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Catchment-scale metal retention revealed from natural bacterial sulfate reduction (BSR)

Sandra Fischer[1], Jerker Jarsjö[1], Gunhild Rosqvist[1], and Carl-Magnus Mörth[2]
[1]Department of Physical Geography, Stockholm University, Stockholm, Sweden
[2]Department of Geological Sciences, Stockholm University, Stockholm, Sweden

Acid mine drainage (AMD) threaten ecosystems world-wide and research on biological remediation techniques are increasing. One of them is bacterial sulfate reduction (BSR) that immobilizes the aqueous sulfate and through coprecipitation removes dissolved metals from the more bioavailable phase. Although BSR has previously only been investigated at the local wastewater treatment scale (e.g. for constructed wetlands), it is unknown to which extent they contribute to contaminant attenuation at larger scales (e.g. a hydrological basin). We developed a new method to trace the activity of BSR within an AMD-impacted catchment using sulfur isotopes ($\delta^{34}S$) and found that they naturally reduce 30% of the riverine sulfate and metal concentrations, with a spread from 10 to 50% reduction within the catchment. These results are based on surface water field measurements from our test site in northern Sweden combined in a mass-balance mixing model where we explicitly addressed the isotopic fractionation from bacterial activity. This innovative mapping of catchment-scale biogeochemical natural attenuation provides important clues to strategically target remediation measures, e.g. potential in-situ enhancement of the BSR activity. In combination with stable water isotopes we hope to refine this method to further identify BSR hot spots within the catchment and to extend its application to other sites, e.g. the Khibiny mining region, Russia.