Sulfate Reducing Bioreactor Dependence on Organic Substrates for Long-Term Remediation of Acid Mine Drainage: Field Experiments

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Abstract Excessive concentrations of metal contaminants identified in coal-generated acid mine drainage (AMD) associated with abandoned mines pose environmental challenges in the Midwestern U.S. Although many promising technologies have succeeded in providing short-term, low-cost systems for treatment of acid mine discharges, long-term treatment efficiency has been unsuccessful. Sulfate-reducing bioreactors have been employed as a passive technology for the treatment of AMD. However field studies demonstrate that long-term efficiency critically depends on the properties of organic substrates and their ability to support sustained microbial SO_4 reduction.

Previous laboratory experiments have been incapable of simulating the dynamic physical (*e.g.* temperature) and chemical (*e.g.* AMD composition) parameters represented in the field and thus are of limited practicality when applied to actual remediation efforts. Therefore, this study reports preliminary results from six field-scale experiments conducted at the Tab-Simco site to constrain the role of various organic substrates in remediation of coal-generated AMD. Tab-Simco is an abandoned coal mine located in southern Illinois that discharges AMD with pH ≈2.7 and average concentrations (mg/L) of dissolves ions: 900 Fe, 220 Al, 40 Mn and 4500 SO_4. We constructed (1) five reactors containing limestone and alternating proportions of herbaceous and woody materials, and (2) one control reactor containing only limestone. For each experiment, we measured temporal trends in field parameters, effluent chemistry, mineralogy of solid precipitates, and microbial communities.

Results from the first four months of operation showed an increase in effluent pH and decreases in SO_4, Fe, Al, and trace metal concentrations in all field experiments. The simulated passive bioreactors removed on average 58 % SO_4, 56 % Fe, and 95 % Al. These results together with the presence of abundant sulfide minerals in the effluent suggest that microbial SO_4-reducing processes have been active. To date, regardless of the organic substrate used, no significant differences in effluent chemistry have been observed among the five simulated passive bioreactors. In contrast, the limestone-only reactor removed on average 33 % SO_4, 52 % Fe, and 49 % Al. In this case, the formation of precipitates has been the main mechanisms of SO_4 removal. Additional mineralogical and isotopic data together with bacterial community analyses will better constrain abiotic and biological processes responsible for effective AMD remediation.

As each reactor matures over 1-year, measurements will reflect genuine temporal changes produced at an actual AMD inflicted site providing practical applications for SRB technology. The results of this study will help improve bioreactor design and reduce the impact of coal-generated AMD.

Keywords Anaerobic Sulfate-Reducing Bioreactors, Acid Mine Drainage, Remediation, Long-Term