Radiochemical Evaluation of a Sequential Extraction Procedure for Trace Metal Characterization of Contaminated Soil

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The goal of this study was to characterize trace metal contamination in selected soils and sediments collected from the Toronto region, each representing different contamination problems and remediation challenges. To more clearly identify where and how contaminants are bound in the soil, sequential (or selective) chemical extraction techniques have often been used. These employ a series of successively stronger chemical leaching reagents, which nominally target the different compositional fractions in soils. By analyzing the liquid leachates and the residual solid components, it is possible to determine the type and concentration of metals retained in each soil phase, and also their potential ecological significance. This provides far more detailed information than the more conventional measurement of simple elemental concentrations.

The BCR (now the Standards, Measurements and Testing Programme of the European Commission) sequential extraction protocol is a recent development towards an internationally standardized method for geochemical analysis of soils. A modified version of this procedure was used to determine the partitioning and retention behaviour of Cd, Cr, Cu, Pb, and Zn, as well as other selected trace and matrix elements within the soil. These results were corroborated through the use of standard reference soils, and suggested possible approaches to remediation of metal contamination, permitting better informed decision-making on the fate of these sites.

In some cases, generalizations on metal partitioning behaviour could be linked to the theory and anecdotal evidence in the soil chemistry literature. For example, in a fill material taken from downtown Toronto and a sediment from Toronto Harbour, Cd would be highly mobile, Cu and Pb primarily associated with organic matter, and Cr non-extractable, while Zn was distributed across all soil fractions. However, the unusual soil properties of material from an abandoned metals recycling operation produced unexpected results, with the trace metals within strongly retained.

Direct solid phase analysis by neutron activation was able to provide some supporting data, but was unable to determine several key elements in soil. Further testing of the BCR procedure focused on possible redistribution of metal between the different soil compartments during the extraction process. There is some controversy in the literature over this phenomenon, which has the potential to invalidate any results obtained. By incorporating radioisotope tracers in the sequential extraction, redistribution effects for Cd and Zn were critically and quantitatively evaluated for the first time.

Measurable readsorption of metal occurred during the sequential extraction, and the role played by Fe and Mn oxides was confirmed. For Cd and Zn, the phenomenon was not as extreme as previously suggested, and could be corrected for, using these radiotracer partitioning results.