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Role of organic acids in controlling the mobility of bioessential and/or toxic trace elements during enhanced weathering

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Enhanced rock weathering (ERW) is a promising approach for atmospheric CO_2 removal, with the potential co-benefit of increasing the nutritional value and yield of food crops [1]. However, the repeated application to soils of mafic or ultramafic rock dust, which contains high concentrations of potentially toxic trace elements (TEs) such as Ni, Cr, Cu and Zn, may pose risks to food production and safety [2].

To assess the long-term risks of TE accumulation in agricultural soils, it is essential to understand the processes driving TE mobility during weathering. Organic ligands are ubiquitous in soils and enhance mineral dissolution rates beyond those promoted by inorganic acids [3], but their role in influencing TE mobility during ERW has not been comprehensively studied. We performed batch experiments using Eifelgold basalt rock powder, organic acids (citric, maleic, and oxalic), and an inorganic acid (HCl) to explore the effects of organic ligands on TE release.

Our results show that organic acids, particularly citric acid, significantly enhance the release of major elements (e.g., Na, Ca, Mg, K, Al, Si, Fe) and TEs (including Ni, Cr, Cu, Co, Mn, Mo, V). In both inorganic and organic experiments, a rapid initial release phase is followed by re-adsorption of many elements onto mineral surfaces or their incorporation into secondary minerals, associated with a pH increase from ~3.5 to > pH 6. Despite this removal, relative mobility of TEs (compared to K) is enhanced in organic acid experiments. Notably, Cu demonstrates very high mobility, approaching congruent dissolution, in citric acid. In contrast, Zn exhibits very low mobility across all treatments, as do Pb and As.

The enhanced mobility of several potentially toxic TEs suggests that organic acids may reduce their accumulation in soils during ERW, potentially reducing the risks of toxicity over multiple growing seasons. Future research should focus on the solid-phase accumulation of Zn, Pb, and As, as well as the bioavailability of all accumulated TEs.

[1] Beerling, Epihov, et al. (2024), *PNAS* 121.9: e2319436121

[2] Dupla, Möller, Baveye & Grand (2023), *Eur. J. Soil Sci*. 74: e13343

[3] Neaman, Chorover & Brandtley (2005) *Am. J. Sci*. 305, 147–185