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Short communication

Salix alba phytoremediation potential of heavy metals

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Introduction

There are 4 categories of interactions of plants with heavy metals: exclusion, accumulative, indicator, and hyperacumulative plants (ability of plants to accumulate more than 100 times the amount of metals). Because the most ecological problems are associated with water and soil pollution with heavy metals/metalloids, the use of plants to transfer toxins from the environment, is one of the most important strategies for preserving natural ecological balance. Heavy metals from the soil to plants get over few processes, such as redox reactions, ionic exchange, precipitation-dissolution, etc. The use of plants to make toxic soil components into non-toxic is called phytoremediation, but in the literature, we can also find such terms as bioremediation, botanical bioremediation and green remediation (Chaney et al., 1997). This is a friendly and efficient natural process by which pollutants are transferred and removed from water, soil and air by plants and organisms that live with them (e.g. microorganisms) and was first introduced in the 1980 by Chaney, and since then it is used to remove heavy metals from the environment. Plants that accumulate metals in large quantities (hyper accumulators) have enormous capability for their use in the remediation of environment from metals. Two significant characteristics of hyper-accumulating metal plants are that they must be tolerant to high concentrations of metals in root and shoots cells and must have potential to uptake these elements quickly and at high levels from the soil. A large number of woody species have been studied or used in phytoremediation and major attention is paid to fast-growing species as genera willow (*Salix* spp.), poplar (*Populus* spp.), etc. Willow trees have large, spreading roots and invasive growth, which increase their utilization and use as in situ phytoextractor (Mertens et al., 2006). Willows are appropriate as phytoextractors with excessive mobility of heavy metals to the shoots and biomass production, due to their high element accumulation (Greger and Landberg, 1999). The potential of the genus *Salix* to accumulate large quantities of toxic metals/metalloids has been proven, particularly for cadmium (Klang-Westin and Eriksson, 2003). Significant differences in metal uptake have been identified between willow types and clones (Vysloužilová et al., 2003). Heavy metal/metalloids concentrations in *Salix* spp. diverse between plant parts and species, in particular arsenic concentration lowered in the following order: leaves > branch bark > stem bark > wood and cadmium concentration in this sequence: leaves > wood = roots (Tlustoš et al., 2007). Willows' resistance to elements such as lead, cadmium, nickel, copper, iron and zinc as well as their capacity to absorb large quantities of metals in their tissues have been demonstrated, implying that they may be used for metal extraction (Keller et al., 2003).

This research presents the metal accumulation potential of *Salix alba* from the soil to plant, expressing also the correlation between them.

Materials and methods

Thirty soils samples (2 kg collected in area 1 – 2 m around the willow tree, depth up to 40 cm) and thirty willow bark of *Salix alba* samples (200–250 g collected 1.5–2 m above ground from trees, averaging 3 m from the river and packed in paper bags) were taken along 30 km of Sitnica river flow, which passes near Kosovo Thermal Power Plants as one of a major contributor to

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environmental pollution in Kosovo (Bajraktari et al., 2019). The amount of metal in the sample was determined using inductively coupled plasma optical emission spectrometry (ICP-OES) using Perkin Elmer Optima 2100 DV and it was set up and optimized according to the manufacturer's instructions; blank samples were prepared in the same way. The following elements are determined: Al (absorbance was measured at 396.153 nm); As (absorbance was measured at 193.696 nm); Ca (absorbance was measured at 317.933 nm); Cd (absorbance was measured at 226.502 nm); Cr (absorbance was measured at 267.716 nm); Cu (absorbance was measured at 327.393 nm); Fe (absorbance was measured at 238.204 nm); Mg (absorbance was measured at 285.213 nm); Mn (absorbance was measured at 257.610); Ni (absorbance was measured at 232.003 nm); Pb (absorbance was measured at 220.353 nm); Zn (absorbance was measured at 213.857 nm).

Results and discussion

The Pearson's correlation matrix revealed significant correlations between Alin soil to Ca in willow bark; As in soil shows moderate correlation with Cd in willow bark; in soil and plant samples Cd shows moderate correlation; Cr in soil shows positive moderate correlation with Cu and negative moderate correlation with Ca in willow bark; Cu shows negative moderate with Mn in willow bark;Fe revealed positive moderate correlation with Ca, Cd, Mn in willow bark; Ni in soil regarding to selected elements in willow bark shows moderate positive correlation with Zn and Ni; Content of Pb in soil is positively moderate correlated with Zn, while Zn content is significantly correlated with Cd in willow bark (Bajraktari et al., 2020).

Transfer factor (TF) can be applied as a measure to establish the efficiency of accumulation of elements (Audet and Charest, 2007) and express the relative mineral and trace element transportability in the soil–plant system. It is plant/element specific (Hooda, 2010) and TF of significant importance is observed in the following order Zn > Cu > Cd > Ni. The highest value of transfer factor for Zn 0.8 was observed in sampling point 27 where was detected the lowest value for Zn in soil sample (S_{27}). Similar potential is demonstrated for Ni where the highest TF is determined to be at the sampling point 1 where the Ni concentration is lowest in the soil sample, (sample S_1). The transfer factor of Cu from soil in plant ranged between 0.06 and 0.47 with highest transfer factor in sampling point 7 where was detected the highest concentration of Cu in willow bark sample. For Cd highest transfer factor value is determined in the sampling point 10 where was detected the highest concentration of Cd in both types of samples, soil and plant.

Conclusion

The results of this research are important for investigation of environmental pollution as a result of external industrial sources, and the results may be valuable for the use of willow in phytoremediation on surfaces contaminated with heavy metals/metalloids. Soil/plant transfer factor of significant importance was observed for zinc, copper, cadmium and nickel. White willow is good and beneficial agent for phytoremediation, due to its ability to tolerate and accumulate heavy metals/metalloids and the properties of rapid growth, translocation ability and high biomass.

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