Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31854

Adsorptive and Desorptive Behavior of Metal Cations on Iron Oxyhydroxide Nanoparticles Under Varying Salinity Conditions

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Metal contaminants in aquatic systems can be effectively sequestered from the dissolved phase through adsorption to mineral surfaces such as those of iron oxyhydroxides. However, the salinity level of natural waters can influence the adsorption, desorption, and retention of metal ions to such sorbents in ways that have not been fully characterized. This study examines the adsorptive and desorptive properties of zinc and copper under saline conditions at concentrations ranging from those in freshwater to saltwater systems.

FeOOH (goethite) nanoparticles were synthesized through an established flash microwave method, washed in 1000 MWCO dialysis tubing against DI water for 5 days, then stored in suspension at 4°C at their as-synthesized pH between 4.5 and 5.0. The nanoparticle suspensions were then exposed to 0.5 mM Cu(II) or Zn(II) with the pH adjusted upwards to 6.5 and 7.5, respectively, to induce metal cation adsorption to the nanoparticles. After a 24-hour adsorption period, the sorbed nanoparticle suspensions were exposed separately to sulfate, chloride, sulfate + chloride, or artificial sea water (ASW) at concentrations representing the range from freshwater to seawater. After an additional 18 hours of equilibration, the suspension pH was reduced to 5.0 to induce metal cation desorption. The suspensions were then centrifuged and supernatants filtered through a 0.45 µm filter and acidified to a pH <2.0 before analysis using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The percentage of metals absorbed and retained in the separate environments were then calculated from the ICP-OES data.

Results demonstrate that saline conditions enhance the adsorption and retention of both metals in the following order: sulfate << chloride < sulfate + chloride < ASW, and that Zn(II) exhibits higher retention than Cu(II) under all conditions. These findings indicate that transport from freshwater to saltwater environments are likely to enhance metal ion retention to particle surfaces and unlikely to result in desorption of metal ions back into the aqueous phase. This has implications for the modeling of metal contaminant transport and geochemical cycling in dynamic water systems.