Advances in the Use of Passive Treatment Systems for Treatment of Selenium-Impacted Minewater

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Background/Objectives. The need to achieve stringent selenium (Se) standards (4.7 µg/L monthly average, 8.2 µg/L daily max) in West Virginia challenged coal mining companies to investigate and implement new technologies to improve mine drainage water quality related to mountain-top mining and related valley fill impoundments. Waste rock sequestered in the valley fills of reclaimed mines may leach oxidized Se and contaminate local surface waters. With selenate (SeO_4) the predominant Se species in the drain water, the application of anaerobic biological treatment in saturated organic compost (biochemical) reactors offered a potentially cost-effective treatment alternative. An important aspect to the implementation of biochemical reactors is the need to treat the byproducts of the anaerobic process, which typically yields initially high concentrations of color, oxygen-demanding organics and sulfide, and excess nutrients. To address this need, post-reactor treatment process include various types of peat- and rock-based media filtration beds and aerobic wetlands and ponds.

Approach/Activities. Following a detailed literature review and a 90-day bench-scale pilot study in the field at one of the drainage outlets, a southern Appalachian mining company constructed three full-scale passive biochemical reactor systems designed to treat Se-contaminated drain water from valley fills.

- System A was designed in late 2010 to treat drain water averaging 10 µg Se/L and an annual average flow of 60 gpm. This 0.2-ac facility includes an initial downflow biochemical reactor (BCR) comprised of organic media for selenium reduction, followed by an upflow BCR composed of peat substrate for selenium polishing and particulate trapping, a "fill-and-drain" subsurface flow wetland for organic matter oxidation, and a surface flow marsh for final polishing.
- System B was designed to treat drain water averaging 23 µg Se/L at an annual flow of 230 gpm. This 0.5-ac facility includes an initial head tank for flow equalization, an upflow biochemical reactor for Se reduction, overlaid with a surface layer of peat, followed by a surface flow wetland for final byproduct polishing.
- System C was designed to treat drain water averaging of 5.6 µg Se/L at an annual average flow of 239 gpm. The 0.3-ac facility includes an initial equalization cell that feeds two parallel downflow biochemical reactors, each followed by upflow peat polishing cells. Both trains discharge to a common aerobic pond for byproduct polishing. Construction was completed by December 2011.

Results/Lessons Learned. After construction was completed in August 2011, System A readily passed an EPA-mandated 2-month evaluation test period, reducing selenium concentrations below method detection levels (0.1 µg/L). Since that time, System A has met daily and monthly Se criteria continuously without exceedance. Outflow concentrations average <2 µg Se/L and typically remain below method detection limits. The ambient winter cold temperature in West Virginia does not impair performance, but above-average inflow rates during the spring provide a slight but measurable reduction in performance. Similarly, since System B construction was completed by October 2011 and System C was constructed by December 2011, both systems have continuously met average and daily Se water quality standards. Additional surface flow

wetlands were implemented to both systems in 2012 to increase the effectiveness of the post-reactor polishing. All systems have operated without incident through seven winters at the time of this writing with no significant reduction in performance.

The collective cost for all three passive treatment systems was estimated to total approximately $2.8 million to build and $60,000 annually to operate, yielding significant cost savings in construction and operational costs (estimated at 40-fold or more) relative to conventional technologies. These “first-in-kind” projects have demonstrated that passive treatment is a practical, cost effective and technologically appropriate way to manage selenium from these southern Appalachian outlets. A similarly cost-effective solution is expected for remote, small flows in other regions where siting and sizing constraints can be met.