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Trace metal mobilization during managed aquifer recharge (MAR): A batch reactor approach assessing the influence of alternating anoxic-oxic cycling on metal release and transformation during MAR

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Years of groundwater over-pumping and drought have drastically depleted aquifers across California. One strategy being used to increase groundwater storage is managed aquifer recharge (MAR), where excess surface water is routed into underlying aquifers. One common MAR approach uses infiltration basins or spreading grounds. If non-conventional water sources are used (e.g., recycled wastewater, agricultural runoff, or stormwater), infiltrating water can have high concentrations of nitrate. Carbon-based permeable reactive barriers (PRBs) installed within basins can effectively remove nitrate from recharge water through stimulating anaerobic microbial processes; however, these same processes can simultaneously enhance the mobilization of naturally occurring metals, including arsenic (As) and manganese (Mn). Currently, little information exists documenting the fate and transport of metals within MAR systems, and how flooding induced redox cycling influences metal mobilization. We utilized a 3-treatment (control; nitrate; and nitrate with wood mulch) batch reactor setup subjected to alternating anoxic-oxic cycling, to simulate basin redox conditions and determine how As and Mn are solubilized. The addition of wood mulch to reactors resulted in increased dissolved organic carbon concentrations, as well as faster rates of denitrification when compared to nitrate spiked reactors without wood mulch. However, the addition of wood mulch also increased the generation of HCl-extractable iron(II), and aqueous Mn and As compared to controls. Aqueous Mn and As concentrations were observed to increase under anoxic conditions and decrease during oxic periods, especially over the first anoxic-oxic cycle. Manganese dissolution likely resulted from the microbial respiration of Mn(III/IV)-containing minerals during anoxic periods, while aqueous Mn(II) is immobilized by oxidation or adsorption processes during oxic periods. Arsenic cycling was likely controlled by the release of As that was adsorbed to Mn- and Fe-oxides that were reduced by microbially-mediated reduction under anoxic conditions, and subsequently re-adsorbed on re-precipitated Mn- and Fe-oxides under oxic conditions. These findings demonstrate that wood mulch can act as an affordable nitrate remediation method to protect rural domestic wells from nitrate contamination, but more investigations to determine the fate and transport of inadvertent metal release are needed.