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## Effects of aging and transformation of Fe(III)-precipitates on the retention of co-precipitated phosphate

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The cycling of phosphorus in terrestrial and aquatic systems is tightly coupled to the redox-cycling of iron (Fe). The oxidation of dissolved Fe(II) in natural waters leads to the precipitation of amorphous to poorly crystalline Fe(III)-solids that can bind phosphate (P) and other nutrients as well as toxic compounds. The EU project P-TRAP is aimed at developing methods to reduce diffuse P inputs into surface waters to mitigate eutrophication, by using Fe-rich byproducts from water treatment (<https://h2020-p-trap.eu/>). Within this project, we study mechanistic aspects of the formation and transformation of P-containing Fe(III)-precipitates and their implications for P retention in soils and water filters.

Freshly formed Fe(III)-precipitates are metastable and can transform into more stable phases over time. This may lead to the release of co-precipitated P. In laboratory experiments, we assessed how Ca, Mg, silicate (Si) and P impact on the formation and transformation of Fe oxidation products (at 0.5 mM Fe) and their P retention in synthetic bicarbonate-buffered groundwater. The time-resolved experiments were performed in electrolyte solutions containing Na, Ca, or Mg as electrolyte cation, without or with Si (at molar Si/Fe of 1), and P (P/Fe of 0.3 and 0.05). Changes in dissolved element concentrations over time were linked to changes in the structure and composition of the Fe(III)-solids; with Fe coordination probed by X-ray absorption spectroscopy, mineralogy by X-ray diffraction, and nano-scale morphology and composition heterogeneity by transmission electron microscopy with energy-dispersive X-ray detection.

The freshly-formed Fe(III)-precipitates were mixtures of amorphous Fe(III)-phosphate with either poorly-crystalline lepidocrocite (without Si) or Si-containing ferrihydrite (with Si). Increases in dissolved P during aging were largest in Na electrolytes without Ca, Mg or Si, and were linked to the transformation of amorphous Fe(III)-phosphate into lepidocrocite with a lower P retention capacity than Fe(III)-phosphate. In Ca- and to a lesser extent Mg-containing electrolytes, the Ca or Mg stabilized the amorphous Fe(III)-phosphate and thereby reduced P release over time. The presence of Si increased initial P uptake and inhibited P release during aging by causing the formation of Si-ferrihydrite with higher P sorption capacity than lepidocrocite formed in the absence of Si. In conclusion, the extents to which P is trapped by fresh Fe(III)-precipitates and

released during aging can be attributed to the individual and coupled impacts of Ca, Mg and Si on Fe(III)-precipitate structure, stability and transformation.

In continuing work, we aim to expand our work to study how organic compounds impact on the formation and colloidal stability of Fe(III)-precipitates and P retention.