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Geochemical controls of manganese release and attenuation in California drinking water systems and implications for future regulatory landscape

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Manganese (Mn) is a naturally occurring, redox-sensitive element ubiquitous in soils. It is primarily released through the reductive dissolution of Mn-bearing minerals, a process controlled by local biogeochemical conditions. Due to the neurotoxic impacts observed in infants and young children, regulatory agencies are considering stricter health-based guidelines for manganese in drinking water. To fully understand Mn behavior in the subsurface and its implications for future regulation, we must examine Mn persistence in private and public water sources and the geochemistry governing its release.

Using a Mn groundwater predictive model, reported Mn concentrations, delineations of private well communities, and demographic data, we observed that water treatment significantly decreased Mn concentrations. However, the range of Mn concentrations in the finished water of very small or small systems was greater than in larger systems, likely due to diminished treatment capacity. Further, private well users have a higher probability of accessing water with Mn concentrations exceeding health-based limits than public water system users, likely due to the absence of monitoring or treatment due to cost.

Because water treatment effectively removes Mn in larger systems, additional funding for treatment would likely improve water quality in very small and small systems. In alignment with California's goal to improve water equity, water system funding primarily supports predominantly rural, Latine communities with lower median household incomes and higher environmental pollution burdens. However, as greater attention is paid to Mn in drinking water sources, it is essential to determine how funding priorities should be adjusted to protect communities currently receiving water with elevated Mn. Our analysis indicates that areas with co-occurring high arsenic (As) and Mn should continue to be prioritized under the current regulatory framework. However, many water systems are unlikely to be prioritized under the existing funding structure because they do not have elevated As, despite having high Mn, which is not yet regulated as a primary contaminant.

A deeper understanding of Mn prevalence and behavior in California's water systems 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.