

Mobilization of arsenic and iron from Red River floodplain sediments, Vietnam

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Abstract: Sediments from the Red River and from an adjacent floodplain aquifer were investigated with respect to the speciation of Fe and As in the solid phase, to trace the diagenetic changes in the river sediment upon burial into young aquifers, and the related mechanisms of arsenic release to the groundwater. Goethite with subordinate amounts of hematite were, using Mössbauer spectroscopy, identified as the iron oxide minerals present in both types of sediment. The release kinetics of Fe, As, Mn and PO₄ from the sediment were investigated in leaching experiments with HCl and 10mM ascorbic acid, both at pH 3. From the river sediments, most of the Fe and As was mobilized by reductive dissolution with ascorbic acid while HCl released very little Fe and As. This suggests As to be associated with an Fe-oxide phase. For oxidized aquifer sediment most Fe was mobilized by ascorbic acid but here not much As was released. However, the reduced aquifer sediments contained a large pool of Fe(II) and As that is readily leached by HCl, probably derived from an unidentified authigenic Fe(II)-containing mineral which incorporates As as well. Extraction with ascorbic acid indicates that the river sediments contain both As(V) and As(III), while the reduced aquifer sediment almost exclusively releases As(III). The difference in the amount of Fe(II) leached from river and oxidized aquifer sediments by ascorbic acid and HCl, was attributed to reductive dissolution of Fe(III). The reactivity of this pool of Fe(III) was quantified by a rate law and compared to that of synthetic iron oxides. In the river mud, Fe(III) had a reactivity close to that of ferrihydrite, while the river sand and oxidized aquifer sediment exhibited a reactivity ranging from lepidocrocite or poorly crystalline goethite to hematite. Mineralogy by itself appears to be a poor predictor of the iron oxide reactivity in natural samples using the reactivity of synthetic Fe-oxides as a reference. Sediments were incubated, both unamended and with acetate added, and monitored for up to 2months. The river mud showed the fastest release of both Fe and As, while the effect of acetate addition was minor. This suggests that the presence of reactive organic carbon is not rate limiting. In the case of the river and aquifer sediments, the release of Fe and As was always stimulated by acetate addition and here reactive organic carbon was clearly the rate limiting factor. The reduced aquifer sediment apparently can sustain slower but prolonged microbially-driven release of As. The highly reactive pools of Fe(III) and As in the river mud could be due to reoxidation of As and Fe contained in the reducing groundwater from the floodplain aquifers that are discharging into the river. Deposition of the suspended mud on the floodplain during high river stages is proposed to be a major flux of As onto the floodplain and into the underlying aquifers. © 2010 Elsevier Ltd.

Index Keywords: aquifer; arsenic; ascorbic acid; floodplain; fluvial deposit; goethite; hematite; iron; iron oxide; mineralogy; organic carbon; reaction kinetics; sediment chemistry; speciation (chemistry); Red River

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