REMEDIATION OF EXTREMELY CONTAMINATED SOIL WITH Cd, Pb AND Zn USING BIOCHAR – 3 YEARS EXPERIMENT

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Keywords: immobilization; willows; risk elements; biochar amendment

Introduction

Under the European Union (EU) Thematic Strategy for Soil Protection, the European Commission has identified soil contamination, occurrence of 342 000 polluted sites have been reported, most commonly polluted with heavy metals and mineral oils (Panagos et al. 2013). For metal polluted soils, phytoremediation appears to be an economically and esthetical attractive in situ technology (Pulford and Watson, 2003). Willow potential for phytoextraction technologies was observed on heavily and moderately polluted soils (Tlustoš et al. 2007; Vysloužilová et al. 2003). However, for reasonable efficiency of phytoextraction the biomass production in field conditions will mainly determine metal removal (Meers et al. 2007). Thus, in specific cases, heavily contaminated sites, should be considered to combine phytoextraction and stabilization technologies to improve plant growth and support the phytoextraction potential. The biochar sorption ability of organic pollutants (Zhang et al. 2011) and heavy metals (Beesley et al. 2010) was observed there. The utilization of cylinder pots placed in laboratory, greenhouse or into field conditions were described as a suitable way for investigation of element transport through soil profile (Trakal et al. 2011). In Břendová et al. (2015) the biochar application into extremely contaminated soil improved willow growth and phytoextraction potential in one year experiment. However relevant long term study supporting first experimental results is missing. The aim of our study was: i) to evaluate the potential effect of elevated rates of biochar application on risk elements transport through the soil profile, and ii) to assess the effect of biochar amendment on plant growth as well contaminant accumulation in willow tissues, in long – term study.

Methods

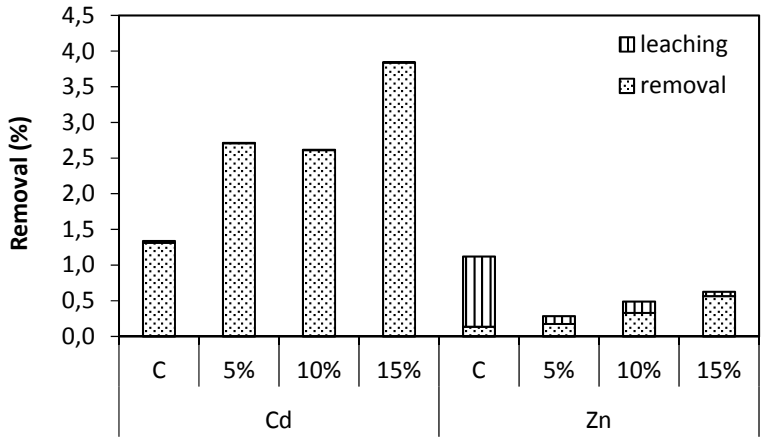
The experiment was established at greenhouse controlled conditions. To observe risk element content in leachate, the lysimeter (40 cm) pots were used. *Salix Smithiana* was chosen as an experimental crop. Biochar was prepared from coconut shells. Soil was sampled at old smelting area, near Příbram city (central Bohemia, Czech Republic). The soil is extremely contaminated with cadmium, zinc and lead. The leachate was analysed (ICP-OES) each 3 weeks during vegetation. The trees were harvested and twigs and leaves were analyzed separately. The experiment consisted of 4 treatments: control (no applied biochar), and rates of 5%, 10%, and 15% of biochar from total mass of soil. At each treatment two willows cuttings were planted.

Results

In the first year, willows were characterized by significantly higher production at amended treatments in comparison to control. In the second year, yield of aboveground biomass significantly decreased at 5% treatment in comparison to previous year. Treatments of 10% and 15% of biochar provided similar yield of biomass to first year of vegetation. In both years, willows leaves at control treatment showed extreme phytotoxic signs and willows grown at treatments with biochar were without them. The lead content

decreased in plant biomass by 43-57% and by 59-56% at amended treatment in first and second year respectively. The limited removal of Cd (lower by 10-28%) and Zn (lower by 22-33%) was not significant, where biochar was applied, during first year of vegetation. Second year, the cadmium content in plant tissues was higher at amended treatments and zinc content was lower by 4-19%. In leachate, both cadmium and zinc content decreased to values below detection limits at all biochar treatments and lead wasn't detected at these treatments during first year. The pH of leachate increased with increasing biochar dose during two years. In third year the pH of leachate decreased and wasn't significantly higher at amended treatments comparing control. The content of elements increased in leachate. Willows were characterized with large phytotoxic signs and died. The comparison of Zn and Cd removal and leaching from contaminated soil in 3 years is given in Fig.1.

Figure 1. Comparison of Zn and Cd relative removal and leaching from contaminated soil (%)



Conclusion

Finally, we can summarize that biochar appears to be a very effective regulator of availability of observed risk elements and is able to improve biomass growth, increase total uptake of Cd and Zn and decrease leaching of these elements, but our results reveals, that this effect has time limitation.

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