Performance and key biogeochemical reactions in full-scale passive mine water treatment systems

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The effective remediation of acidic mine effluents in passive treatment systems is dependent on the rates and balance of a potentially complex series of inter-related, chemical and biogeochemical reactions involving carbon, sulfur and iron. Combined field and laboratory studies have allowed us to quantify the main reactions occurring within three passive systems treatment coal mine effluents in NE England: two reducing and alkalinity-producing systems at Bowden Close (BC), and a surface flow wetland at Quaking Houses (QC). Monitoring at BC of influent and effluent pollutant loadings over an annual cycle indicates removal of ~90% iron, 99% Al and 15% sulfate; pH increases to 7 – 7.5 from starting values of 4 – 5.5. Much of the Fe and Al is removed as oxihydroxide, with lesser amounts of Fe as sulfide. Sulfur is removed as iron sulfide, elemental sulfur and sulfate.

Alkalinity generation results from both dissolution of calcite in the wetland substrate and also from the oxidation of organic matter coupled to both microbial iron and sulfate reduction. We have studied the rates of microbial iron and sulfate reduction in laboratory microcosms using QH and BC substrates. Despite the high loadings of organic matter, iron and sulfate, rates of bacterial sulfate reduction are 0.07 – 2.0 μmol $cm^{-3}d^{-1}$, and 0.7 – 2.7 μmol $cm^{-3}d^{-1}$ for iron reduction, within the limits determined in natural sediments. We infer that the rates of bacterial sulfate and iron reduction are controlled by the rate at which the requisite low molecular weight fatty acids are formed from the breakdown of macromolecular organic matter. In these wetlands, the rate of degradation of cellulose appears to be critical; 16S rRNA data show that cellulose degraders are an important part of the wetlands' microbial community, and the addition of cellulose to microcosms rapidly stimulates sulfate reduction, and results in the rapid build up of acetate, propionate and butyrate in pore waters.

The isotopic composition of organic carbon in Adirondack Spodosols

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Decomposition of organic matter is a dominant process governing the amount and distribution of carbon in soils. We studied carbon isotope ratios in several Adirondack soil profiles, including the litter layer, to determine whether decomposition processes resulted in fractionation or redistribution of ^{12}C and ^{13}C with depth. As shown in the figure below, a distinct trend of enrichment in ^{13}C with depth was found for all soil samples analyzed.

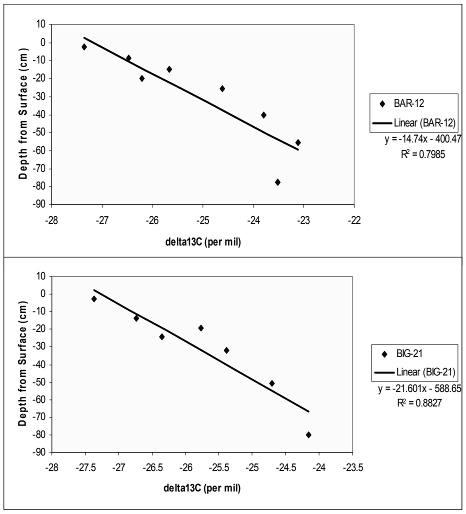

Figure 1: Plots of $\delta^{13}C$ vs. depth showing a consistent trend of ^{13}C enrichment with depth in these soil profiles.

In decomposition experiments in the laboratory using freshly collected litter from the forest floor, respired carbon in CO_2 was found to be consistently heavier isotopically than carbon in the source litter. Although seemingly counterintuitive, other studies have found similar results and have suggested that isotopic signatures of respired CO_2 may be related to shifts in soil microbial communities over time [1, 2].

As far as we know, this study provides some of the first data on the isotopic composition of soil organic carbon in Adirondack Spodosols.

[1] Bostrom *et al.* (2008) *New Phytologist* **177**, 1012-1019.
[2] Crow *et al.* (2006) *Soil Biol. & Biochem.* **38**, 3279-3291.