SUSTAINABILITY OF PHOSPHATE TREATMENT OF LEAD CONTAMINATED SOILS[1]

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Abstract. Over the past few years, MSE under the U.S. Environmental Protection Agency's (EPA) Mine Waste Technology Program (MWTP) has provided some support to two evaluations studies of phosphate-based in situ treatment of soils for reducing lead (Pb) bioavailability at the Joplin (Missouri) and Coeur d'Alene (Idaho) Superfund sites. These assessments correlated physicochemical (i.e., various spectrometric) data with results obtained from in vivo (i.e., swine or waterfowl-dosing) methods, plus in vitro methods that mimic mammalian or avian gastrointestinal systems.

The major findings of these two MWTP projects will be presented and discussed. Most of the information presented is extracted from the final or draft versions of MWTP project-specific documents. This paper is an extended abstract with only cursory project details and is meant to serve as an additional information source to the presentation materials. More detailed information will be available in published EPA Final Report and subsequent publications.

The first project to be presented was an evaluation of whether phosphate based treatment could reduce the relative bioavailability (RBA), bioaccessibility, and phytoavailability of lead (Pb) in mine waste-contaminated soils at the Joplin, Missouri NPL site. In this MWTP study, it was found that interpretation of RBA data from pig soil-dosing studies was substantially limited by the lack of simultaneous testing of treated and untreated soils within the same study. The consequent loss of statistical power precluded the quantitation of any reduction in lead RBA due to phosphoric acid treatment of mine waste-contaminated soils. However, it there a consistent tendency was noted for RBA to be somewhat lower in the 1% phosphoric acid treated soil than in the 0.75% phosphoric acid treated soil; and given the unusually low absorption of lead (into pig tissues) from untreated mine waste soil, the RBA in such soils may be higher than that estimated by VMDL.

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This point is supported by a previous investigation by VMDL, wherein young pigs were dosed with three different soil types (including those contaminated by mine/mill wastes) from the Joplin Superfund site. The lead RBA results from such testing varied between 58% to 83%. If untreated mine waste soils indeed exhibit RBAs in this range, it would add credence to both NERL's bioaccessibility study results and observations of reduced lead levels in LSB from plants grown in 1% phosphoric acid treated soils.

The recommendation from this MWTP study was a further evaluation of whether ≥ 1% phosphoric acid treatment of mine waste soils actually lowers lead RBA in young pigs, and environmental mobility of lead in general, appears to be justifiable. This investigation should include: 1) direct comparisons of RBAs from pigs dosed with treated, controls, or untreated soils, 2) comparisons of lead bioaccessibility in phosphoric acid treated vs. untreated soils, and 3) heavy metals phytoavailability study for phosphoric acid treated soils having rooting zone pH values of ≥ 6.5. (Cornish and Lewis 2004)

The second presented project evaluated phosphorus-lead interactions in soil with respect to decreased waterfowl lead bioavailability in the Lower Coeur d'Alene Basin. This MWTP study was to correlate the treatment-induced reaction mechanisms with previously preformed toxicological studies conducted by the Idaho Department of Environmental Quality and the U.S. Fish and Wildlife Service. In this previous work, different soil amendment treatment technologies were applied at a field site in the Lower Coeur d'Alene River Basin. The University of Idaho, under the MWTP, investigated the fate of lead in these remediated soils to provide additional support that phosphorus-based remediation of lead-contaminated soils reduces lead bioavailability to waterfowl. A physiologically based extraction test model for waterfowl (W-PBET) was developed to evaluate the effectiveness of soil treatments to reduce lead bioavailability in the phosphate-amended soils. Experiments using advanced spectroscopic and microscopic techniques are also conducted to demonstrate the effectiveness of phosphate-soil amendments to reduce lead bioavailability, solubility, and leachability through formation of low-solubility lead compounds.

The W-PBET lead concentrations were positively correlated to the previous bird feeding study results, exhibiting a logarithmic relationship. Results from this study indicate that a W-PBET extraction test can be used to assess relative changes in bioaccessibility, and therefore will be a valuable test to help manage and remediate contaminated wetland soils. W-PBET results as well as bird feeding results indicate that phosphorus amendments significantly reduce lead bioavailability. (Furman 2004 and Strawn 2006)

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