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ISEQ Work Summary as of December 2004

The long-term fate of trace metals in contaminated soil systems is a significant issue in environmental science. Anthropogenic inputs of trace metals have resulted in a significant increase in the metal content of soils. Sources of metal contamination include spoil from metal mining operations, fallout from refinery emissions, combustion of fossil fuels, and the application of agricultural pesticides and biosolids. The resulting heavy metal contamination threatens the viability of surrounding ecosystems and poses significant health risks to neighboring communities. Traditional *ex-situ* remediation strategies (i.e., removal and treatment or disposal of contaminated soil) are expensive, costing ~$1M/acre. Therefore, effective *in-situ* remediation methods based on a sound understanding of soil metal speciation are increasingly attractive. Unique plant species have evolved an ability to accumulate trace metals in their harvestable biomass, and thereby offer a sustainable method for treatment of metal contaminated sites (phytoremediation). For example, several plants in the *Brassicacea* family, including species of *Alyssum*, have demonstrated the ability to hyperaccumulate nickel (Ni) in both laboratory and field studies. Growing hyperaccumulator plants in Ni-rich soils and ashing the harvestable biomass to produce Ni ore (phytomining) is an economically sound alternative for metal recovery (Chaney, 1983).

A better understanding of the factors and mechanisms involved in metal accumulation and tolerance can be achieved through detailed observation of plant metal speciation, which will ultimately lead to optimization of phytoremediation technology. Few methods are available for determining metal speciation in soils and plants, and most methods involve excessive sample pre-treatment that could alter the sample properties being measured. Methods capable of determining (*in-situ*) metal speciation with minimal chemical or physical sample treatment are preferred for investigations of environmental systems. Our laboratory applies X-ray absorption spectroscopy (XAS) to the speciation of metals in contaminated soils and more recently to hyperaccumulator plants. Preliminary work with a Ni hyperaccumulator (*A. murale*) highlights the applicability of these techniques to biological systems.

A. murale has demonstrated the ability to hyperaccumulate both Ni and cobalt (Co). We are currently employing XAS to resolve the speciation, localization, and association of several metals within *A. murale* plants from mixed-contaminant systems (i.e., co-contaminant metals). The effect of metal interactions on metal uptake and partitioning behavior is being explored in these systems as well as tissue- and age-dependent trends in metal localization. Additionally, the *in-situ* speciation of Co within *A. murale* is being investigated in order to resolve the ligands used by these plants to bind and detoxify Co. Information on the localization, speciation, and associations of metals with other elements in plants can shed light on the mechanisms used by hyperaccumulator plants to accumulate and tolerate metals from contaminated soils.