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Effect of phosphate on ferrihydrite transformation and the associated arsenic behavior mediated by sulfate-reducing bacterium

KUN GAO

Southern University of Science and Technology

Presenting Author: gangk@sustech.edu.cn

Ferrihydrite is a potent scavenger for the arsenic (As) in aquifer environments, while it may suffer redutive transformation when encountered sulfate-reducing bacteria (SRB). PO_4^{3-} is commonly found in association with ferrihydrite, and the effect of PO_4^{3-} on ferrihydrite reduction, mineralogical transformation, and associated As transport mediated by SRB remains unclear. In this study, batch experiments, together with geochemical, mineralogical, and biological analyses were conducted collectively to elucidate the above processes. The results showed that SRB reduced ferrihydrite via direct and indirect processes, and PO_4^{3-} promoted ferrihydrite reduction by supporting SRB growth at low and medium PO_4^{3-} loadings. However, at high loadings, PO_4^{3-} stabilized the ferrihydrite via forming Fe-O-P complexes. PO_4^{3-} shifted the transformation of ferrihydrite from magnetite and mackinawite to vivianite, which scavenged As effectively by incorporating As into its particle. In systems with 0.5 mM SO_4^{2-}, As remained in the solids during the reductive transformation of ferrihydrite, and PO_4^{3-} exerted a weak effect on As behavior. However, in systems with 10 mM SO_4^{2-}, substantial amounts of As were released into the solution, and PO_4^{3-} impacted the fate of As strongly. Low PO_4^{3-} loadings increased the mobilization of As because of the competitive adsorption of PO_4^{3-} on mackinawite. Medium and high PO_4^{3-} loadings were beneficial for As immobilization due to the substitution of mackinawite by vivianite. These findings have important implications for understanding the biogeochemistry of iron (oxyhydr)oxide and As behavior in SRB-containing sediments, and are helpful for the risk assesement and remediation of As contamination.