The role of sediment heterogeneity on arsenic mobilization during managed aquifer recharge

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The release of naturally-occurring arsenic from sediments to groundwater has been observed at numerous managed aquifer recharge (MAR) sites and attributed to various geochemical mechanisms including shifting redox conditions, pH changes, and competitive ion displacement. The geochemical cycling of As during MAR depends on recharge water chemistry, native aquifer geochemistry, and type of MAR system. Here, we investigate the release of As during MAR where highly purified recycled water is used for recharge. The treated effluent is of extremely low ionic strength (<0.01 M electrolyte concentrations) and highly oxidizing, containing disinfectant residuals including approximately 2.5 mg/L hydrogen peroxide. We focus on injection of this purified oxidizing water into a deep (>150 m) aquifer within the Orange County Groundwater Basin (Orange County, CA – USA).

We use reactive transport modeling to evaluate the geochemical mechanisms of arsenic release at several depth locations within the Orange County Groundwater Basin. Injection occurs via a single injection well which is screened at depth intervals ranging from 160 to 365 m, allowing recharge into multiple zones of a confined, deep aquifer. However, these zones vary depending on depositional environment, historic groundwater pumping and longterm infiltration from the overlying shallow aquifer. The resulting sediment geochemical heterogeneity plays a critical control on the release of As during MAR. In zones with extensive prior oxidation, arsenic mobilization occurs via As(V) oxyanion desorption from Fe-(hydr)oxides; while within zones which are reduced prior to injection, arsenic release is attributed to oxidative dissolution of As-bearing pyrite. Our results show that arsenic release can be attributed to various geochemical causal mechanisms within a single injection well owing to sediment geochemical heterogeneity, which poses a complex challenge to water managers seeking to optimize recharge operations by minimizing contaminant mobilization.