

Geochemical controls of Mn release and attenuation at the soil-water interface inform persistence of manganese in California drinking water systems

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Manganese (Mn) is a naturally occurring, redox-sensitive element ubiquitous in soils, and its release into groundwater occurs primarily as a result of reductive dissolution of naturally-occurring Mn-bearing minerals controlled by local biogeochemical conditions. Due to the neurotoxic impacts observed in infants and young children, regulatory agencies are currently considering stricter manganese health-based guidelines in drinking water sources. To fully understand Mn behavior in the subsurface, we need to interrogate both the persistence of Mn in private and public water sources and the geochemistry at the soil-water interface that informs its release into groundwater used for human consumption.

Using a Mn groundwater predictive model, reported Mn concentrations, delineations of private versus public well communities, and demographic data, we observed that while water treatment significantly decreased Mn concentrations, the range of Mn concentrations in the finished water of very small or small systems was much greater than in larger systems, likely due to diminished treatment capacity due to system size. Further, private well users have a higher probability of exposure to Mn concentrations exceeding secondary notification and health-based limits than public water system users, likely due to the lack of systematic monitoring or treatment processes.

We also experimentally investigated the abiotic attenuation and re-mobilization of Mn(II) from clay and Fe-oxide minerals under diverse subsurface conditions to inform how geochemistry at subsurface extraction points might inform Mn persistence in water systems. A series of batch adsorption experiments examined the impact of mineral type, pH, and salinity on Mn(II) sorption in anoxic subsurface conditions. To measure the long-term impacts of sorbed Mn on mineral surfaces, we utilized flow-through experiments to simulate the aging and desorption dynamics found within aquifer systems. Ongoing XAS analysis will allow microscopic characterization of Mn-binding geometry to the mineral surface and the differentiation between precipitated Mn solids and adsorbed Mn(II). A deeper understanding of Mn prevalence and behavior in California's water systems in coordination with its geochemical mechanism of release and attenuation will improve our ability to predict Mn behavior under diverse environmental conditions and facilitate management decisions to reduce the risk of Mn exposure from groundwater.