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THE ROLE OF BIOTECHNOLOGY IN THE TREATMENT OF GEOTHERMAL RESIDUAL SLUDGES

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ABSTRACT

Power plants which use geothermal heat to generate electric power produce a residual sludge in large quantities. This material precipitates from supersaturated brines and contains toxic metals, some of which are present in concentrations exceeding the non hazardous waste disposal regulations. Disposal of this waste as hazardous waste is costly. Work in this laboratory has shown that a biotreatment of the geothermal waste in which toxic metal resistant acidophilic organisms are used can serve as a basis for a new biotechnology for detoxification of geothermal residual brine sludges. Phase one studies have shown that an economically and technically feasible biotechnology can be developed. The efficiency of this technology depends on a number of parameters such as the bioreactor design, residence time, and the number and concentration of toxic metals to be removed. Further, the process, while rendering a detoxified material, produces a liquid phase which is enriched in toxic metals. This aqueous phase can be reinjected into the wells, or processed for the recovery of toxic metals, some of which are commercially valuable, for example, chromium. A parallel study in this laboratory has shown that a combined chemical and biochemical process for the recovery of these metals may also be feasible. Data presented in this paper illustrate various aspects of the detoxification and recovery processes.

INTRODUCTION

Liquid-dominated hydrothermal systems utilize liquids containing large amounts of dissolved mineral salts which are the cause of considerable scaling and corrosion problems in geothermal power production equipment. For example, high pressure geothermal brines in southern California may average up to 350,000 ppm of total dissolved solids remaining in the brine during flashing to generate steam. In this process water content is reduced and the temperature lowered, causing precipitation of the solids which are the principal causes of scaling and plugging. These solids, produced in large quantities, are filtered and disposed of in hazardous waste disposal sites (ref 1). For example, a typical 50 MW liquid-dominated hydrothermal power plant produces about 70,000 lb/day (ref 2) of sludge, in which toxic metals are present in concentrations not suitable for conventional recovery. Studies in this laboratory have explored the possibilities of developing biotechnology which utilizes microorganisms capable of leaching metals from ores (refs 3 and 4). These studies have led to the identification of suitable biochemical processes in which selected strains of microorganisms can be used in a technically and economically feasible biotechnology (ref 5). Laboratory experiments have also shown that the concentration and distribution of metals in geothermal residual brine sludges (BR) varies. This influences the reaction time and the manner of treatment. Further, experimental results have indicated that mixed cultures of acidophilic organisms are more efficient in removal of metals and that the actual chemical composition for a given BR batch predetermines the choice of strains and the type of bioreactors. Some of these parameters will be discussed in the light of most recent studies.

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OUTLINE OF STUDY AND MATERIALS

Details of the analytical procedures have been reported elsewhere (ref 5). In this work the analyses were carried out on filtered solutions and the metal content analyzed by atomic absorption spectrometry. Comparisons have been carried out between different batches of residual sludges, different metal contents, various quantities of sludges and residence times, as well as metal solubilizing efficiencies of different strains of acidophilic microorganisms.

RESULTS

Typical efficiency of metal solubilization by single strains of *Thiobacilli* vs. selected mixed strains is shown in fig 1.

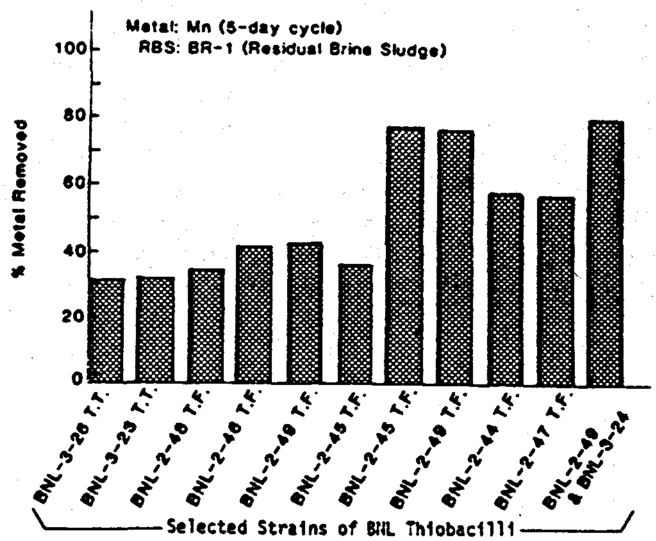

Fig. 1 Extent of manganese removal from residual brine sludge (RBS), BR-1 by different strains (BNL-X) of *Thiobacillus thiooxidans* (T.T.) and *Thiobacillus ferrooxidans* (T.F.).

Thus BNL-3-26, for example, removes only about 30% of manganese, while BNL-2-45 strain removes about 76%. Combination, however, of BNL-2-49 and BNL-3-24 removes >80% of the metal in the five day cycle. In this work a cycle means the residence time in which the biomass and the sludge are allowed to interact. Similar results for removal of other metals, e.g., copper, chromium, zinc and others have been obtained (ref 6). Combination of different strains as well as the time of addition of the microbial biomass and the concentrations of individual metals determine the duration of the cycle and the process efficiency (ref 7). In this paper the initial concentration of the metal has been mentioned several times. The significance of this is evident in figs 2 and 3. The initial concentration of copper (9 ppm) and zinc (78 ppm) is relatively low; however, in this type of sludge copper is removed more rapidly than zinc. The effects of concentration upon the extent and the rates of metal removal are therefore significant.

In comparative studies of different types of bioreactors, such as fluidized bed, agitated bed and others currently under way, another factor in

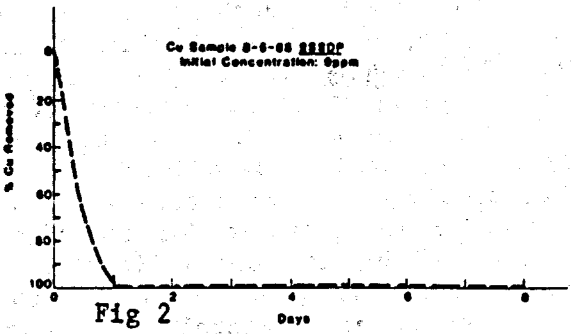

Fig 2

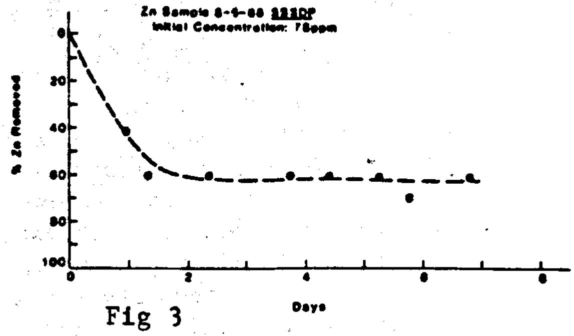

Fig 3

Fig. 2 Rate of removal from a sample derived from the Salton Sea Scientific Drilling Project (SSSDP).

Fig. 3 Rate of zinc removal from a sample derived from the Salton Sea Scientific Drilling Project (SSSDP).

the process design may also have to be considered. Several studies in this laboratory have indicated that concentration of residual brine sludges in a bioreactor may affect the extent of metal removal per single cycle. This is shown for two different residual sludges, BR-2 and BR-5 and four different metals, zinc, manganese, chromium and copper in figs 4 and 5.

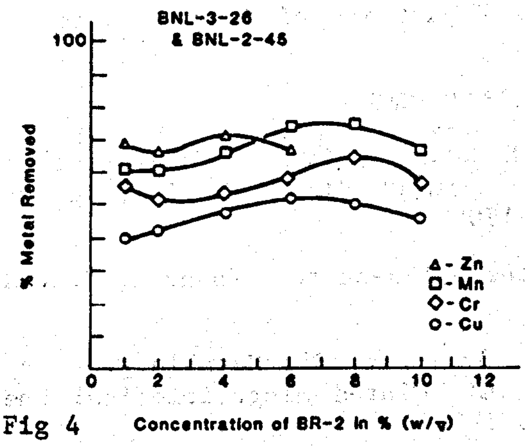

Fig 4

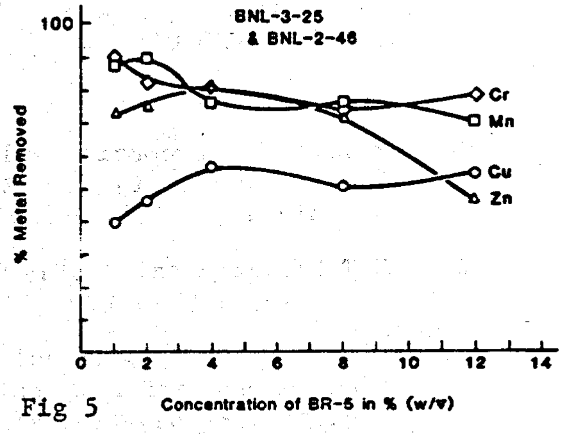

Fig 5

Fig. 4 The concentration effect of BR-2 sludge on the extent of metal removal.

Fig. 5 The concentration effect of BR-5 sludge on the extent of metal removal.

Whether this observation is peculiar to the two residues studied or is a general phenomenon has as yet to be determined.

The bioproceses and ultimately the biotechnology based on these processes produce an aqueous phase enriched in toxic metals. Since some of these metals have also commercial value, for example, chromium and vanadium, a secondary inexpensive metal recovery process, operating in conjunction with the detoxification process may be justified. The current practices would suggest reinjection of such water. Indeed some waters produced in the power generating processes are being re-injected (ref 5). We are exploring the feasibility of using combinations of chemical and biochemical processes leading to the recovery of metals. Our preliminary results (ref 8) indicate that biomass from different microorganisms may selectively remove metals from dilute aqueous solutions. A technology based on co-precipitation of metals and bioaccumulation may prove to be cost-effective and suitable for the recovery of metals from aqueous streams produced by the detoxification process described in this paper. Recent results from the studies in this area will be discussed elsewhere. However, experimental results to date allow us the following conclusions:

1. Biotechnology for detoxification of geothermal residual sludges and substances with similar geochemical properties is feasible.
2. Optimization of microbial combinations, minimizes the residence time.
3. Initial chemical properties of the residual sludge may influence the kinetics of metal removal.
4. Aqueous wastes generated by the new biotechnology may be reinjected or further treated by a combination of chemical and biochemical processes, which would render recoverable products and environmentally satisfactory wastes.

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