In CD: Bruce M. Sass (Conference Chair),
Remediation of Chlorinated and Recalcitrant Compounds—2008.
Proceedings of the Sixth International Conference on Remediation
of Chlorinated and Recalcitrant Compounds (Monterey, CA; May 2008).
Published by Battelle, Columbus, OH, Abstract H-008

Pilot Scale In Situ BioTransformation of Mercury-Contaminated Groundwater in Kazakhstan Utilizing Native Bacteria

Svetlana A. Abdrashitova (Institute of Microbiology and Virology, Almaty, Kazakhstan),
Richard Devereux (U.S. EPA Office of Research and Development, Gulf Breeze, FL, USA)
Simon Jackman (United Kingdom FIRSTFARADY, University of Oxford, Oxford, UK)
Wendy J. Davis-Hoover (davis-hoover.wendy@epa.gov)
(U.S. EPA Office of Research and Development, Cincinnati, Ohio, USA)

The Northern outskirts of Pavlodar were contaminated with mercury as a result of activity at the former PO "Khimprom" chemical plant. The plant produced chlorine and alkali from the 1970s into the 1990s using the electrolytic amalgam method entailing the use of massive amounts of mercury. Ground water became contaminated with Hg resulting in a plume 470 m wide, 1.9 km long, estimated to contain 2 million cubic meters of water. This plume could reach the River Irtysh, a source of drinking water for large cities in Kazakhstan and Russia. Significant amounts of mercuric compounds are deposited in the sediments of Lake Balkyldak, 1.5 km north of the factory. This lake occasionally received wastewater from the factory. Phase I of the PO "Kimprom" clean-up that isolated the major sources of mercury at the site was completed in 2004. However, significant amounts of mercury remain underground including groundwater contaminated with Hg in the form of HgCl2 with little to no elemental or methyl mercury (MeHg).

Under the ISTC K-756 Project, we worked on developing a biological filter to remove the soluble mercury contaminant in the groundwater. This project resulted in the isolation and characterization of aerobic, facultative anaerobic and anaerobic sulphatereducing bacteria from soils and sediments taken from contaminated areas on the outskirts of Pavlodar. These isolates were tolerant to 0.005 mM, 0.02 mM and 0.05 mM concentrations of HgCl2. Several properties of these bacteria make them promising candidates. Development would provide a broadly applicable, cost-effective approach to treat mercury contaminated groundwater in Kazakhstan and elsewhere. Sulfate-reducing bacteria (SRB) release hydrogen sulfide during growth. Sulfide can effectively immobilize mercury forming insoluble mercuric sulfides, but some SRB can also methylate mercury. However, several cultures of SRB isolated in the vicinity of the chemical plant formed minimal amounts of MeHg when grown on acetate. This is an important trait. Laboratory studies were carried out to simulate the clean-up of Hg contaminated water using SRB growing with acetate and a flow rate approximating conditions at the contaminated site. The results showed that our SRB isolates could effectively immobilize mercury with little to no detectable MeHg formation and lower the level of Hg in the groundwater to meet water quality standards. A facultative anaerobic bacterium isolated from the contaminated site produced H2S under anaerobic conditions when grown in thiosulfate media in the presence of HgCl2. These conditions could lead to the formation of insoluble mercuric sulfide precipitates. But, although no methyl mercury was formed, the media retained relatively high levels of residual dissolved Hg compounds. This suggests the formation of soluble Hg polysulfides. We have shown that HgCl2 (at the same concentrations found at the Pavlodar site) may be removed from groundwater using support material colonized with our isolated aerobic or anaerobic bacteria.

The two objectives of the research are: (1) to scale up the bench scale bioreactors to pilot scale reactors in order to optimize the conditions for removal of mercury with limited formation of dissolved or methylated mercury, and (2) to conduct small scale field trials at the contaminated site using the bacterial cultures. This new work will be discussed.