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GEOTHERMAL BRINES AND SLUDGES: A NEW RESOURCE

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1. ABSTRACT

Development of cost efficient biochemical processes for the treatment of geothermal brines and sludges is the main thrust of a major R&D effort at Brookhaven National Laboratory (BNL). This effort has led to the design of an environmentally acceptable, technically and economically feasible new technology which converts geothermal wastes into products with significant commercial potential. These include valuable metals recovery with a metal extraction and recovery efficiency of better then 80% over short periods of time (5-25 hours). The new technology also yields valuable salts, such as potassium chloride and generates high quality pigment free silica. The basic technology is versatile and can, with slight modifications, be used in the treatment of hypersaline as well as low salinity brines and sludges. Concurrently traces of toxic metals, including radium are removed to levels which are within regulatory limits. The current status of the new biochemical technology will be discussed in this paper.

2. BACKGROUND

Hot water and steam exit at many subsurface locations in the world (Geothermal Energy, 1996, Freeston, 1996) and represent a major energy resource. These hydrothermal resources are already being tapped in many parts of the world, where hot water and steam is brought from the underground reservoirs to the surface via production wells. Depending on the chemistry, the steam/water system can be used directly or separately to drive turbines and generators to produce power. A schematic diagram showing a hydrothermal resource is shown in Figure 1. Currently, there are about 5700 megawatts/a of power generated from geothermal energy in 20 countries and about 11,000 thermal megawatts/a are being used for direct applications. Compared to coal, oil, and gas resources, geothermal energy is a clean source of electric power which does not produce sulfur and nitrogen oxide emissions. However, on cooling the high saline brines produce a sludge which contains, in trace amounts, a mixture of toxic and valuable metals. The sludge is considered a mixed waste and is, therefore, subject to regulatory requirements. Studies in this laboratory have shown (Premuzic et al., 1995a-d) that a biochemical technology for the treatment of brines and sludges is most promising, cost-efficient, and environmentally acceptable. The technology depends on the chemistry of the resources which influence the choice of plant design and operating strategies. Laboratory studies have also shown that a number of process variables have to be taken into consideration in the design and engineering of the total process as well as in the cost analysis. The parameters which have to be considered include rates of input, volume, batch, or continuous processing, residence times, recycling of biocatalysts, corrosion and the chemical characteristics of the incoming materials as well as those of end products. Further, the technology has to be flexible

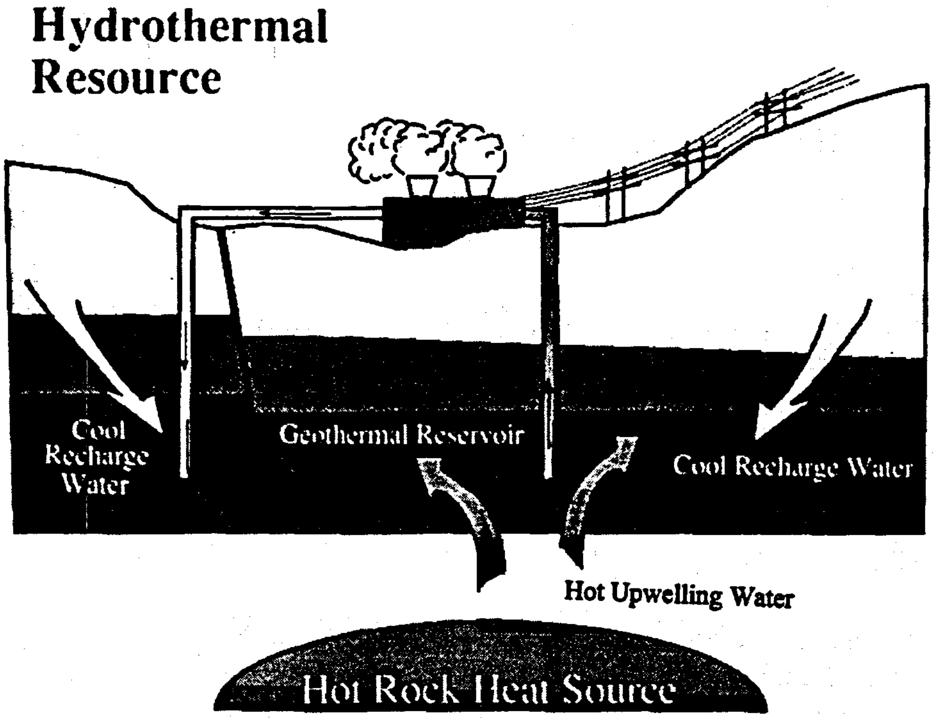

Figure 1. Hydrothermal Resource (after Earth Sciences Laboratory, 1995)

and adaptable to variables such as high and low salinities, temperatures, quantities of geothermal materials to be processed and the chemical properties of brines and by-products. These variables are of critical and economic importance in areas such as the Geysers and the Salton Sea type resources of California. A typical process design is shown in Figure 2 (for details, see the quoted references, Premuzic et al. 1995). In this process, designed for the treatment of quantities of about one ton per hour of filtered sludge, the supply of biocatalysts and the treatment of produced waters become determining factors. Experimental data have shown that a significant cost-reduction can be achieved by recycling the biocatalysts and changing the ratios of the biocatalyst mix. Other options have also become apparent during the studies. These include metals and salt recovery possibilities as well as strategies which would lead ultimately to the utilization of the sludge from which toxic and valuable metals have been removed. To facilitate optimization studies and explore alternative strategies, a scaled-down laboratory batch process has been used. In this process, streams A and B are combined for metal recovery, where stream A is derived from the plant and stream B is derived from the biochemical reactor via stream 9 in which the solids are removed and the filtrate stored in tank B. In the earlier versions, the filtrate which contains toxic and valuable metals was neutralized with calcium hydroxide, the precipitate filtered and the aqueous phase reinjected. There are disadvantages to this approach. Precipitate in stream 14, although greatly reduced in volume compared to that generated in stream 10, has still to be disposed of. Maintaining an appropriate anionic and cationic concentration allows to pool stream 11 from the holding tank B with stream A with the full elimination of all the steps beyond B.

In addition to power production, there are other economic benefits which may be derived from geothermal brines and sludges, now disposed of as wastes. This is particularly so, since the emerging biochemical technology is inexpensive and can be integrated with other processing options which convert residual materials (e.g. "wastes") into commercially useful products.

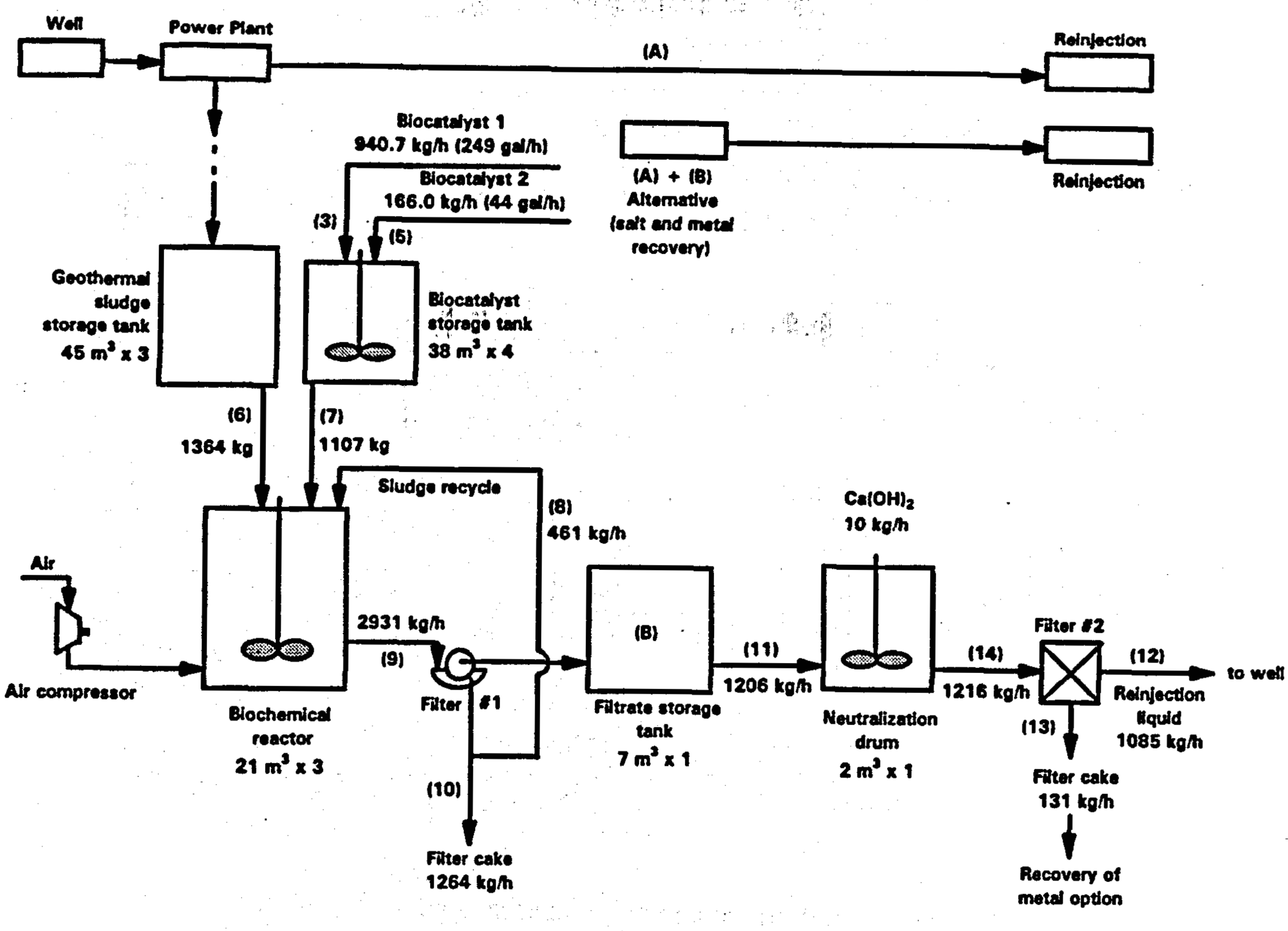

Figure 2. The biochemical process for geothermal sludge (3000 lb/h flux, BC1:BC2=85%:15%)

In a joint effort between industrial collaborators and BNL, several engineered processes for the treatment of secondary and other by-products generated in the power production from geothermal resources are being tested. In terms of field applications, there are several options, some of which will be discussed in this paper.

3. RESULTS AND DISCUSSION

A fully developed process, including all the processing options and alternatives, is summarized in Figure 3. This scenario assumes the use of brines with high concentrations of dissolved solids at elevated temperatures and relatively fast flow rates. Current R&D addresses several options. In the following discussion, the filter cake option will be considered first. Cooled brine and sludge which exits from the power plant is filtered and the accumulated filter cake stored in a tank. Assuming a production of filter cake at a rate of over a ton per hour, as shown in the scenario given in Figure 1, a substantial annual yield of this material is realized. If the chemical and physical properties of this material can be manipulated, then formulation of a new product might be feasible. Chemical analysis has indicated that with some additional treatment, the bulk of the material in the filter cake can be converted into a paper and/or paint filler (Smook, 1992) and become a commercially attractive product, an avenue which we are currently exploring jointly with our industrial colleagues. Typical analysis of the filter cake produced by the process is given in Figure 4. After additional treatment, the material is depigmented leaving predominantly high quality silicates.

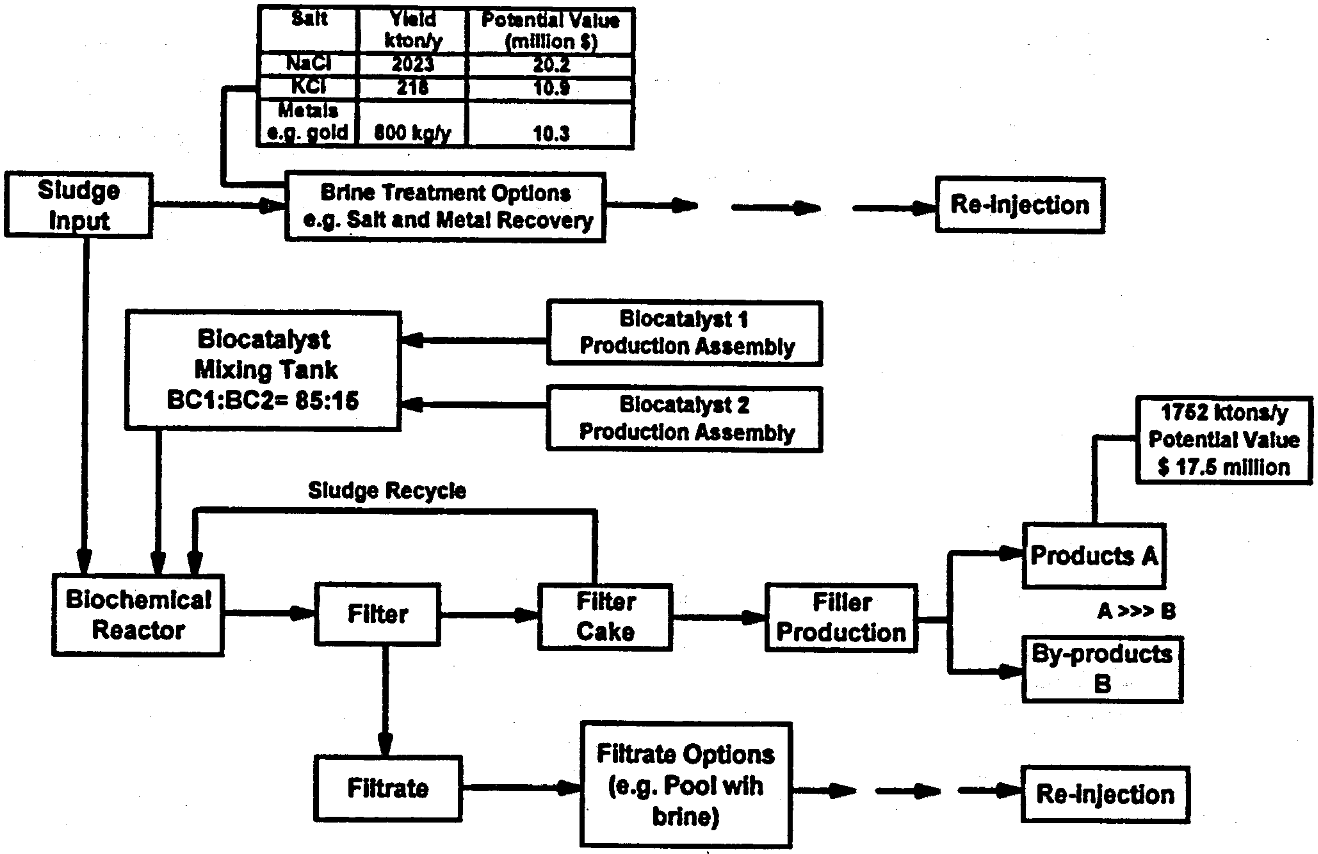

Figure 3. Total processing of geothermal sludges and brines

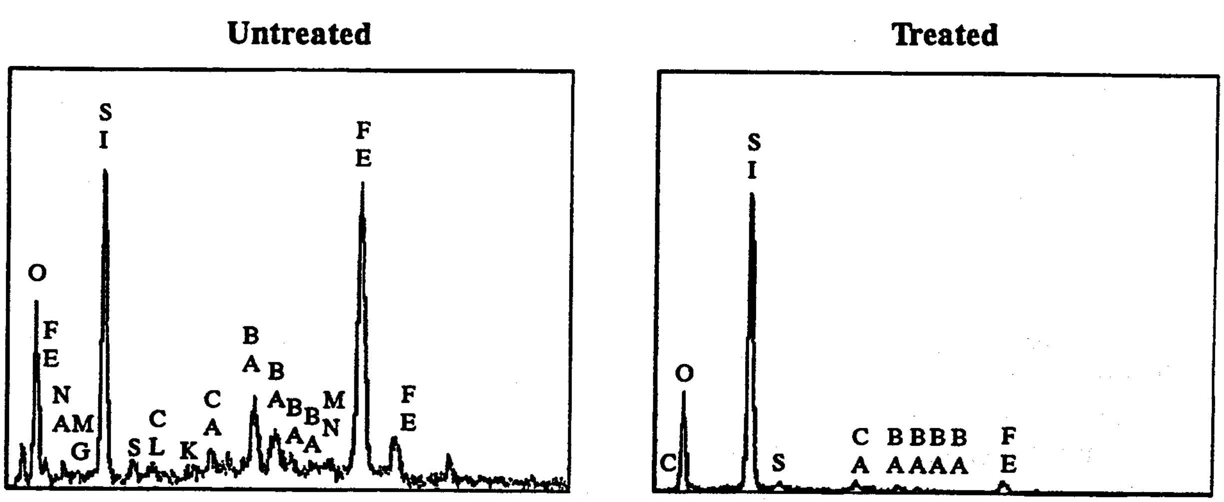

Figure 4. Energy Dispersive Spectroscopy (EDS) x-ray analysis of processed geothermal residues

Further modification of the total process allowed it to be applied to a different type of a sludge. In a joint development agreement between CET Environmental Services, Inc., BNL, and PG&E, a modified BNL process is being tested for the treatment of the slurry, generated in the hydrogen sulfide abatement technology, an integral part of the overall geothermal power production in the Geysers area of California. In this application only two metals, arsenic and mercury, and a non-metal sulfur have to be considered. The flow diagram for the modified process is shown in Figure 5. Consistent with the original total process, the rates of removal of metals are fast (e.g. Premuzic et al., 1996b) as shown in Figure 6.

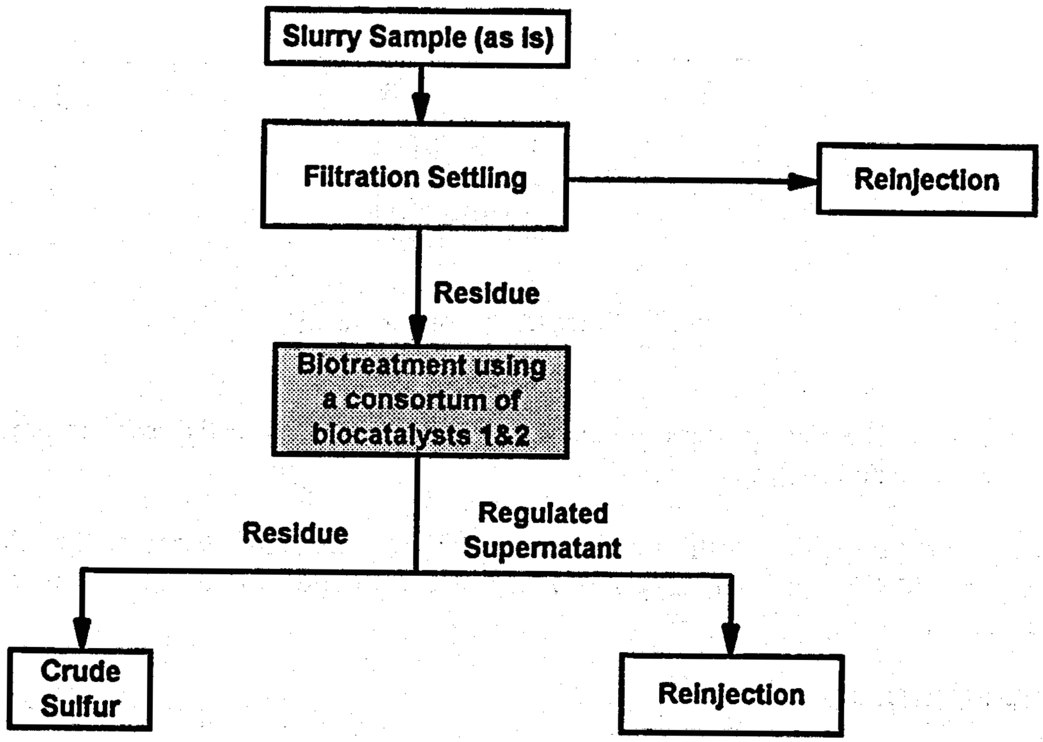

Figure 5. Flow diagram for the treatment of geothermal waste slurry (CET/PG&E/BNL)

After separation, the aqueous extract meets the analytical and regulatory requirements and is reinjected. The residue is arsenic and mercury free, predominantly sulfur of a lower commercial grade. Optimization of this process is currently in progress.

4. CONCLUSIONS

1. An integrated biochemical process for the treatment of geothermal brines and sludges is technically, economically, and environmentally feasible.

2. Biochemical processing of geothermal brines and sludges produces income generating products with a potential of full cost recovery of the initial investment as well as a net profit to the operators.

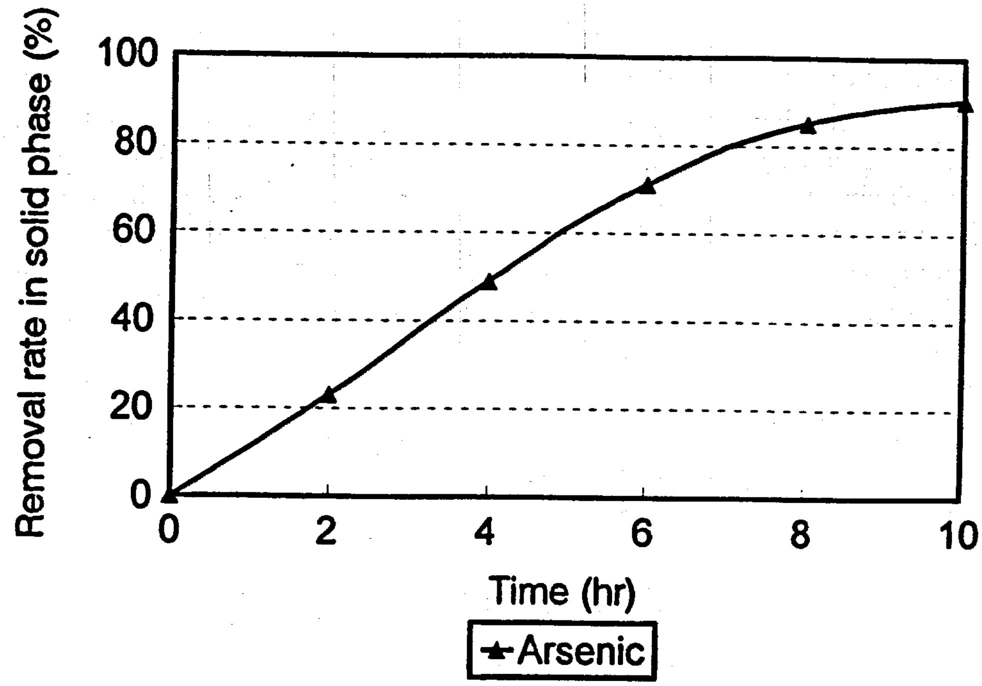

Figure 6. Rates of aresenic removal

3. The emerging biochemical process is flexible and complimentary to the existing processing of geothermal brines and sludges.

4. Active collaboration with industry (in this case CET Environmental Services, Inc., Pacific Gas and Electric, and California Energy) makes it possible to field test and fully develop the new biochemical technology.

5. ACKNOWLEDGEMENTS

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