New Options for Site Management

Metals Bioavailability Reduction

Remediation Trends • June 2005

Stabilization of metals has been used in the management of contaminated soil and waste for a number of years. Initially, management decisions typically focused on stabilization to meet disposal goals when the soil and waste are removed from a site to an off-site landfill (with Toxicity Characteristic Leaching Procedure [TCLP] as management criterion). More recently, stabilization has been applied to mitigate the leaching of treated soil and waste into water (with Synthetic Precipitation Leaching Procedure [SPLP] as management criterion). Treated media that meet site-specific leaching criteria can be managed on site. However, this process does not reduce the concentration of metals in the soil or waste. Therefore, the potential for adverse effects resulting from direct contact with and ingestion of the treated soil still needs to be addressed. Covering and institutional controls are common means to mitigate exposure to treated soils.

In the last few years our understanding of the role of bioavailability of metals has increased substantially. The evaluation of bioavailability of metals has begun to be put to use in making risk management and remediation decisions for untreated soil and waste. Research efforts have also begun to address the potential for reductions in bioavailability by adding metals sequestering or stabilizing agents. Lead and arsenic have been evaluated to the greatest extent and the time is ripe to move from research to carefully documented field applications. Incorporation of bioavailability into remedial decision making may potentially support raising remediation cleanup concentrations or support the ability of stabilization methods in the reduction of bioavailability. Where metals are not bioavailable, it may be appropriate to manage the soil or waste on a site, rather than remove the material to a landfill.

Physiologically Based Extraction Tests

The Solubility/Bioavailability Research Consortium (SBRC) developed a streamlined test specifically for lead. Continued validation efforts by J. Drexler, University of Colorado at Boulder, has lead to sufficient standardization that the test is offered for use on a commercial basis. Development of an approved EPA method is in progress. An arsenic test is expected to follow.

Bioavailability of Contaminated Media

Inherent Relative Bioavailability. The bioavailability of arsenic and lead using *in vivo* and *in vitro* methods have been found to be significantly less than the bioavailability of the soluble metal salts that are used in toxicological studies.

Human absorption of lead from dietary sources is on the order of 50 percent for children and 10 percent for adults. The bioavailability of lead is very dependent upon the form of the lead in the soil or waste. Other important factors include age and nutritional status of the subjects, whether the exposure occurred under fasting or feeding conditions, and particle size for any given lead mineral species or sorbing mineral.

A number of *in vivo* tests with animals and humans have been completed using soil and waste from mining and smelter sites with the resulting relative bioavailability factors ranging from 0.004 to 1.1. Other contaminated media tested to date include paint-contaminated soil (relative bioavailability of 80 percent), refinery soil (bioaccessibility of 1 to 100 percent, mean of 30 percent), and foundry sands (bioaccessibility of 49 to 100 percent, mean of 68 percent).

Regulatory Application of Relative Bioavailability. Default cleanup goals are typically conservatively defined to be protective in the absence of site-specific considerations, and assume that all of the contaminant in soil or waste is available for absorption by organisms. The USEPA's Integrated Exposure and Uptake Biokinetic Childhood Lead Model (1994) assumes a relative bioavailability of 60 percent. As noted in the previous discussion of inherent relative bioavailability, the USEPA default assumption appears to reflect "typical" bioavailability of lead in untreated soil from a number of different contaminated sites. General risk assessment guidance does not preclude the use of relative absorption factors (RAFs). Reduced bioavailability results in smaller RAFs which increases potential cleanup levels. However, regulatory agency risk assessors are very reluctant to apply RAFs from the literature to a site-specific determination due to the natural variability in metals bioavailability.

Application of bioavailability to remedial decision making has, to date, focused on adjusting cleanup levels to reflect site-specific metals bioavailability. Nine sites have been documented where cleanup levels were increased as a result of bioavailability evaluations and one site confirmed the default lead bioavailability of 30 percent was confirmed. Four of the ten sites were regulated under state authorities while the other six were under USEPA regional oversight. At least one state, Florida, is in the process of incorporating bioavailability into its regulatory cleanup target levels.

Bioavailability Reduction by Stabilization

A number of reagents have been used to stabilize or sequester metals for purposes of meeting disposal requirements or environmental leaching requirements. These include phosphate, iron/manganese oxyhydroxides, magnesium oxyhydroxides, sulfur, cement, flyash, lime, and organic polymers. Several recent studies have demonstrated that the addition of some of these sequestering agents as part of a remedial action can reduce the bioavailability of metals. ***Such a reduction suggests that treated soils with higher metals can be safely managed on-site relative to untreated soils.***

Phosphate-based and iron-based treatment has been found to reduce the bioavailability or bioaccessibility of lead on the order of 50 percent (with a range of 15 to 90 percent reductions). This suggests that it is not unreasonable to expect a 2- to 10-fold increase in acceptable lead concentrations in treated soil with respect to human bioavailability. Such an increase could have a significant impact on the nature of remedial actions at many lead-contaminated sites.

ReSolution Partners has been evaluating the potential for bioavailability reduction through the addition of stabilizing agents. The evaluation includes both literature reviews and our own bench-scale testing of stabilization reagents. If your site may benefit from the application of bioavailability, contact Bernd Rehm at 608.669.1249 or brehm@resolutionpartnersllc.net.