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Isotope biogeochemical assessment of natural biodegradation processes in open cast pit mining landscapes

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In Germany, a major share of the energy production is based on the burning of lignite from open cast pit mines. The remediation and re-cultivation of the former mining areas in the Lusatian and Central German lignite mining district is an enormous technical and economical challenge. After mine closures, the surrounding landscapes are threatened by acid mine drainage (AMD), i.e. the acidification and mineralization of rising groundwater with metals and inorganic contaminants. The high content of sulfur (sulfuric acid, sulfate), nitrogen (ammonium) and iron compounds (iron-hydroxides) deteriorates the groundwater quality and decelerates sustainable development of tourism in (former) mining landscapes. Natural biodegradation or attenuation (NA) processes of inorganic contaminants are considered to be a technically low impact and an economically beneficial solution.
The investigations of the stable isotope compositions of compounds involved in NA processes helps clarify the dynamics of natural degradation and provides specific informations on retention processes of sulfate and nitrogen-compounds in mine dump water, mine dump sediment, and residual pit lakes.
In an active mine dump we investigated zones where the process of bacterial sulfate reduction, as one very important NA process, takes place and how NA can be enhanced by injecting reactive substrates. Stable isotopes signatures of sulfur and nitrogen components were examined and evaluated in concert with hydrogeochemical data. In addition, we delineated the sources of ammonium pollution in mine dump sediments and investigated nitrification by 15N-labeling techniques to calculate the limit of the conversion of harmful ammonium to nitrate in residual mining lakes.
Ultimately, we provided an isotope biogeochemical assessment of natural attenuation of sulfate and ammonium at mine dump sites and mining lakes. Also, we estimated the risk potential for water in different compartments of the hydrological system. In laboratory experiments, we tested reactive materials that may speed up the process of bacterial sulfate reduction. In in-situ experiments, we quantified nitrification rates. Based on the results, we are able to suggest promising technical measures that enhance natural attenuation processes at mine dump site and in mining lakes.
The natural water cycle in lignite mining landscapes is heavily impacted by human activities. Basically, nature is capable of cleaning itself to a certain extent after mining activities stopped. However, it is our responsibility to support biogeochemical processes to make them more efficient and more sustainable. Isotopic monitoring proved to be an excellent tool for assessing the relevance and performance of different re-cultivation measures for a positive long-term development of the water quality in large-scale aquatic systems affected by the impact of lignite mining.