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Experimental investigation of critical metal removal by biotic manganese oxides

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Ore grade concentrations of energy critical metals have been identified in the precipitate by-products from some acid mine drainage (AMD) treatment systems that utilize microbially-mediated oxidation (passive) technology. These metals are often disproportionately associated with manganese oxides and hydroxides (collectively referred to as MnO_x) through adsorption and/or coprecipitation.[1]

To understand the conditions that facilitate critical metal enrichment in passive AMD treatment systems, we investigated the attenuation of ten critical metals (Co, Ni, La, Ce, Nd, Pr, Gd, Dy, Yb, and Y) in solutions with and without MnO_x produced by two fungal species, *Paraphaeosphaeria sporulosa* (previously *Paraconiothyrium sporulosum)* and *Stagonospora* sp. These species are known to produce forms of MnO_x such as δ-MnO_2 or acid birnessite that are highly disordered and have a high adsorption capacity.[2] In our experiment, critical metals were allowed to interact with the biotic MnO_x and fungal biomass for 31 days with periodic sampling to assess critical metal removal by the minerals and/or biomass. Control experiments were also conducted to assess the behavior of critical metals with no MnO_x or biomass present, and with fungal biomass only.

Our results indicate that the fungi differ in their capacity to oxidize manganese. *Stagonospora sp.* oxidized 99% of Mn in solution after 14 days, whereas *P. sporulosa* oxidized 60% of Mn over the same period. The critical metal removal capacity also varied between the two fungal species. Cobalt in solution decreased by 90% and 80% in the presence of MnO_x produced by *Stagonospora* sp. and *P. sporulosa,* respectively. For both fungi, Co removal from solution was 30% greater than Ni removal after 31 days. Near total rare earth element (REE) and Y removal was achieved (95% - 99%) within 18 days, both in the presence of biotic MnO_x and with fungal biomass only. Normalized REE patterns show a preferential removal of light REE over 31 days with little to no apparent Ce anomaly.

[1] Hedin B. C. et al. (2019). *Int. Jour. Coal Geol. 208*, 54-64.

[2] Rosenfeld C. E. et al. (2020). *Env. Sci. Technol. 54*, 3570-3580.