Assessment of glycerol-enhanced bacterial sulfate degradation in lignite mining sediments by stable isotope investigations

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Abstract The generation of acid mine drainage (AMD) is known to create significant impact on the hydrochemical conditions in lignite mining sediments. Especially high loads of acidity, iron and sulfate pose an immense risk to adjacent ground- and surface water bodies. Bacterial sulfate reduction (BSR) is the only natural process that can counteract those major effects of AMD contamination.

Often, BSR is limited due to a low supply of organic carbon, acting as an electron donor. Therefore, the injection of additional electron donors into the aquifer may stimulate the sulfate degradation. Glycerol is particularly suitable due to its chemical properties, *e.g.* low freezing point. So it is possible to use easily degradable substrate with defined quantity over the whole year. This technique was tested in a lignite mine dump aquifer section in the Lusatian lignite mining district, Germany.

Glycerol was added to the groundwater via injection wells and channelized by a funnel-and-gate system. The decision whether sulfate reduction is occurring in the investigated aquifer section was based on the observation of the stable isotopic composition and concentration of sulfate. The sulfate concentration showed significant changes in the wells, sometimes with little alteration in the isotopic composition. Therefore, part of the sulfate concentration changes seem to be due to transport phenomena such as dispersion and dilution. Only samples with changed isotope signatures provide the evidence for the occurrence of BSR. The significant enrichment of both heavy sulfur and heavy oxygen in the remaining sulfate pool can be interpreted as a direct result of the activity of sulfate-reducing bacteria. The preferable reactive zone for microorganism is relatively fixed to the location the glycerol injections. Groundwater sulfate is being reduced stepwise as it progresses through the reactive zone. Subsequently, the residual sulfate is transported with the groundwater flow and appears at certain times at the different wells. The temporal variability of the process intensity and transport of reaction products in the groundwater flow affect the sulfate concentrations and sulfate isotope signatures and lead to a spatially heterogeneous distribution. Also, the residence time of the groundwater in the reactive zone and the availability of the electron donor influence the extent of sulfate degradation.

Regardless of the inhomogeneous distribution, the overall turnover of sulfate by sulfate reducing bacteria justifies the injection of glycerol and proves the applicability of this enhanced natural attenuation method to handle the restoration of aquifers contaminated with AMD.

Keywords bacterial sulfate reduction, isotope fractionation, glycerol, lignite mining