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RECENT ADVANCES IN BIOCHEMICAL TECHNOLOGY FOR THE PROCESSING OF GEOTHERMAL BYPRODUCTS

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DISCLAIMER

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ABSTRACT

Based on Laboratory studies, the biochemical technology for the treatment of brines and sludges that are generated in the production of electric power from geothermal resources is promising, cost-efficient, and environmentally acceptable. In terms of scaled-up field applications, the new technology depends on the chemistry of the resources which influence the choice of plant designs and operating strategies. The latter have to be flexible 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. In addition to power production, the economic benefits which may be derived from geothermal brines and sludges, now disposed of as wastes, are attractive. This is particularly so, since the emerging biochemical technology is inexpensive and can be integrated with other processing options which convert residual materials into commercially useful products.

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 these options will be presented and discussed.

BACKGROUND

Extensive studies leading to the development of biochemical technology for the treatment of geothermal sludges and brines have shown (1-4) that the emerging technology is cost-efficient and environmentally acceptable. Concurrently, the 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 on 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. In a typical full design for processing of large input of (~1 ton/h) filtered sludge, shown in Figure 1, the supply of biocatalysts and the treatment of produced waters become determining factors. Thus, experimental data (e.g. 1) have shown that a significant cost-reduction can be achieved by recycling of 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 laboratory scale batch process is being used. Typical scenario for the batch process is shown in Figure 2. In this scenario, 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 and 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, will still have 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. The sterilizers used in the preparation of biocatalysts are inexpensive commercially available units, normally used in water treatment processes and are needed only prior to the mixing of biocatalysts and are not needed in downstream applications of the biocatalyst mix. Other options, such as the recovery of select metals, production of potash and further treatment of the purified filter cake are also possible and the cost-efficiency of such scenarios has already been discussed elsewhere (4). As mentioned earlier, further adaptations of the system are possible and will be discussed briefly in the next section.

RECENT ACTIVITIES

A fully developed process, including all the processing options and alternatives, is summarized in Figure 3. This scenario assumes use of brines with high concentrations of dissolved solids at elevated temperatures and relatively fast flow rates. Current R&D addresses these options and in the following discussion, the filter cake option will be considered first. 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. Analysis of this material 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(5) 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 shown in Figure 1, is given in Figure 4. After additional treatment, the material is depigmented, leaving predominantly high quality silicates.

Further modification of the total process allowed it to be applied to a different type of a sludge. In a joint venture in the form of a "Collaborative Research and Development Agreement" (CRADA) between CET Environmental Services, Inc. and BNL and other arrangements between CET and PG&E, the modified BNL process is being tested for the treatment of the slurry generated in the hydrogen sulfide abatement technology. In this application, one has to consider only two metals, arsenic and mercury and a non-metal, sulfur. As shown in Figure 5, there are two treatment options available. One involves an initial sulfur extraction followed by the biochemical processing of the residue and the other the direct biochemical treatment of the slurry. The rates of the metal removal in either of the options are given in Figure 6. Scenario 2 involves a solvent extraction step to isolate a high quality sulfur. Because of environmental considerations, Scenario 1 is the process of choice and is now being fully explored. For this purpose, CET Environmental Services, Inc. has designed a process, diagramatically shown in Figure 7. In this process, the sludge from a settling tank is mixed with prepared biocatalysts in bioreactor 1 for the first treatment, followed by a shorter treatment in bioreactor 2. 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.

CONCLUSIONS

1. New biochemical technology for the treatment of different residues derived in the production of geothermal power is versatile and cost-efficient.

2. Collaboration with industry, particularly CET Environmental Services, PG&E, and CALEN is active and efficient which makes

possible a full development and field applications of the new technology.

ACKNOWLEDGMENTS

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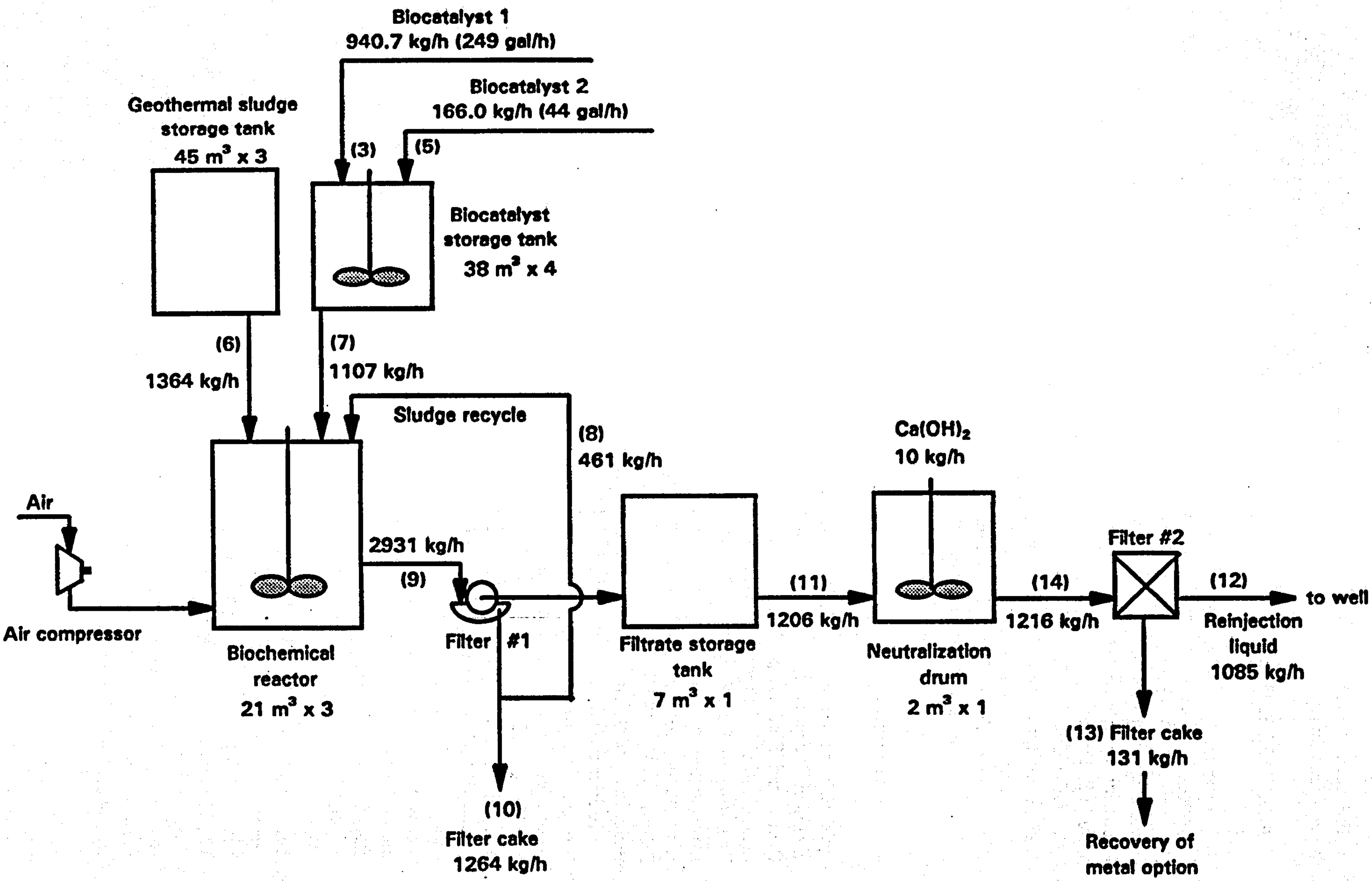


Figure 1. The biochemical process for geothermal sludge (3000 lb/h flux, BC1:BC2 = 85%:15%)

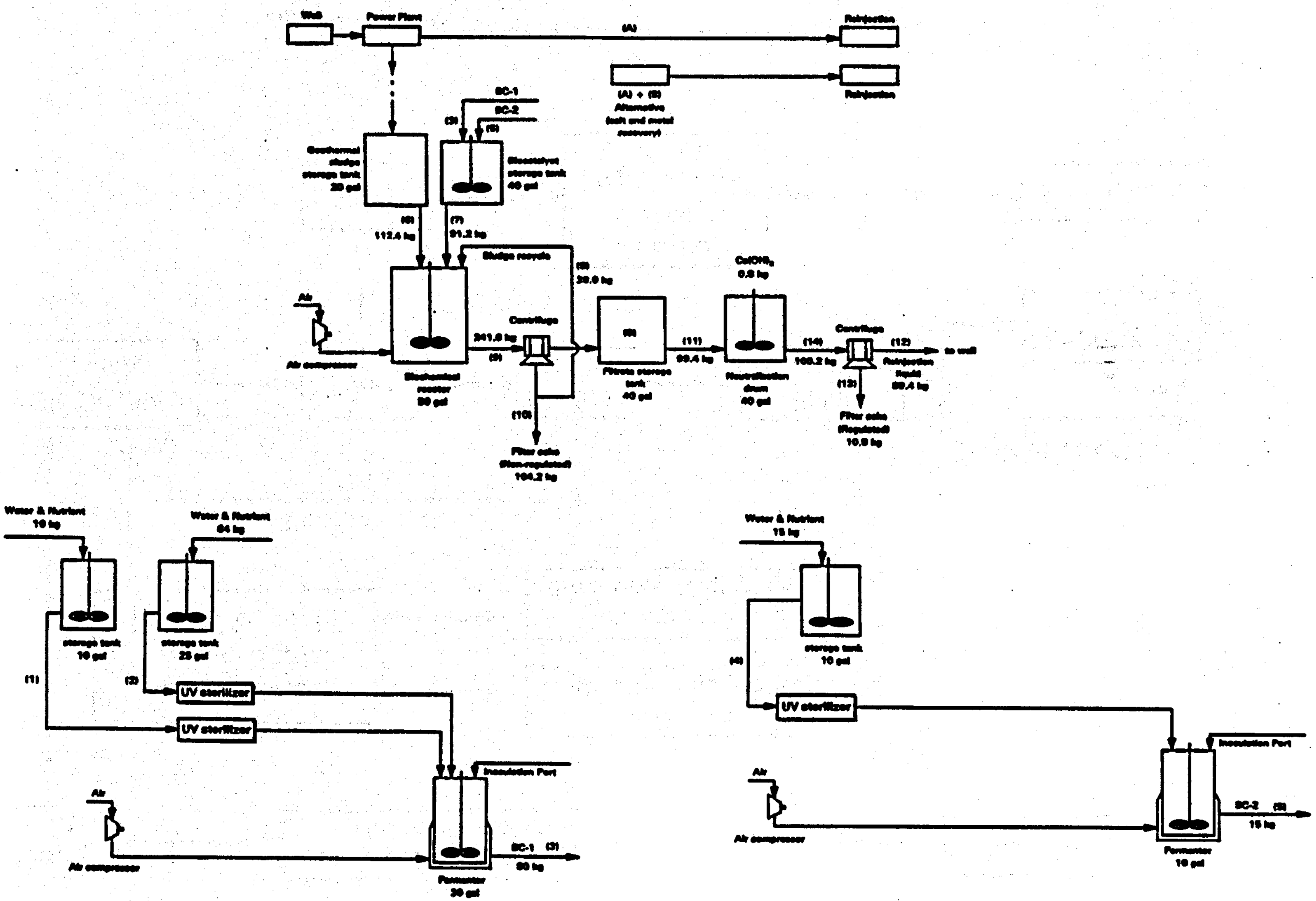


Figure 2. Laboratory batch process for the production of biocatalysts and the treatment of sludges and brines

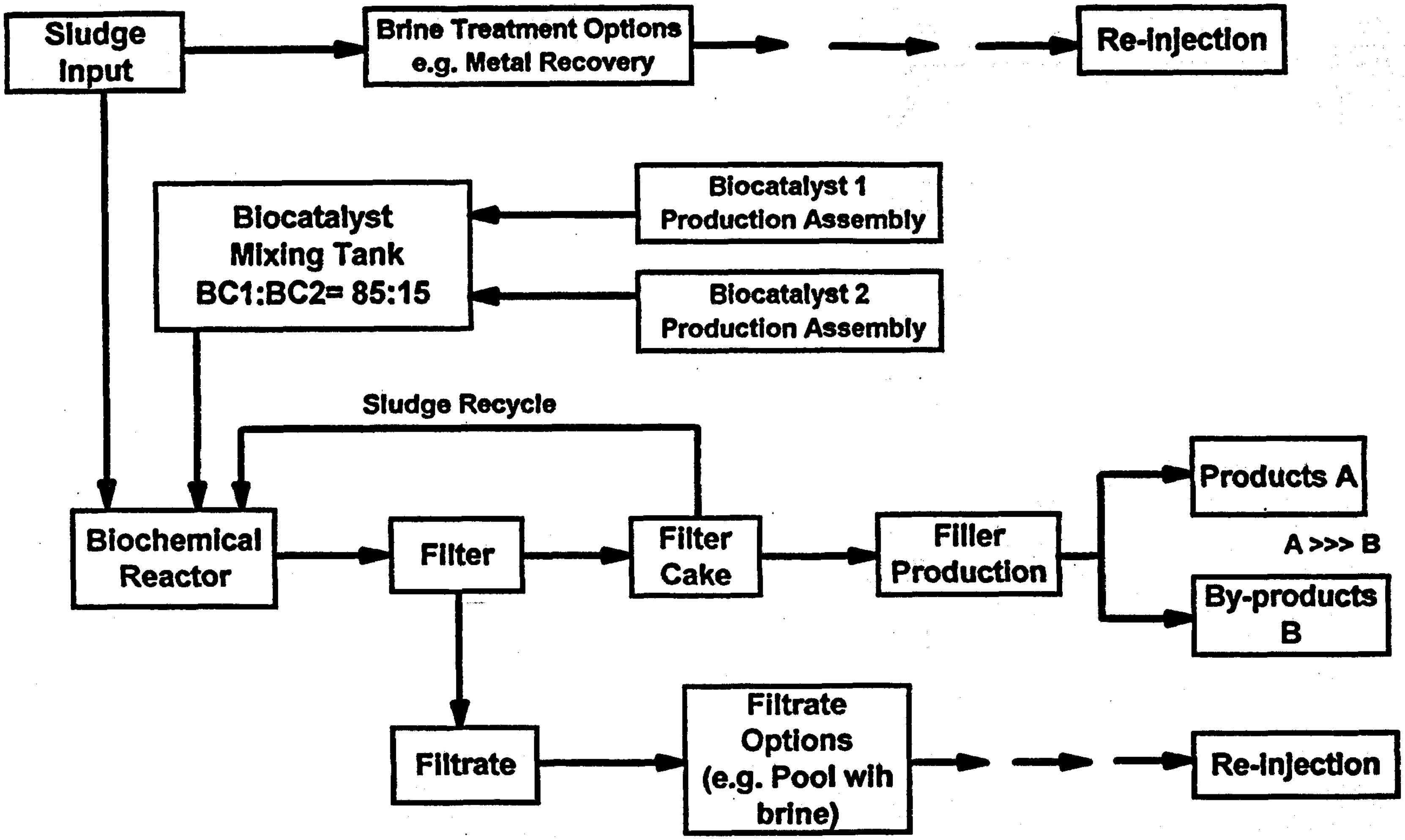
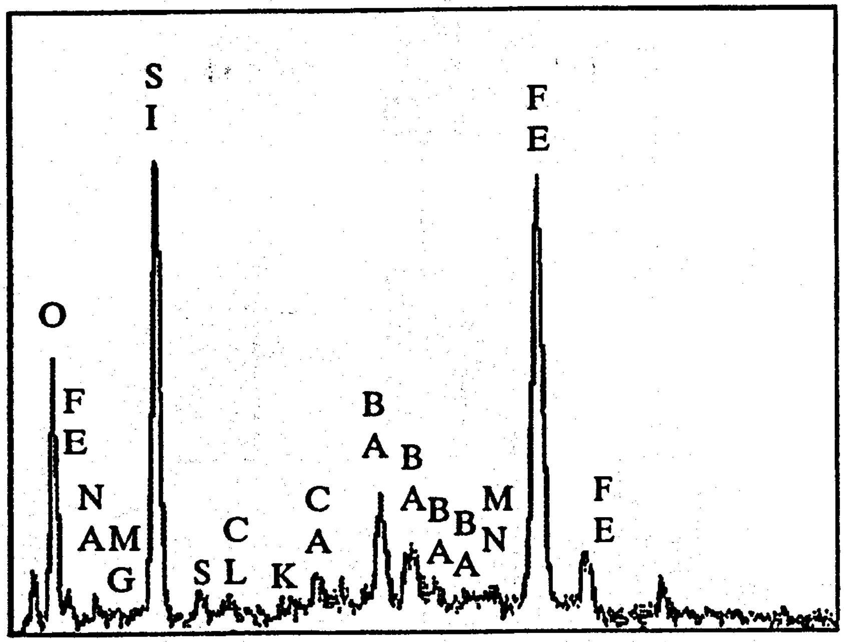


Figure 3. Total processing of geothermal sludges and brines

Untreated



Treated

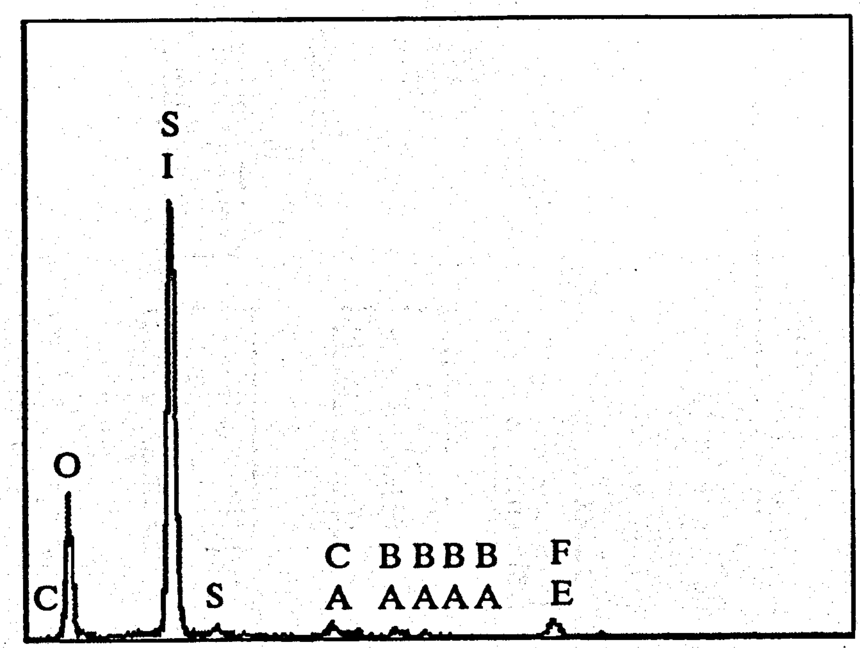


Figure 4. Energy Dispersive Spectroscopy (EDS) x-ray analysis of processed geothermal residues

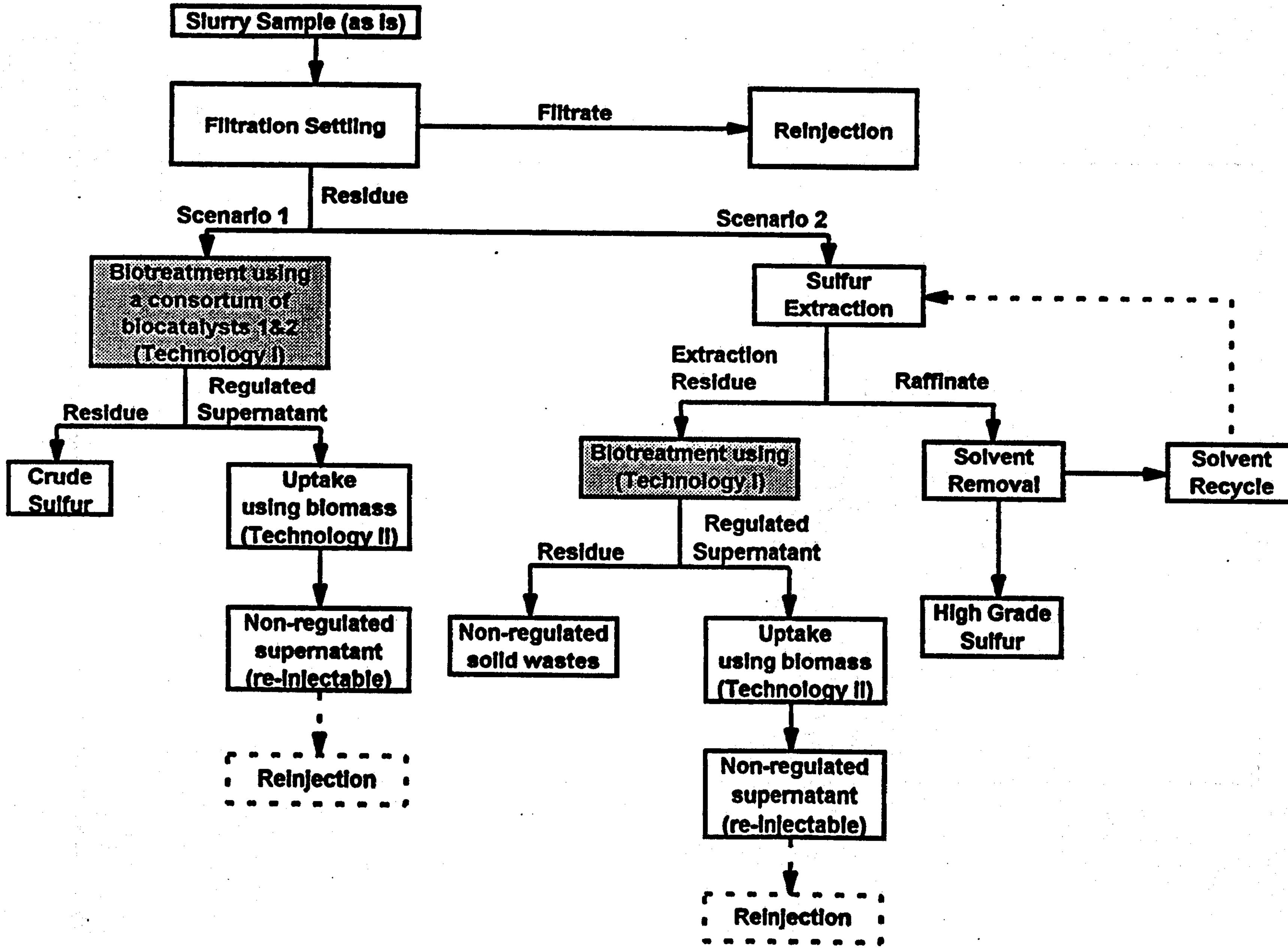


Figure 5. Proposed scheme for the treatment of geothermal waste slurry (CET/P.G.&E./BNL)

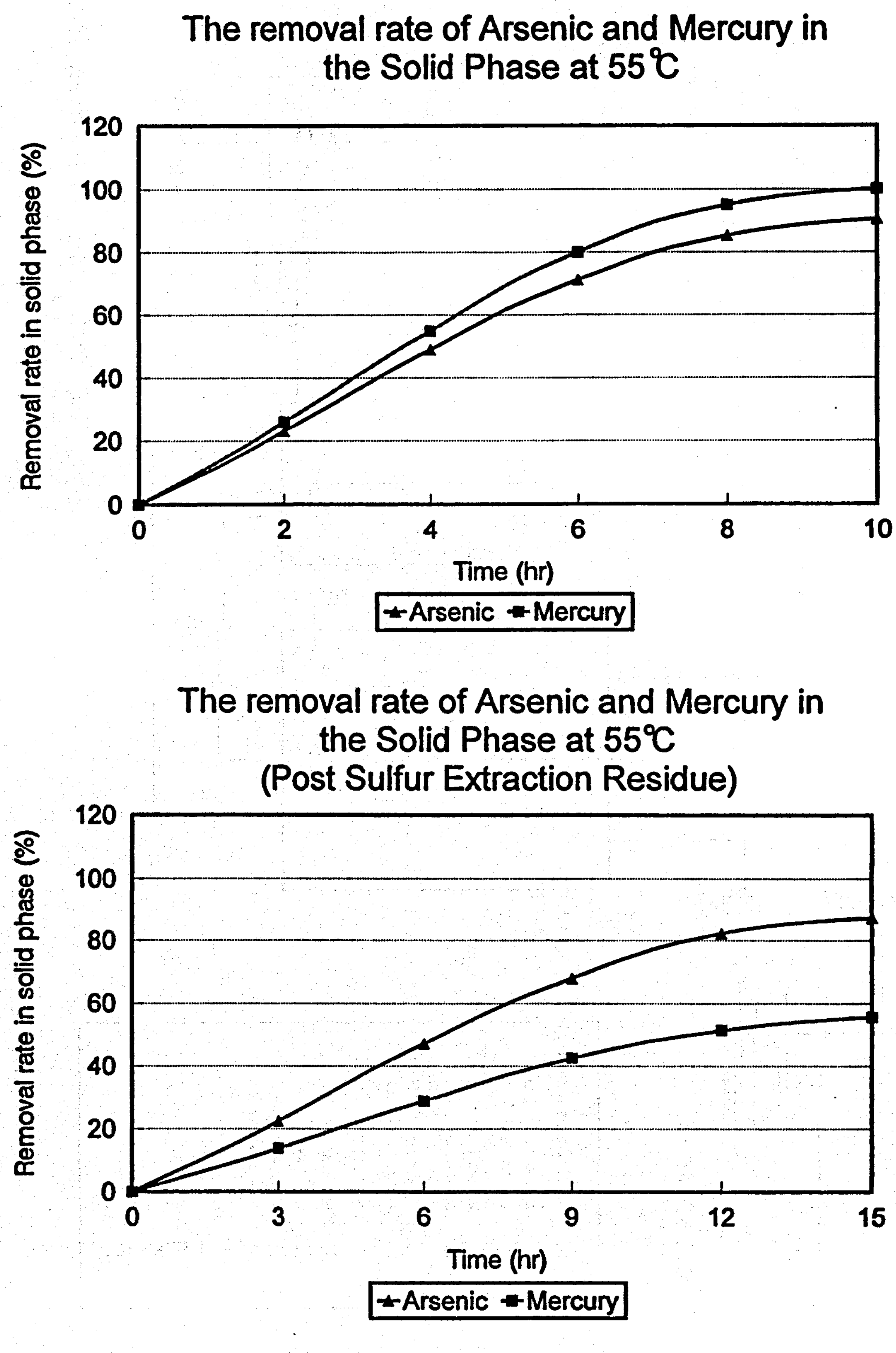


Figure 6. Rates of arsenic and mercury removal

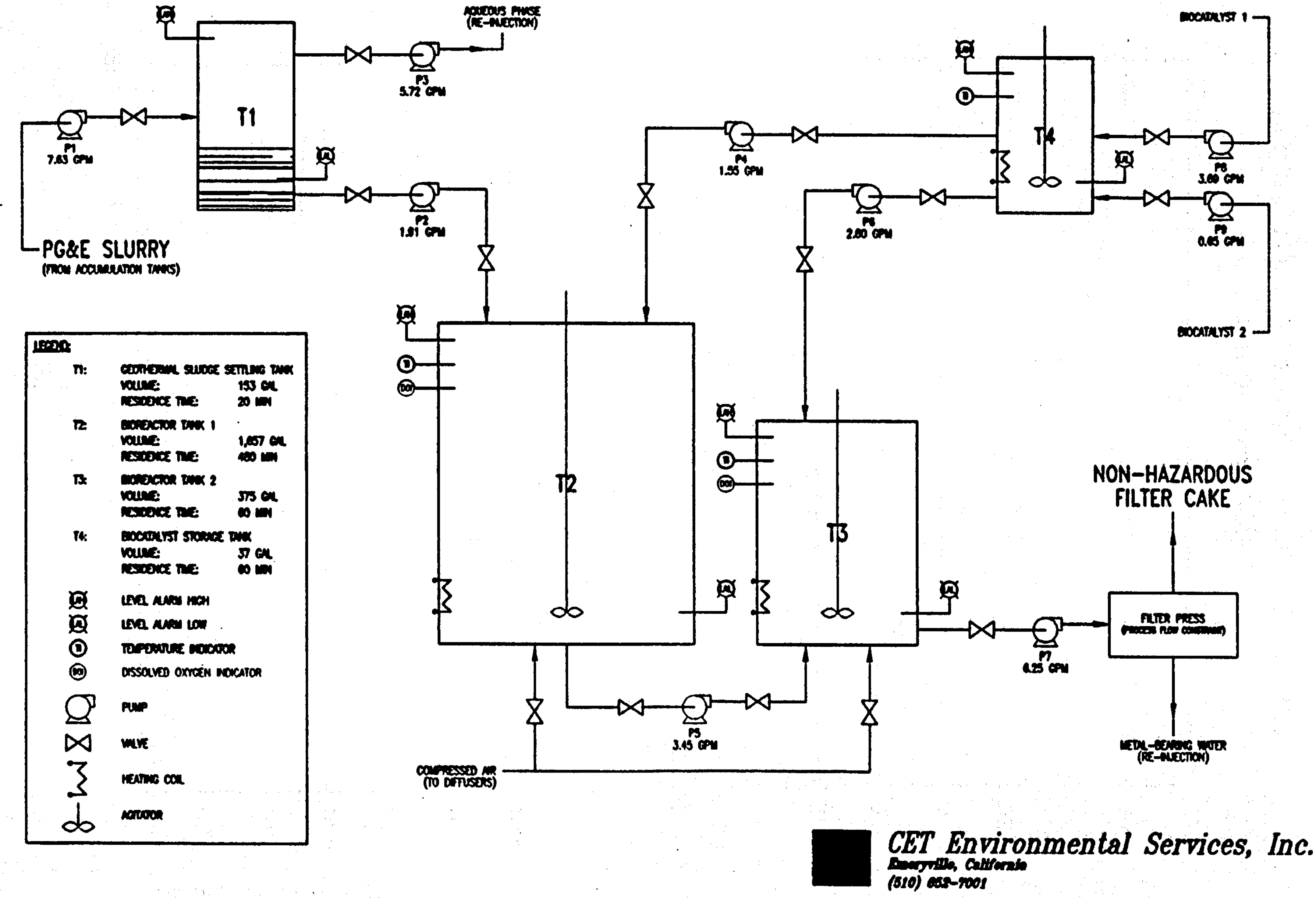


Figure 7. Basic process flow diagram. Bioremediation of geothermal sludges