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ABSTRACT

Biosorption of copper by sludge from a lab-scale activated sludge was studied. S-typed isotherms were found in almost all cases. This revealed the importance of reversible sites on the cell surfaces. Hydroxyl groups on the neutral polymers of the cell surfaces were likely to be the biosorption sites.

The equilibrium time of biosorption could be divided into two phases. The fast initial phase was observed within thirty minutes. The second phase went to an equilibrium after six hours. The biphasic equilibrium time was explained by the adsorption on the cell surfaces and active uptake, respectively.

Freundlich isotherms were found to describe the biosorption fairly. From constants of Freundlich equation, it was found that unwashed sludge could biosorb about 16 mg copper per gram dry weight of sludge.

Washing of sludge by various concentrations of EDTA and 0.85% NaCl did not show any difference from unwashed sludge. Anyway the optimum washing time in this study was three hours. The specific biosorptions were decreased after the long period of washing. The high concentration of EDTA (1% EDTA) gave the lowest biosorption capacity.

Sludge characteristics play the most important role in copper biosorption. Type of organisms influenced the biosorption capacity. The population proportion was changed due to the operation conditions of the reactor and the biological interaction among species. Effects of hydraulic retention time (HRT) and solids retention time (SRT) were discussed. Although they could not control the biosorption directly, they influenced sludge characteristics and the performance of exocellular polymers.

Behaviour of the lab-scale activated sludge was monitored during the operation period in order to compare the adsorption with the biological characteristics of sludge. At the high dilution rate (0.042 hr^{-1}) the solids in the reactor fluctuated and did not reach a steady state after a prolonged period of six months. In contrast, the solids concentration of 0.021 hr^{-1} dilution rate went to a stable state after one month.

The interrelationship of three groups of organisms in the reactor was proposed in order to explain the transient behaviour of the system. The combination of dilution and predation separated the fast and slow growing bacteria resulting in the instability of the system.

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CHAPTER 1

INTRODUCTION

Biosorption in this thesis means the uptake of a solute by biomass either living or dead cells. The two mechanisms of the biosorption are the physico-chemical, and biological process. These mechanisms are often named passive and active immobilization, respectively. The important physico-chemical processes are adsorption, and ion exchange on cell surfaces. With living organisms, active transport also contributes to the process. Surprisingly microorganisms, bacteria, fungi and algae, can biosorb significant amounts of metals. Therefore, biosorption was proposed to decontaminate the industrial effluents containing metals (Tsezos, 1990).

Due to some specific properties of copper, such as the good thermal and electrical conductivity, softness and resistance to most environments, mankind knew how to utilize it for a very long time. It is also an essential element for living organisms. The important role of copper in the intracellular metabolism is another reason that its properties are studied widely. Copper in the earth's crust down to 45 kilometres is estimated to be $14 * 10^{20}$ g (National Academy of Science, 1975). However, that amount is only 0.001 percent of the total mass in the lithosphere. Most of the copper sources are in the sedimentary rocks and ocean (Nriagu, 1979).

Moreover, copper is a trace element but it is an essential element in enzymetric processes in living organisms. On the other hand, it can inhibit or can even be lethal to cells at the excessive concentrations. Each organism has a limit of tolerance depending upon type and adaptability individually. Some animals are more sensitive to copper than others. For example, copper is highly toxic to fish and most aquatic organisms but it is less toxic to terrestrial species both plants and animals. If the amount of copper in the metabolic pathways is not appropriate, this might cause diseases.

The main sources of high copper contaminated effluents are from mining processes and the effluent of industrial wastewater, particularly, electroplating and dyeing. After the wastewater treatment processes, high copper contaminated sludge cannot be applied to land because it maybe leached by biogeochemical processes resulting in the bioaccumulation in food chain. The contaminated sludge can cause problems to both plants and livestock. Furthermore, the leachate from contaminated sludges finds its way to ground water.

Brooks (1985) highlighted the incentives for the recovery and recycling of metals from waste effluents. They are; (a) minimizing the environmental impacts of metal waste on the receiving water because of their toxicity; (b) maximizing the conservation of raw materials; (c) minimizing the cost of disposal of the contaminated sludge.

Wastewater treatment plants dealing with metal contaminated effluents in future are likely to use the biosorption technology at some stage of the treatment process. Some inactivated bacterial products and some synthetic polymers have been patented and have been applied commercially by some factories (Tsezos, 1990). The treated biomass can be regenerated and possibly the biosorbed metals, particularly, precious metals for example gold, uranium etc., could be recovered by the bioleaching or chemical processes. Although the process is applied commercially, there is little understanding of the process.

This thesis can be separated into two main parts. A lab-scale model activated sludge system in order to maintain the consistent sludge was operated. Biosorption experiments of copper by sludge microorganisms were studied at different points during the activated sludge operation.

Interrelationships among organisms that directly affect the biosorption were studied. Filamentous bacteria, which are the main competitors in the system

and cause bulking sludge, also were evaluated by an abundance score. The important changes in a simulated activated sludge system during the cultivation period will be discussed. The effects of sludge characteristics on biosorption will be discussed. Finally, the possibilities in bioleaching based on the biosorption data are proposed.