Conf-950955--1

BNL-61285

BIOCHEMICAL TECHNOLOGY FOR THE DETOXIFICATION OF GEOTHERMAL BRINES AND THE RECOVERY OF TRACE METALS

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May 1995

To Be Presented at the 10th International Conference
Heavy Metals in the Environment
Hamburg, Germany
September 18-22, 1995

Under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

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ABSTRACT

Studies conducted at BNL, have shown that a cost-efficient and environmentally acceptable biochemical technology for detoxification of geothermal sludges is most satisfactory, as well as technically achievable. This technology is based on biochemical reactions by which certain extremophilic microorganisms interact with inorganic matrices of geothermal origin. The biochemical treatment of wastes generated by power plants using geothermal energy is a versatile technology adaptable to several applications beyond that of rendering hazardous and/or mixed wastes to non-hazardous by products, which meet regulatory requirements. This technology may be used for solubilization or recovery of a few metals to the isolation of many metals including radionuclides. In the metal recovery mode, an aqueous phase is generated which meets regulatory standards. The resulting concentrate contains valuable trace metals and salts which can be further converted into income generating products which can off-set the initial investment costs associated with the new biotechnology. In this paper, recent developments in this emerging technology will be discussed.

INTRODUCTION

Chemical composition of geothermal brines and sludges varies from high salinity containing many trace metals such as those from Southern California to low salinity brines containing a few select metals, such as those found in the Geysers area of Northern California (ref 1). Because such brines and sludges contain traces of toxic metals such as arsenic, mercury, and others, including trace radionuclides, they require treatment prior to disposal. At BNL, a biochemical technology has been developed for a cost efficient removal of toxic and valuable metals (ref 2,3). In addition to being cost-efficient, new and emerging technologies have to be also environmentally acceptable. In order to meet these requirements, a major research and development effort is often required. This was the case in the development of the technology for the detoxification of geothermal sludges and brines. During the development of this technology at BNL, it became evident that the chemical composition of geothermal sludges may become an asset, because the sludge contains also significant amounts of salts, such as potassium chloride as well as traces of valuable metals, e.g. zinc, silver, gold, and others. Recovery of salts and valuable metals, therefore, becomes a very attractive option. Combination of this option and the optimization of processing parameters for example, recycling of biocatalysts, allows for the development of a technology which encompasses a detoxification process, i.e. removal of toxic metals from the sludges and, therefore, satisfies

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environmental requirements, a process which produces a byproduct containing marketable components. This by product contains valuable metals and salts which can be recovered by combining the detoxification technology with a metal/metal salts recovery process. This means that the geothermal "waste" is being converted into a "feedstock" for new materials. Recent advances in the development of the combined technology will be briefly discussed in this paper.

OUTLINE OF STUDY AND METHODS

Construction of a pilot plant and chemical analytical methods have been described elsewhere (ref 2,4) and will not be discussed here. In the studies reported in this paper, the pilot plant has been used as a model for chemical engineering calculations projected to a full scale plant capable of handling from one to two and half tons of geothermal sludge per hour, as shown in Fig. 1 for a full scale process servicing a 50 MW plant. In this process a mixture of biocatalysts has been used (ref 4).

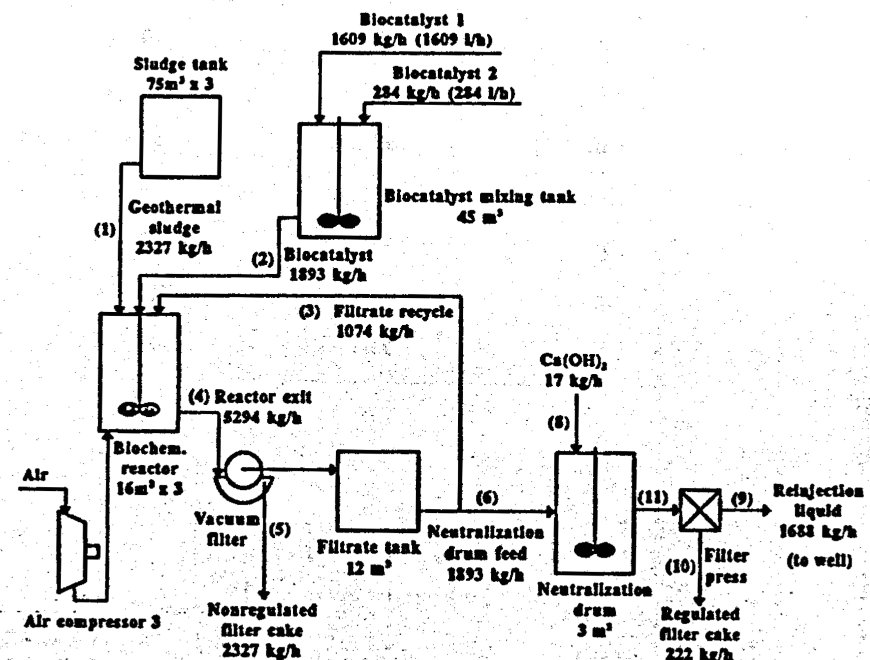

Figure 1. Total biochemical process for geothermal sludge.
Treatment biocatalyst 1(85%): biocatalyst 2(15%).

RESULTS

Rates of metal removal from geothermal sludges have been determined by kinetic studies of biochemical reactions under optimized condition (ref 2). Biochemical solubilization of metals from geothermal sludges follows first order kinetics and efficiencies of better than 80% metal removal can be achieved in short periods of time, e.g. 5-24 hr., depending on the metal. The overall process operates at 55°C and a pH ≈ 2.

In Fig. 1, the aqueous phase from the process (Stream 6) is neutralized with calcium hydroxide to yield a highly reduced volume of waste. Stream 6 can also be treated for the recovery of metals. Recovery of metals by biosorption is comparable to chemical precipitation as shown in Table 1. The non-regulated sludge (Stream 5) is a high quality amorphous silica, with an additional commercial potential currently being explored at BNL. Extension of the metal recovery option in which selective technology is combined with salt recovery leads to the development of a combined technology resulting in several marketable products as shown in Fig. 2. In this scenario stream "B" from the biochemical treatment can be pooled with Stream 1 and processed for salt recovery, or it can be combined with streams (10) for re-injection.

Table 1.

Typical Recovery of Metals from the Aqueous Phase Generated by the Biochemical Processing of Geothermal Sludges

Metal	% Metal Recovery	
	Chemical Precipitation	Biosorption
Al	96	98
Cr	92	40
Ni	99	82
Cu	99	92
Zn	99	56
Ag	99	98
Hg	66	100
Pb	93	95

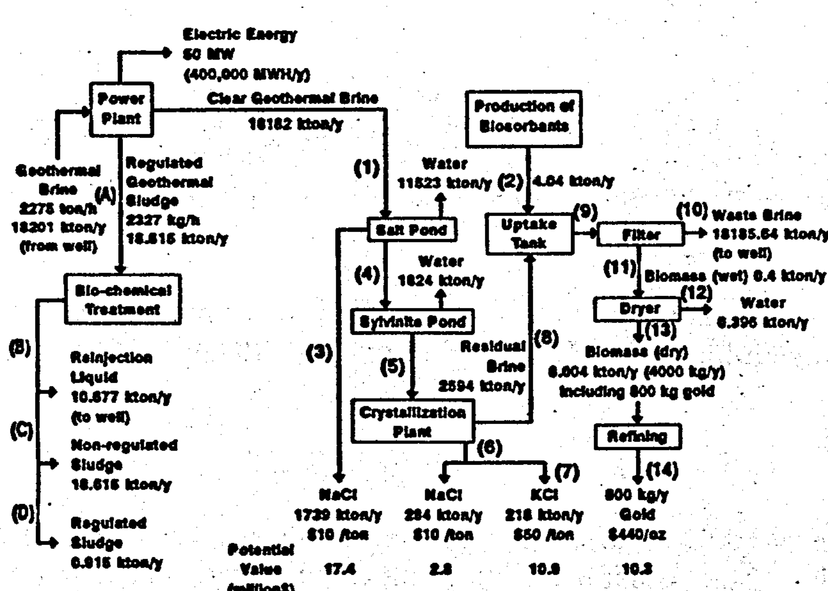

Figure 2. Biochemical processing of geothermal sludge and brine: Combined processes for sludge, brine, and precious metal recovery.

In geothermal applications, there are circumstances in which a certain level of salinity in the aqueous phase must be maintained prior to re-injection into the well. This adjustment in the salinity may be achieved by the use of some of the sodium chloride recovered in stream (3) and (6). Further refinements in the emerging biochemical technology are currently being explored.

CONCLUSIONS

The new technology based on biochemical processing of geothermal brines is cost efficient and environmentally acceptable. Biochemical technology can be integrated with other processing technologies. The emerging technology is flexible and adaptable to different types of feedstocks. The technology shows promise as being capable of conversion of geothermal waste streams to revenue generating resources.

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ACKNOWLEDGEMENTS

This work has been supported by the U.S. Department of Energy, Department of Energy Conservation, Division of Geothermal Technology, Contract No. AM-35-10 and the U.S. Department of Energy Contract No. DE-AC02-76CH00016.