Due to the surface deposition of pollutants, the pollution limit in the upper layer was exceeded in many sample points. In a few sample points, available heavy metal content showed extremely high values in the lower layer.

5) For both layers the highest total load was found in soils of public parks in Sopron. In Szombathely, the highest total load was detected in soils of Gyöngyös creek.

6) For both investigated cities the Cd, Co and Ni values of the soil samples were lower than the suggested natural background limits.

7) The copper values exceeded the natural background concentrations in several cases. In Szombathely, the pollution limit (40 mg Cu/kg) was not reached, whereas in viticulture areas of Sopron, extremely high values were

measured (>90 mg Cu/kg). Around 75% of this copper content is available for plants.

8) Samples taken alongside busy roads, especially in the city center, were contaminated with lead due to the continuous contamination. The accumulation of Pb was confirmed by moderate enrichment of sediment samples, which are originated from the busiest transport hub of Sopron.

9) Zn values exceeded the interventional pollution limit (80 mg/kg) several times. These samples were taken from the bank of the Gyöngyös creek in Szombathely. In case of Sopron, outliers were typical in soils of the traffic zones.

Publications

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