Surfactant Facilitated Remediation of Heavy Metal Contaminated Soils: Efficacy and Ecotoxicological Consequences

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Desorption experiments were conducted to evaluate remediation efficacy of a range of chemically unique surface active agents (surfactants) in removing Zn, Cu, Pb, and Cd from a Superfund soil associated with more than eighty years of heavy metal deposition. The rhamnopyranosyl-based biosurfactant (anionic), oleyl dimethyl benzyl ammonium (nonionic), and 1-dodecylpyridinium chloride (cationic) dramatically induced desorption of Zn, Cu, and Pb by an order of magnitude. The rhamnolipid formulation induced the greatest desorption, with an overall reduction of Zn, Cu, Pb, and Cd by 39, 56, 68, 43 % respectively. Surfactants were also prepared at varying pH levels (7.0, 5.0, 3.5), and in mixture with I^- (at 0.05, 0.10, and 0.15 M) and ethylenediaminetetraacetic acid (at 0.005, 0.010, 0.100 M) chelating agents. While results were metal- and surfactant-specific, acidified surfactants lead to enhanced removal of metals (>95 %). Only moderate increased rates of decontamination were observed using surfactant solutions containing I^-. EDTA had the most pronounced impact on surfactant desorption efficacy, in most cases removing 90–98 % of all metals at the highest EDTA concentration (0.100M). However, the relationship between EDTA concentration and metal desorption in surfactant emulsions was not always linear. Finally, on the basis of toxicological impact to receptor species, assays revealed that in two species of earthworm, *Eisenia fetida* and *Lumbricus terrestris*, metal bioaccumulation was reduced by ~ 30 to 80 %, total biomass was enhanced by ~ 3 to 6-fold, and survival was increased to > 75% in surfactant-remediated soil compared to untreated soil. This study presents the most comprehensive examination of surfactant remediation technology, and is the first of its kind to link both chemical and toxicological parameters to assess the feasibility of implementing such technology to remove contaminants aged for nearly a century.

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