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Bioaccessibility: Improving Risk Assessments for Contaminated Sites

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Regulations and guidelines for contaminated site remediation in Canada are currently based on the total concentration of the target substance in a particular substrate (soil, sediments or water). Contaminants in soil, however, maybe be tightly bound and thus there is a growing trend to consider bioavailability – the fraction of a substance that is absorbed by the organism – in determining suitable risk based endpoints for site remediation in Canada. Bioavailability is usually measured by using in vivo methodologies, which tend to be expensive and time consuming; bioaccessibility measurements using simulated gastrointestinal conditions to estimate the soluble fraction of a substance are increasing in desirability for incorporation into risk assessment. Bioaccessibility measurements can be carried out with a simple extraction procedure and hence are more accessible, less expensive and quicker than in vivo studies to estimate bioavailability. For these measurements to be meaningful, however, it is important to compare bioaccessibility to in vivo bioavailability results and determine their accuracy. This talk will focus on the development of bioaccessibility methods for arsenic and nickel, validation of the results using soils that have been subjected to in vivo testing, as well as the effect of more realistic exposure scenarios on risk assessment outcomes. It will also provide insight into the acceptance of the bioaccessibility results by Canadian regulators. It will conclude with a description of activities of Bioaccessibility Research Canada (BARC) – a newly formed network of parties interested in furthering the development and implementation of bioaccessibility in Canada.

Ashish K. Sahu

Perchlorate Reduction in a Packed Bed Bioreactor Using Elemental Sulfur

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Perchlorate release in groundwater has affected water supplies to approximately 15 million people in the US and has primarily occurred in association with manufacturing of missiles, rockets, fireworks and industrial processes. Presently, perchlorate contamination has been recorded in drinking water in 38 US states[1]. The Commonwealth of Massachusetts has proposed limits on perchlorate of 1 mg/L because of adverse effects to the thyroid[2]. Although perchlorate is on the EPA contaminant list, no standards have been set so far.

Various researchers and have found that perchlorate can be used as an electron acceptor in anaerobic microbial metabolism2. A variety of electron donors including H2, ethanol, acetate and sugar derivatives have been investigated for perchlorate removal using both mixed and pure cultures.

This study investigated a novel process for treatment of perchlorate contaminated water using elemental sulfur as an electron donor. A microbial culture capable of coupling sulfur oxidation with perchlorate reduction was enriched from a denitrifying wastewater inoculum under anaerobic conditions. Microbial biomass was added to flasks containing elemental sulfur, crushed oyster shell and 5 mg/L ClO4- . An initial acclimatization period of approximately 15 days was observed, after which perchlorate was reduced to below detection limits (500ppb).

Subsequently, the cultures were inoculated into an upflow bioreactor packed with elemental sulfur and crushed oyster shell media. Groundwater containing ~5 mg/L of ClO4- was continuously fed to the column at an initial hydraulic retention time (HRT) of 53 hours. HRT was optimized to 13 hour over the first three months of operation. Intermittent recirculation resulted in faster degradation of perchlorate, possibly due to more uniform distribution of the biomass through the column. The column is presently being operated with low levels of perchlorate (100 ppb) and with other co-contaminants, which shall be discussed at the meeting.

[1] MADEP 2005. The Occurrence and Sources of Perchlorate in Massachusetts .Draft report URL: http://www.mass.gov/dep

[2] Edward, T. U. 1999. Perchlorate in the Environment. Kluwer Academic/Plenum publishers, NewYork, NY.

Christina L. Stauber

The Use of Local Carbon Sources in Encouraging Acid Mine Drainage Bioremediation

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Acid Mine Drainage (AMD), occurring at abandoned mines, is a water problem characterized by low pH and high levels of metals. Factors aiding in the bioremediation of AMD are currently being studied by an interdisciplinary group at UMass Amherst, focusing around the Davis Mine, located in Rowe, Massachusetts. Natural attenuation of the AMD has been observed at Davis Mine, as evidenced by a rise in pH and reduction of sulfate and iron in the stream bed. A prior microcosm study indicated that local carbon sources, such as algae, could be useful in encouraging the attenuation by acid tolerant anaerobic bacteria.

To further investigate the effects local carbon sources have on AMD bioremediation, a second microcosm study is being conducted at the University of Manchester in England. Samples were taken from two sites: Mam Tor, an ancient land slip located in Derbyshire, England, and Parys Mountain, an abandoned copper mine in Anglesey, Wales. While natural attenuation is occurring at Mam Tor, Parys Mountain is characterized by low pH levels of around 2, very high metal contents in the stream water, and little natural attenuation.
Local algae, wood chips, and glycerol were added to the sediment and water samples taken from the Mam Tor and Parys Mountain sites in a microcosm study. Geochemical parameters linked to the microbial reduction of sulfate and Fe(III) were studied including changes in pH, oxidation reduction potential (ORP), Fe(II), and sulfate. Both wood chips and algae have been found to be promising carbon sources, encouraging a rise in pH and a reduction of Fe(II) more quickly than glycerol. Quick responses were observed in the Mam Tor samples, while the Parys samples were delayed due to harsher conditions. Local materials provide an interesting, sustainable source of carbon for microbial reduction of Fe(II) and sulfate and attenuation of AMD.