Cr isotopes and the engineered attenuation of Cr(VI)-rich runoff

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Chromium stable isotope compositions can provide information on the extent of Cr(VI) reduction to Cr(III) in natural and engineered environments. Laterite soils developed on ultramafic rocks are rich in Cr(VI) and water draining these soils can have Cr(VI) concentrations considered ecologically harmful. Reduction of Cr(VI) to Cr(III) provides a means to mitigate the potentially harmful effects of Cr(VI). Faucets delivering an $Fe(SO)_4$ solution to drainage of laterite soils in Indonesia have been implemented to reduce Cr(VI). Here we used Cr isotopes (expressed as $\delta^{53}Cr$) from both aqueous and sediment samples to evaluate the efficacy of Cr(VI) removal and track Cr cycling along this stream.

Greater than 99.9% of Cr(VI) was removed from solution by a first treatment faucet, however, downstream Cr(III) was oxidized and remobilized as Cr(VI). This remobilized Cr(VI) was removed by a second treatment faucet and concentrations remained low throughout the remainder of the stream. Based on current knowledge of Cr isotope systematics, partial reduction of Cr(VI) in stream waters should lead to increasingly positive $\delta^{53}Cr$ values in the residual pool of unreacted Cr(VI). Before treatment, runoff Cr(VI) had a $\delta^{53}Cr$ of 3.40‰, but in contrast to expectations based on the directionality of isotope fractionation during reduction, downstream Cr(VI) became lighter with values reaching 2.56‰. Using a suite of geochemical analyses, we show that the lowering of $\delta^{53}Cr$ is the result of Cr recycling and remobilization. We attribute this to Cr(III) oxidation by Mn oxides present in the drainage system. While the efficacy of the treatment was high, it's efficiency at intermediate sites would be improved if remobilization by reaction with Mn oxides could be attenuated.