Canadian Network of Toxicology Centres

Metals In The Environment

Research Network

SCIENCE BRIEF (June 2004)

DETERMINING THE BIOLOGICAL AVAILABILITY OF METALS IN FOREST SOILS

ISSUE

Soils can be contaminated with metals from both natural and human sources. A principal route by which such metals can enter biological systems is via plants such as trees growing on contaminated forest soils, specifically by uptake at the soil:root interface (the rhizosphere). However, most of the scientific processes available to estimate uptake do not involve direct measurements of plant tissues. Rather, they are based on chemical analyses of soil and/or of the liquid phases in the soil. Such indirect measurements are known to have a large margin of error.

SIGNIFICANCE

This research has clearly shown the importance of the soil:root interface as a sink for biologically available metals compared to bulk soil. This "rhizosphere effect" appears to be independent of tree species (aspen, white birch, balsam fir, sugar maple), which means that generalizations are possible among species. Greater soil contamination will result in variable (depending on the specific metal) increases in the concentrations of biologically available metals in the rhizosphere, but increases will generally be limited to slightly less than a factor of ten. Effectively this research, by providing a greater understanding of metal distribution and speciation in the rhizosphere, provides the basis for realistic assessments of the biological availability of metals in forest soils. It also provides the basis for developing metal bioremediation technologies.

BACKGROUND

Previous to this research there had been little basis for relating uptake and storage of metals by plants such as trees to soil metal content. This critical data gap had occurred for several reasons. First, there were few data on metal concentration and speciation in the rhizosphere of forest soils. Second, there was uncertainty regarding the heterogeneity in metal concentrations in the rhizosphere that could be due to different tree species and/or to the magnitude of soil metal contamination. Third, there was a poor understanding, related to metal bioaccumulation, of the links between soil solutions, the soil:root interface, and plant tissues.

FINDINGS

This research, carried out through the Metals in the Environment Research Network (MITE–RN) program, has shown the importance of the rhizospheric environment as a sink for metals such as cadmium, copper, nickel, lead and zinc. The rhizospheric sink tends to be proportionally greater for biologically available metals than for those that are not biologically available. Of the factors that control these increased metal concentrations in the rhizosphere, differences between tree species account for a variability of less than two-fold, whereas levels of soil contamination account for a variability of less than ten-fold. Future assessments of metal uptake by plants focusing on the rhizosphere rather than on indirect measurements of bulk soil or soil solutions, will provide much greater certainty regarding ecological risks than has previously been possible.

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FUTURE RESEARCH

An additional tree species (red pine) is being assessed to confirm that there are in fact limited inter-species differences. The role of organic substances and soil microorganisms in the rhizosphere effect is also being investigated. Research is specifically focusing on concentrations of the most reactive metal forms (Cu^{++}, Zn^{++}). Two ultimate practical goals of this research are the identification of key indicators of the response of soils to environmental stressors, and providing the basis for development of new bioremediation technologies for the clean-up, when necessary, of metal-contaminated soils.

ADDITIONAL INFORMATION

http://www.mite-rn.org/research/era/era.shtml

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