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Bioleaching and Chemical Leaching of the Soil Contaminated with Radionuclides

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ABSTRACT

Contamination of soil with radionuclides can pose significant hazards to human health. Once pollution occurs, intensive removal process of radionuclides from contaminated soil should be performed immediately. Released radionuclides may migrate to biosphere through air and natural water and be adsorbed onto soil particles. The objective of the study was to investigate whether bioleaching technique using Fe- or S-oxidizing bacteria, which has been extensively studied for treatment of heavy metal-laden soil, can also be effectively applied to removal of radionuclides adsorbed onto soil particles.

Experiments of bioleaching and chemical leaching of soil artificially contaminated with Co and Sr, which serve as surrogates of their radioactive counterparts, were performed. *Acidithiobacillus ferrooxidans* and *A. thiooxidans* were used in bioleaching experiments under various conditions. In chemical leaching, diluted sulfuric acid, acetic acid and EDTA were employed as leaching agents. Aliquots were periodically removed from batch-type experimental sets and Co, Sr, Fe and pH were determined.

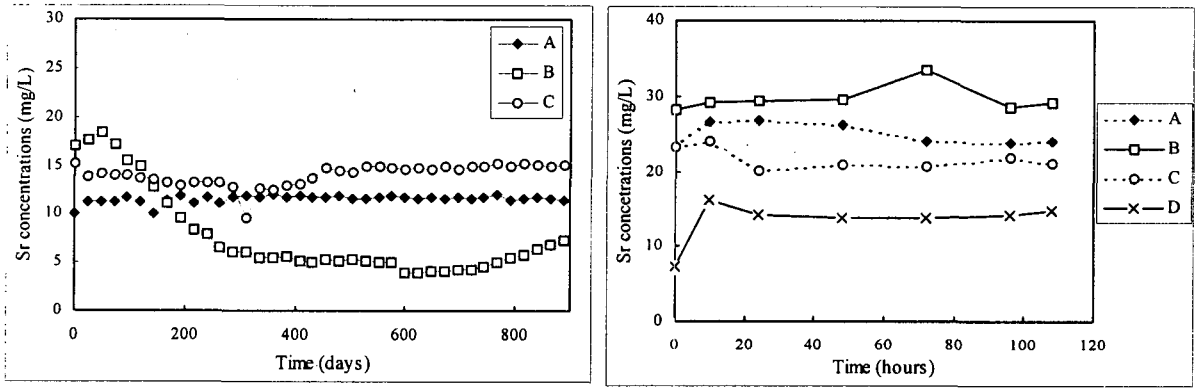
Initial pH was set at 2 in both biotic (*A. ferrooxidans*) and abiotic leaching. Regardless of leaching type, the initial pH appeared to be one of the most critical parameters, since the low pH led to dramatic increase in Co and Sr extraction during the very initial period of incubation. This was likely because these elements were loosely adsorbed onto soil particles, not in crystal lattice. The initially leached amounts were maintained throughout the remaining experimental period. Since pH and aqueous Fe^{2+} concentration decreased with time in the case of biotic solution, active metabolism of *A ferrooxidans* was allowed in the given condition. However, microbially-leached Co and Sr showed slightly lower values than abiotic control. *A. ferrooxidans* oxidized Fe^{2+} to Fe^{3+} resulting in subsequent formation of Fe(III)-precipitates such as jarosite and/or Fe-hydroxides. Such Fe(III)-precipitates seemed to adsorb the dissolved Co and Sr in

solutions, leading to lower concentrations of these elements than the abiotic control. Especially, when Fe^{2+} was supplied into solution, the concentrations of dissolved Sr were decreased without exception. Conceivably, dissolved Sr might be highly restrained by bacterially-produced Fe(III)-precipitates.

Leaching experiments with *A. thiooxidans* were performed at the initial pH of 5. The higher initial pH resulted in lower removal efficiency for both elements than that of *A. ferrooxidans*.

Chemical leaching experiments were conducted under the condition of the initial pH spanning 2 to 4.5. Chemical agents resulted higher removal efficiency of the elements than bioleaching. In addition, because the chemical agents used in this study were diluted or organic acids without production of Fe-precipitates or continuous decrease of pH, unfavorable impact on natural soil after treatment may be lower than bioleaching.

Conventional bioleaching techniques using *A. ferrooxidans* or *A. thiooxidans* showed low removal efficiency of Co and Sr, especially when Fe^{2+} was supplied into solution (Fig. 1). Regarding many studies which showed high removal efficiency of heavy metals by use of Fe- or S-oxidizing bacteria, the present result is remarkable. The difference is likely due to the occurrence mode of the inorganic contaminants in soil particles. Preliminary geochemical and mineralogical investigation on toxic elements should be thoroughly conducted before practical application of leaching techniques to natural soil system especially contaminated with radionuclides.



(a) (b)

Fig. 1. Comparison of biological (a) and chemical (b) removal efficiency of Sr from the contaminated soil with time. In (a), A: *A. thiooxidans*, B: *A. thiooxidans* + *A. ferrooxidans*, and C: distilled water. In (b), A: diluted H_2SO_4, B: acetic acid, C: EDTA, and D: distilled water.

Key words: bioleaching, radionuclides, soil, contamination, Fe/S-oxidizing bacteria