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Leaching of trace metals (Pb, Zn) from contaminated tailings: New insight from a modelling approach

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Reclamation measurements are commonly applied to mitigate the leaching of metal pollutants in order to reduce the risk for humans and the environment. Organic and/or inorganic amendments are often recommended to stabilize tailings and to reduce leaching of contaminants. In a recent microcosm percolation experiment (Thouin et al., 2019), the addition of a mining slurry called ochre and manure, either alone or in combination, drastically reduced the leaching of several metal pollutants, notably Pb. Nevertheless, the biogeochemical processes involved in the immobilization of metal pollutants remain unknown, preventing the management of this remediation technique from being optimized and its extension to other sites. To fill this gap, a multicomponent reactive model was developed to simulate and forecast the impact of amendments on the leaching of metal pollutants. This model accounts for the following biogeochemical processes: kinetically-controlled dissolution and precipitation reactions, sorption reactions (i.e. surface complexation reactions), water-gas interactions and microbially-driven redox reactions with an explicit microbial growth. For all treatments, simulations revealed that Pb reactivity followed dynamic patterns driven by watering steps. The decrease in Pb concentration in the leachates of amended tailings compared to untreated tailings was also accurately reproduced. In untreated tailings, Pb reactivity is mainly controlled by the dissolution of Pb-bearing mineral phases. These reactions were maintained in thermodynamic disequilibrium due to the renewal of pore solution at each watering step. In amended tailings, this pattern was strengthened as the iron oxides contributed by ochre maintained a low Pb concentration in pore solution by sorbing released Pb. Sorption reactions were enhanced by the increase in pH induced by the dissolution of calcium carbonate initially present in ochre. The latter reaction was partially counterbalanced in tailings amended with manure as organic matter provided sufficient energy to fuel microbial aerobic respiration, leading to the release of protons. Pb desorption was promoted by this pH drop. By providing a better understanding of the effect of amendment, this multicomponent reactive model is a powerful tool to optimize the reclamation of tailings, in order to limit contaminant transfer to the environment.

Thouin H. et al. (2019), *Appl. Geochem.* 111, 104438