

Hot spots for biogeochemical transformations in a restored riparian groundwater system

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This study aims to investigate the effect of environmental heterogeneity and hydrological connectivity, resulting from restoration measures in a riverine floodplain, on organic matter (OM) and nutrient transfer and transformation processes. Water samples were collected during different flow conditions over an annual cycle along surface-subsurface flow paths across a restored and a channelized river-floodplain section that differed in connectivity and heterogeneity (prealpine Thur River, Switzerland). Strong hydrological connectivity is expected to tightly link different functional process zones within the aquifer. It thereby enables the transport of material and energy in vertical and lateral directions and fosters the conditions for biogeochemical hot spots. The source and diagenetic state of OM were characterized using C and N stable isotopic measurements, polydispersity, and fluorescence, as well as the composition of amino acids in fine suspended particles. Concurrently, concentrations of dissolved N species and the dual stable isotope signature of nitrate were determined to assess active denitrification and other N-transformations. Biogeochemical data were linked to bacterial extracellular enzymatic activity, abundance, and biomass production. In the restored part, local additions of OM from soil and sediment increased the efficiency of OM turnover and removal. This gain of OM was most pronounced during high-flow conditions. Substantial loss of nitrate and enrichment in nitrate-¹⁵N helped to identify hot spots of denitrification. The dissolution of soil-derived matter may potentially induce a co-metabolism of refractory OM and enhance N transformations. Comparable transformations could not be detected in the aquifer of the channelized section. Overall, seasonal variability influenced transformation capacities less than hydrological conditions. This study demonstrates that introduction of increased environmental heterogeneity fosters microbial reworking of C and N within a floodplain aquifer.

Sulfur cycling at the Mid-Atlantic Ridge: A multiple sulfur isotope approach

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The role of sulfur in two hydrothermal vent systems at the Mid-Atlantic Ridge, the Logatchev Hydrothermal Field (LHF) at 14°N and various sites between 4° and 9° and between 12° and 13°S (SMAR), are examined by utilizing multiple sulfur isotopes.

Isotope compositions for sulfide minerals and vent H₂S from SMAR range from +1.5 to +8.9‰ in δ³⁴S and from +0.001 to +0.051 in Δ³³S. Combined δ³⁴S and Δ³³S systematics reveal that vent sulfide results from two component mixing between the principal endmembers mantle sulfur and reduced seawater sulfate in a ratio of ~70:30%, respectively. Additionally, isotope data uncover non-equilibrium isotope exchange between dissolved sulfide and sulfate in an anhydrite bearing zone below the vent systems at temperatures between 355 and 420°C.

δ³⁴S values between +0.2 and +8.8‰ for dissolved and mineral sulfide from LHF point to the same mixing process of mantle sulfur and reduced seawater sulfate. δ³⁴S values between -24.5 and +6.5‰ and Δ³³S values between +0.001 and +0.125‰ for sulfide-bearing sediments and mafic/ultramafic host rocks from drill cores taken in the region of Logatchev clearly indicate a contribution of biogenic sulfide formed via bacterial sulfate reduction.

Distinct differences in the sulfur isotopic composition of sulfides from MAR and EPR reveal fundamental differences with respect to the subsurface fluid evolution at slow and fast spreading mid-ocean ridges. Multiple sulfur isotope measurements enable identification of disequilibrium isotope exchange in addition to isotope mixing as a second important factor affecting the isotopic composition of dissolved sulfide during fluid upflow. Moreover, based on Δ³³S we are able to clearly distinguish biogenic from hydrothermal sulfides in sediments even when δ³⁴S are identical.