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Role of colloids in the mobilization of geogenic contaminants during managed aquifer recharge

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Managed Aquifer Recharge (MAR) is an increasingly popular approach to counteract groundwater overdrafts. However, one outcome of expediting groundwater recharge is the mobilization of naturally occurring contaminants such as arsenic, uranium, and chromium, which pose a threat to groundwater quality and human health. This study aims to better understand the mechanisms for geogenic contaminant mobilization during MAR via dry-well injection. We hypothesize that oscillations in redox conditions during water injection via dry wells can lead to the reductive dissolution of geogenic contaminants and metal oxides, their mobilization into groundwater, and subsequent oxidative re-precipitation of electron donors such as iron and manganese as mobile colloids. To test this hypothesis, we analyzed groundwater samples associated with direct injection of surface water to a depth of about 70 m in an agricultural field in Helm, CA, in California's Central Valley. We also utilized batch reactors under well-controlled oxygen conditions using natural aquifer sediments collected at depths of 18, 30.5, and 54.8 m, spanning different soil textures and mineralogical compositions. Batch reactors were designed to mimic site conditions as pore water was sampled at similar depths. Pore water sample filtrate and batch reactor filtrate were analyzed via inductively coupled plasma mass spectrometry (ICP-MS). Initial sediments, batch reactor solids, and pore water solids were also characterized using X-ray absorption near-edge spectroscopy (XANES) and transmission electron microscopy (TEM). Our preliminary findings show that under anoxic conditions iron, manganese, and arsenic undergo reduction. Additionally, analysis of field pore-waters revealed a significant Fe-rich colloidal fraction with distinct mineralogy than the bulk sediment. Chromium and uranium concentrations varied temporally in batch reactors depending on sediment depth but on average concentrations increased under oxic conditions. Implications of this research can be utilized to further expand knowledge of contaminant transport to make greater informed groundwater management decisions to benefit groundwater quality and public health.