RHIZOSPHERE PROCESSES IN PHYTOREMEDIATION OF METAL-POLLUTED SOILS

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Introduction

The few millimetres of soil surrounding the plant roots are termed "rhizosphere" In spite of its limited volume the rhizosphere plays a key role in controlling the soil-plant relationship. Rhizosphere soil differs largely from the bulk soil and represents the microenvironment in which root activities and soil properties closely interact. Plant-microbe relationships ranging from symbiosis to parasitism as well as microbial population dynamics are also influenced by these particular conditions. Availability and uptake of nutrients are largely controlled by soil conditions in the rhizosphere and the bioavailability of pollutants may differ substantially from that in the bulk soil.

Induced phytoextraction enhancing metal-accumulation of high-biomass annual crops by application of chelates to soil has been explored by various groups (e.g. Blaylock *et al.* 1997). Other approaches employ perennial metal (hyper-) accumulating tree, shrub and herbaceous species, grasses and ferns for continuous phytoextraction of metals and metalloids. In both approaches, indigenous rhizosphere processes as well as their manipulation are considered key factors controlling metal bioavailability and the efficiency of phytoextraction (Wenzel et al., 1999; McGrath et al., 2000). This paper presents an overview on the role of the rhizosphere in phytoextraction.

Methods

Using screening in the field, field lysimeter, pot and related rhizobox experiments, we studied the efficiency of metal (hyper-) accumulator plants such as *Thlaspi goesingense* (Ni), *Pteris vittata* (As) as well as of *Salix* and *Populus sp*. to extract heavy metals and metalloids from soil and rhizosphere processes involved.

Results - discussion

Phytoavailability of a metal is a prerequisite of its uptake by phytoremediation crop plants. Manifold interactions between soil and plant factors are involved in metal phytoavailability and toxicity and the regulation of the actual uptake by the plant roots.

In **induced phytoextraction** the metals are rendered phytoavailable via addition of synthetic chelates (e.g., Blaylock et al., 1997). While in various studies this method has been found to be efficient in enhancing metal solubility (Wenzel et al., 2000), it has been also demonstrated in bench scale and field lysimeter studies that risk of groundwater pollution increases and may be difficult to control. Data from pot and field lysimeter experiments will be presented.

Current efforts are therefore focussing on the development of **continuous phytoextraction** technologies. We identified willow and poplar ecotypes that are able to accumulate Cd, Pb and Zn in their leave tissues. Recently, ferns that hyperaccumulate As were found in Florida (Ma et al., 2001). In contrast to members of the *Brassicaceae* family, these trees and fern species are associated with mycorrhizal fungi. It will be crucial for the further development of continuous phytoextraction to understand the role of mycorrhiza in metal tolerance and in controlling phytoavailability of metals in the rhizosphere. Identification of micro-organisms, including mycorrhizal associations from the rhizosphere of metal-accumulation species, using molecular genetical methods, and subsequent development of preparative inoculates for rhizosphere management will be essential and is currently undertaken by our group

Rhizosphere research also needs to address the viability of the concept of **bioavailable contaminant stripping** proposed by Hamon and McLaughlin (1999). While currently remedial goals are defined in terms of lowering the total metal concentrations, the applicability of continuous phytoextraction would benefit from targeting the bioavailable fraction. This would provide a means of risk reduction during phytoextraction and might extend economically-sound applications also to highly-polluted soils as the time needed for extracting the bioavailable fraction will be considerably less than for the totals. Yet, it is unclear as to whether metal mobilization through root activities counteracts the extraction by the plants. Similarly, it will be important to know for aftercare management of phytoremediated soils if metal mobilization after termination of remedial action would imply a risk (longevity / sustainability of phytoextraction). Pot and rhizosphere experiments along with modelling of the relevant rhizosphere processes are underway to address these questions and to explore the potential of chemical and microbiological rhizosphere manupulation.

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