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Relationship between P and the most reactive fraction of Fe(III) oxyhydroxide in various aquatic and sedimentary environments

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Phosphorus can experience a series of biogeochemical pathways. Primary P has an igneous origin and occurs mostly as apatite in bedrocks. Once P is dissolved as phosphate ion, it can incorporate organic matter or become adsorbed onto inorganic particles. The liberation of P from organic matter through bacterial respiration produces a subsequent flux back to the biota or a storage in Fe and Al oxyhydroxides, or in authigenic or biogenic phosphate minerals. The adsorption of phosphate on Fe- and Al-oxide and oxyhydroxide has been extensively studied in soil science because phosphorus is a limiting nutrient in terrestrial ecosystems, and sorptive removal of natural or fertilizer phosphorus impacts the production level of crops and forests. Fe(III) oxides/oxyhydroxides are subject to reductive dissolution, and consequently redox conditions play an important role in soil P-bioavailability. The main process of phosphorus removal from the aquatic systems is burial with sediments. Exchange between sediment and overlying water takes place through benthic biogeochemical processes, including organic-P mineralization, redox-driven Fe–P cycling, and benthic phosphorus efflux from sediments. A portion of the pore-water phosphate derived from organic matter mineralization may be adsorbed onto detrital or authigenic iron oxyhydroxides in the oxidized zone of the sediment. Once advected in the reduced zone of sediments through burial or bioturbation, the most reducible fraction of Fe(III) phase can be reduced and solubilized, leading to a release of phosphate. Eventually, P can be buried over long period as relict organic-P, P associated with refractory iron oxides, and apatite. Therefore, Fe-bound P is often the initial sink of P supplied by organic matter, but not the major final sink. Several techniques have been developed to extract P bound to Fe(III) phases. The citrate-dithionite buffered (CDB) solution is one of the most often used solution to measure Fe(III)-bound P. CDB solution lacks selectivity because dithionite is a strong reducing compound that reduces amorphous and crystalline Fe(III)-oxide and oxyhydroxide. An ascorbate solution buffered at pH 8 extracts selectively the most reactive fraction of Fe(III). In surface sediments, soils and suspended particles P is mostly adsorbed on this most reactive fraction of Fe(III)-oxide, i.e. on the fraction leached with an ascorbate solution. I will show why the ascorbate extraction is suitable for studying the most reactive Fe(III) phases. I will present a compilation of ascorbate-Fe:P ratios of a suspended particles continuum form rivers to ocean; of a set of surface sediments from intertidal zones to deep sea sediment (including OMZ); of modern oxic sediments to buried anoxic sediments; of hydrothermal deposits ; of sediment exposed to experimental redox oscillation. Whatever the environment studied, the ascorbate Fe:P ratio of oxic particles is very often 6±1. This seems to be a saturation value of sorption capacity of reactive Fe(III) phases. This compilation gives an overall view of the adsorption capacity of sediments and soils for phosphate.