Selenium biomineralization applied to mine facility design

LISA BITHELL KIRK[1], CHIACHI HWANG[2], CAGAN ERTUNA[2], HANNAH R. KOEPNICK[2], CHRIS KENNEDY[3], BRENT M. PEYTON[2]

[1] Enviromin, Inc., 1807 W. Dickerson St, Suite D, Bozeman MT 59715 USA
[2] MSU Center for Biofilm Engineering, 366 EPS Building, Bozeman MT 59717-3980, USA
[3]SRK Consulting (Canada), Inc., 1066 West Hastings Street, Vancouver, BC V6E 3X2, CANADA

The biological reduction of oxidized Se(VI) to less mobile Se(IV) and Se(0) in mine waste rock facilities can reduce the cost of protecting water quality during mining operations. Native microbial communities can promote Se reduction and attenuation along biomineralization pathways which vary in rate and efficiency in response to oxygen, nitrate, and carbon concentration. Batch and column studies of native microbial community capacity to reduce Se in unsaturated surficial waste rock and saturated backfills from Canadian coal deposits show that oxygen and nitrate inhibition is overcome via carbon substrate addition. Biofilm in oxygen-exposed groundwater columns developed over a 21 day acclimation period at 10ºC, and showed 50 to 99% nitrate reduction followed by 40 to 95% selenium removal, with no associated sulfate reduction. Microprobe and XAFS studies indicate that the selenium in oxygen-exposed columns was sequestered as selenite. Under microaerophilic conditions, both nitrate and selenate removal increased to between 75 and 98%, with up to 25% sulfate removal as sulfide. Control columns (i.e., native sediment without carbon addition) showed increasing rates of selenium removal with decreasing oxygen. Attenuation of Se can therefore be promoted through carbon addition to saturated fills, under steady state loading of Se concentrations of 1000 ppb.