Microbial Electrochemical Reactors for Metal Recovery from Leachates

Oskar Modin[1], Karin Karlfeldt Fedje[1,2]
[1]*Chalmers University of Technology, Department of Civil and Environmental Engineering, Division of Water Environment Technology, Gothenburg, Sweden*
[2]*Renova AB, Gothenburg, Sweden*
Email: oskar.modin@chalmers.se

Metals are essential elements used in a wide range of technologies in modern society, but they are also major environmental contaminants. For example, in Sweden there are over 80 000 contaminated sites, many of which are polluted by metals. Moreover, fly ash generated from the incineration of municipal solid waste have high content of metals such as Cu, Zn, Pb, and Cd. Management of such ash is difficult and specialized landfills are required to avoid potential release of metals into the environment (Karlfeldt Fedje *et al.* 2010).

Microbial electrochemistry could potentially play a role in the treatment and recovery of metals from fly ash and contaminated soil. Using water, acid and other types of leaching media, metals can be extracted from the contaminated material. Recovery of many metals from the leachate can be accomplished using electrochemical reduction. Conventional electrolysis is very energy consuming and need concentrated solutions in order to be efficient. However, using microbial electrochemical reactors, waste organics can be oxidized at a biological anode and provide some of the energy needed to drive the reactions. Organic fuel for the biological anode could e.g. be obtained from wastewater or organic solid waste. A microbial electrochemical reactor, with biological anode and abiotic cathode for metal recovery, was first described by Ter Heijne *et al.* (2010) who used it to recover Cu. Since Cu has a relatively high reduction potential, the system could be operated as a fuel cell with net energy output. We investigated recovery of Cu, Pb, Cd, and Zn from a mixed solution simulating a municipal solid waste fly ash leachate. By varying the control of the reactor, the individual metals could selectively be extracted from the leachate (Modin *et al.* 2012). There are several options for controlling microbial electrochemical reactors including control of cell potential, anode- or cathode potential, or current. An important aspect is to avoid drawing a current that exceeds the capacity of the biological anode as this leads to high energy consumption and could cause irreversible damage to the microbial community on the anode surface. By controlling anode potential or cell voltage such problems can be avoided; however, for selective reduction of different metals from a mixed solution, control of the cathode potential is desirable. Advantages and disadvantages of different control and design strategies will be discussed in this presentation.

The ion exchange membrane separating anode and cathode compartment is another critical aspect of microbial electrochemical reactors for metal recovery from leachates. A membrane separator between anode and cathode is essential because the leachate is typically a strong acid (e.g. Karlfeldt Fedje *et al.* 2015) whereas the biological anode functions best at a near neutral pH. However, all membranes allow some transfer of both water and ions, which will eventually lead to acidification of the anolyte. Thus, the nature of the membrane (cation-exchange or anion-exchange), the current generated in the reactor, the anolyte and catholyte flow rates and ionic composition are all important parameters determining whether a suitable environment can be maintained for the biological anode. This aspect will also be discussed in the presentation.

References

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