Abstract

Heavy metals are prevalent and tenacious contaminant in many sediments and dredged materials. Sand is often used as a passive barrier to slow release of metals from the sediment and to separate benthic organisms from the sediment. Materials that effectively absorb metals have the potential to provide significantly greater effectiveness by further retarding metal release. In this study, the effectiveness of apatite and phosphil, which contain phosphate in a form that can absorb many metals, is evaluated with a series of column experiments. Experiments evaluating kinetics and equilibrium sorption and migration of metals on the cap materials were conducted.

Metal (Cr, Cu, Zn, Pb) sorption isotherms for several capping materials (i.e., sand, Florida Phosphate and Phosphil) and Anacostia river sediment were measured. Langmuir shape isotherms were observed suggesting that the effectiveness of these materials decreases at high concentration. The sorption isotherm experiments also revealed that the phosphate cap materials were much more sorbing than sand and therefore would more effectively retard contaminant migration. (e.g. the order of maximum sorption capacity for phosphate materials investigated is :Pb>Cu>Cr>Zn)

Column experiments designed to study metal transport under natural conditions (using field contaminated sediment as a migration source) had difficulty achieving measurable migration depths (above and beyond metal spreading due to intermixing between sediment and cap materials) and differentiate the metal migration characteristics of different materials within a reasonable time scale. An analytical model of contaminant migration was developed. Metal migration in the same capping materials was studied utilizing experimental columns in which high concentrations of metals were ponded over a solid layer of capping materials. Migration profiles were measured two ways: a "traditional" sectioning method followed by ICP-MS analysis of the section; and non-destructive scanning using synchrotron X-ray Fluorescence. The latter method allowed determination of metal profiles with sub-mm resolution. In migration experiment Zn migrated fastest among all four metals and sand exhibited the least retardation of any metals. These are consistent with the equilibrium sorption data. Although the experiments with a high concentration metal solution allowed the observation of metal migration in reasonable periods of time (days), the experimental setup resulted in buoyancy effects which artificially enhanced metal migration. In addition, the use of high metals concentration resulted in reducing the effectiveness of the capping material due to the limited sorption capacity exhibited by the Langmuir isotherm.

A diffusive model incorporated Langmuir isotherm is developed to simulate the migration of metals in these column systems. The model is numerically solved by the finite difference method using the initial observed profile as initial condition.