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Study of phytoremediation by use of willow and rape

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ABSTRACT The mining activity surrounding the historic Pb/Zn mine at Gyöngyösoroszi (Hungary) causes heavy metal problems, being a potential risk for all organisms. One of the promising methods for cleaning of metal polluted soils is phytoremediation. Uptake and translocation of heavy metals by two selected plants, willow (Salix spp.) and rape (*Brassica napus* L.) was studied at Gyöngyösoroszi (Hungary), near to a lead/zinc mine, lower flooded area of Toka valley, where the soil is charged with high content of Pb, Zn, Cd, Cu (>1000, >3000, >18 and >280 mg/kg, respectively). The increased uptake and translocation rate of Cd and Zn from root to shoot indicated that phytoextraction technology is possible, while high Cu and Pb concentrations in roots with low translocation rate suggested the phytostabilisation method. Uptake and translocation rate of metals were generally higher in willow than in rape. Based on our results, under the present ecological conditions willow is rather applicable for phytoremediation purposes.
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KEY WORDS

phytoremediation
willow
rape
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heavy metal concentration

The mining activity surrounding the historic Pb/Zn mine at Gyöngyösoroszi (Hungary) causes heavy metal problems (Horvath and Gruiz 1996). One of the promising methods for cleaning of heavy metal polluted soils is phytoremediation. Plants used to phytoremediation have to deal with some important characters: toxic metal concentration tolerance in soil, capability to reduce available fraction or total quantity of soil heavy metal content by means of extraction (phytoextraction) or of bounding (phytostabilisation; Baker 1981; Cunningham et al. 1995).

Willow and rape are plants often investigated for phytoremediation, having high metal accumulation capacity and easily cultivable characters (EPA 2001; Tremula et al. 1997; Kádár et al. 2003; Pulford and Watson 2003).

In this study, heavy metal uptake and translocation of willow (Salix spp.) and rape (*Brassica napus* L.) was investigated on the observed station in lower flooded and polluted part of Toka valley.

Materials and Methods

Site

Our study site is located in Gyöngyösoroszi (North-East Hungary), near the Pb/Zn mine, lower flooded area of Toka valley, where the soil type is brown forest soil. The climate of the region is temperate with continental features. Observed plant species are frequent plants of natural or cultivable sites of this region.

Soil and plant samples

Soils and plants were sampled (seven samples of rape and six samples of willow) from separated, polluted parts of our observation station. Soils and roots were collected one by one from 0 to 20 cm depth of rhizosphere of willow and winter rape.

Sample preparation and chemical analysis

Plant samples (shoots and roots) were separated and after mechanical cleaning and washed with deionized water, and then dried at 70°C. The metal concentrations of soils and plant shoots were determined after standard preparation (soil extraction by HCl/HNO_3 and plant by HNO_3) by ICP spectrometry.

Statistical analysis

Mean values and SD of the element contents were calculated, and analysis of variance (ANOVA) and Student's t-test were performed.

Results

Heavy metal content of soil and plant samples

Soil heavy metal content of this area traditionally cultivated as garden (orchard and vegetable garden) indicated high pollution level. Cd, Cu, Pb and Zn content of polluted soil of field plots were high (≥18.3, ≥ 285.6, ≥1115, ≥3082 mg/kg, respectively).

Distribution of observed pollutants (Pb, Cu, Cd, Zn) was very different according to plant species and parts (Table 1). Pb concentration of root was 31 times higher than those of shoot; and Cu concentration of root was 9-12 times higher than those of shoot by both plants similarly. Compared to the previous data, Zn and Cd concentration of plant parts was somewhat different, moreover trend of plant parts' metal concentration slightly reversed by willow.

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Table 1. Heavy metal content of rape and willow (mg/kg dry weight).

plant	plant part	element content (mg/kg dry weight)			
		Cd	Cu	Pb	Zn
rape	root	26.57 ± 7.85	173 ± 20.90	480 ±125	2296 ± 287
	shoot	8.09 ± 2.43	18.60 ± 7.53	15.23 ± 11.82	1145 ± 376
willow	root	57.98 ± 15.08	253 ± 123	331 ± 254	3175 ± 1927
	shoot	63.27 ± 18.2	20.88 ± 5.68	10.62 ± 8.68	3792 ± 727

The high uptake and translocation rate from root to shoot of Cd and Zn indicated the possibility of phytoextraction technology and the high Cu and Pb concentration of root with low translocation rate indicated the possibility of phytostabilisation. Cd concentration showed the highest value of root uptake (>3), whereas Pb concentration showed the lowest one (0.2). Most of the heavy metals were accumulated in the roots except willow, which had elevated concentration of Cd and Zn in the shoot. BAFs (bioaccumulation factors) of willow for Cd and Zn were >1; not only in root but also in shoot.

Uptake and translocation rates of willow were generally higher than of those rape. Based on our results, willow population that is characterised by higher individual differences, is rather applicable for phytoremediation purposes under the present ecological conditions. It seems that willow leaves (with their high Cd and Zn concentration) are to be cut out for phytoextraction.

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