Stable isotope tools for assessing flow dynamics and contaminant degradation in mining landscapes

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Extended Abstract

The extraction of mineral resources and solid fossil fuels and the impact of the various extraction technologies on the natural hydrogeochemical environment may result in a widespread diffuse contamination of vast landscapes. Major symptoms of this contamination type are acidification and extremely high mineralization of the (sub-) surface water with sulfate, iron and/or heavy metals. In some cases, technological measures are successfully applied for an active remediation of the environmental impact, in many other cases, however, the only appropriate way to manage such vast diffuse contamination sources is the implementation of the natural attenuation concept.

Independently of the applied concept, successful remediation always depends (i) on a precise determination of hydrogeological boundary conditions, (ii) on a suitable monitoring approach for controlling the effectiveness of the measures and (iii) on a reliable prediction of future scenarios for sustainability. In that context, stable isotope signatures are a very powerful tool for assessing the dynamics that control the flow of water through the contaminated system and its hydrological interaction with the surroundings. Also, stable isotopes are successfully applied for the identification and quantification of biogeochemical transformation processes leading to a degradation of the contaminants.

Besides basic concepts of stable isotope applications, two examples are presented that give insight into the successful application of isotope tools for scientific governance of remediation measures. The first example refers to an isotope based decision support related to the covering of a heavy-metal emitting slag heap in a former copper mining region with an impermeable barrier. The second example shows how isotope signatures can be used to predict the natural attenuation potential in a lignite mining dump.

Key words: stable isotope signatures, flow dynamics, biogeochemical processes, natural attenuation