Remediation of Coal-Mine Drainage by Sulfate-Reducing Bioreactor

LILIANA LEFTICARIU[1,2,*], PAUL T. BEHUM , JR[2], CHARLES W. PUGH[3] AND KELLY S. BENDER[3]

[1]Southern Illinois University, Department of Geology, lefticar@siu.edu (*presenting author)
[2]Southern Illinois University, Environmental Resources and Policy, pbehum@siu.edu
[3]Southern Illinois University, Department of Microbiology, bender@micro.siu.edu

Acid mine drainage (AMD) associated with abandoned coal mines is produced by biochemical weathering of organic (e.g., macerals) and inorganic (e.g., pyrite and other sulphides, clays, carbonates) components found in coal, overburden, and mine waste piles [1, 2]. Hydrologic conditions allow most coal mines in the Illinois Basin to be reclaimed without deleterious drainage problems. However, localized AMD from historic surface and underground mining within the basin have required remediation.

A passive-treatment system constructed in 2006 at one of these sites, the Tab-Simco mine near Carbondale, Illinois, remediates AMD characterized by low-pH (~2.9) and high-metal concentrations. Over the past five years the treatment system has increased the median pH of the AMD to ~6.0 and decreased the median acidity to 22.7 mg/L CCE, SO_4^{2-} from 2,981 to 1,750 mg/L, Fe from 450.6 to 3.76 mg/L, Al from 113 to 3.42 mg/L, and Mn from 36.4 to 23.3 mg/L. Continuous monitoring over the past five years has revealed significant temporal trends, including (1) seasonal variations in acidity, dissolved SO_4^{2-} and metals, (2) a general decline in the amount of alkalinity produced, and (3) an overall decline in the efficiency of the of treatment system in removing sulphate and metals. Bacterial community analyses targeting 16S rRNA and dsrAB genes indicated that the pre-treated samples were dominated by bacteria related to iron-oxidizing Betaproteobacteria, while the post-treated water directly from the reactor outflow was dominated by sequences related to sulfur-oxidizing Epsilonproteobacteria and complex carbon degrading Bacteroidetes and Firmicutes phylums. While initial microbiological results indicated that the passive treatment system was successful in stimulating sulfate-reducing bacteria to a certain extent, the algae and bacteria related to sulfur and iron oxidizers dominated the system. Cultures capable of sulfate-reduction have been enriched from the bioreactor and isolates are being used to determine optimal growth substrates. Molecular analysis targeting the 18S rRNA gene is also being used to characterize the algal and microscopic eukaryotic communities present in order to determine their metabolic contribution to the site chemistry. The geochemical and biological trends suggest that the AMD treatment system has to be modified in order to both stimulate sulfate-reducing bacteria and inhibit sulfur-oxidizing bacteria.

Our study demonstrates that passive treatment is an important technology for remediation of streams impacted by coal mining. This result is significant because it provide evidence that reclamation of abandoned coal mines can reduce significantly the environmental impact to water quality degradation.

[1] Behum *et al.* (2011) *Appl. Geochem.,* **26**, S162–S166. [2] Burns *et al.* (2011) *Biodegradation* doi:10.1007/s10532-011-9520-y

Street sediment and lichen as proxies to constrain source of urban lead pollution using lead isotopes

ERIN LEGALLEY[1*], ELISABETH WIDOM[1], MARK P.S. KREKELER[1], AND DAVID C. KUENTZ[1]

[1]Department of Geology and Environmental Earth Science, Miami University, Oxford, Ohio 45056, U.S.A., legallem@muohio.edu (* presenting author)

Introduction and methodology

Street sediment and lichen samples were used as proxies to investigate the source of urban lead (Pb) pollution in Hamilton, Ohio. Pb is a well-known environmental pollutant that poses a significant risk to human health and the greater environment. The study area includes a coal-fired power plant, the Great Miami River, athletic fields, industry, residential neighborhoods, and roadways.

Previously studied street sediment samples exhibit high concentrations of heavy metals (Pb, Zn, Cr, Cu, and Ni) and contain evidence of coal-derived pollution such as fly ash spherules.[1] Lichens are extensively used as bioindicators of atmospheric pollution[2,3] and have not been previously investigated in this study area. Heavy metal concentrations and Pb isotopic compositions of street sediment and lichen samples are combined to develop a more complete picture of local pollution. Major potential sources of Pb pollution in the study area include road paint containing $PbCrO_4$ as a yellow pigment and emissions from the coal-fired power plant.

Samples of local coal, fly ash from an anonymous coal-fired power plant in Kentucky, local road paint, lichen, and sieved (<38 µm) street sediment were analyzed. Two soil samples and one glacial till sample representing regional background were also analyzed. Elemental concentrations were determined by ICP-MS and Pb isotope ratios were determined by either TIMS or MC-ICP-MS.

Results and discussion

Street sediment samples exhibit highly variable Pb concentrations ranging from 130 to 1398 ppm. Pb concentrations in lichen range from 11 to 54 ppm. Pb concentrations range from 17 to 94 ppm in coal and fly ash samples and from 14 to 18 ppm in regional background samples. Road paint samples contain up to 0.63 wt% Pb. Pb isotope ratios in sample materials also exhibit substantial variability and potential pollution sources are isotopically distinct.

Street sediment and lichen samples exhibit strong positive correlations of $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$ and $^{208}Pb/^{206}Pb$ vs. $^{207}Pb/^{206}Pb$, consistent with two-component mixing between regional background and road paint samples. In $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$, coal and fly ash samples fall distinctly off this mixing trend, confirming the dominant contribution of Pb from road paint. Electron microscopy investigations of street sediment and the utilization of lichens as bioindicators of atmospheric pollution demonstrate the fine particulate nature of Pb pollution, and efforts to reduce health and environmental risks are encouraged.

[1] LeGalley, Krekeler, Widom, and Kuentz. (2011) *GSA Abstracts with Programs* **43**, 409. [2] Conti and Cecchetti (2001) *Environ. Pollut.* **114**, 471-492. [3] Cloquet, Carignan, and Libourel (2006) *Atmos. Environ.* **40**, 574-587.