INCREASING PHYTOMINING EFFICIENCY ON WASTE INCINERATION BOTTOM ASH

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Introduction

Facing a predicted shortage of primary resources, different strategies to deal with a decreasing availability of raw materials have been proposed that involve the use of secondary resources (EC 2014). Waste incineration is a technology widely used in Western Europe, leaving behind a great resource potential in the form of waste incineration bottom ash. Phytomining could offer an environmentally sound and cheap technology to recover valuable metals from these waste incineration residues. Successful application of this technology on soil has been shown previously (Bani et al. 2015). However, the use of this technology in combination with waste incineration residues is a novel and innovative approach. The aim of our research work is to investigate the potential of phytomining of valuable trace elements (TE) on waste incineration bottom ash by growing metal accumulating and hyperaccumulating plants on these substrates.

Methods

Fresh bottom ash from Vienna's municipal solid waste incineration (MSWI) and hazardous waste incineration (HWI) were extensively characterised for pseudo-total and mobile TE pools as well as for plant-growth relevant characteristics. Based on that characterisation, a substrate mixture of 70% (w/w) bottom ash mixed with 20% (w/w) material from mechanical biological treatment of municipal solid waste and 10% (w/w) biochar was selected for a series of pot experiments. The initial experiment involved metal hyperaccumulators and metal tolerant high-biomass plants on MSWI and HWI bottom ash. A second experiment involved high-biomass plants and EDTA-induced metal solubilisation. In a third experiment inoculants of PGP-bacteria were tested for their positive effect on biomass production and TE accumulation in plants. A substrate mixture consisting of 80% (w/w) bottom ash and 20% (w/w) compost that was naturally aged on a landfill was used for two further pot experiments, one currently ongoing and a still ongoing field experiment on a landfill in Vienna, Austria. In these experiments, more than 20 plant species were tested for accumulation of valuable TE, among them *Sedum plumbizincicola*, *Alyssum serpyllifolium*, *Noccaea caerulescens, Berkheya coddii* and clones of *Nicotiana tabacum* and *Salix smithiana* that were previously described to show enhanced TE tolerance and uptake.

Results

Fresh bottom ash is a difficult substrate for plant growth, characterised by an extremely alkaline pH, high salinity and soluble concentrations of some TE toxic to plants. Treating and amending the fresh bottom ash was essential to make plant growth possible. The hyperaccumulator species tested in the pot experiments, *A. serpyllifolium, S. plumbizincicola* and *N. caerulescens* grew slowly and most likely suffered from the high salinity and the high soluble Cu concentrations in the substrate. Nevertheless, they showed elevated concentrations of Ni and Zn, respectively, in the above ground biomass. Regarding the PGP-bacterial treatments, increased biomass production in tobacco shoots and willow roots could be detected. Regarding the EDTA-treatments increased uptake of Zn in *S. smithiana* and *Chenopodium album* could be achieved. However, the use of EDTA is only recommended in closed systems where uncontrolled leaching can be avoided.

Conclusion

We were successfully growing a series of plant species on waste incineration bottom ash with high accumulation of Ni and Zn in hyperaccumulators. Moreover, the use of PGP-bacteria or metal chelating agents in combination with high-biomass plants might offer an alternative to slowly and moderately growing hyperaccumulators. Nevertheless, in the focus of phytomining and the need of accumulation of high concentrations of a certain TE in the above-ground biomass, the use of hyperaccumulators is a more appropriate choice. Therefore, further experiments on the optimisation of plant growth and biomass production of these plants are necessary.

References

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