

# Assessing Inadvertent Trace Metal Mobilization During Distributed Stormwater Collection - Managed Aquifer Recharge: The Influence of Alternating Anoxic-Oxic Cycling and Carbon Availability

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Groundwater over-pumping and drought have drastically depleted aquifers across California. One strategy to increase groundwater storage is distributed stormwater collection managed aquifer recharge (DSC-MAR), where excess surface runoff is diverted into aquifers, often through infiltration basins or spreading grounds. If alternative water sources are used (e.g., stormwater, or agricultural runoff), infiltrating water can have high levels of nitrate. The use of carbon-based permeable reactive barriers (PRBs) within DSC-MAR basins can effectively remove nitrate from recharge water by stimulating anaerobic microbial processes. However, these same conditions can simultaneously enhance the mobilization of naturally occurring toxic metals, such as arsenic (As) and manganese (Mn), posing a potential risk to human health and groundwater quality. Currently, the fate, transport, and transformation of metals within redox fluctuating DSC-MAR systems is poorly understood. We propose to use synchrotron-based flow-through reactors to investigate how repeat fluctuating wet-dry cycles impact solid phase metal distribution and transformation dynamics within DSC-MAR basin soils during simulated infiltration, and couple this to changes in electron donor chemistry, basic microbial community composition, and aqueous metals release and speciation. Novel reactor systems have been developed to run in-line at the Stanford Synchrotron Radiation Lightsource (X-ray fluorescence imaging beamline 7-2), allowing us to track solid-phase metals speciation and spatial distribution relative to the PRB, and potential anoxic microsites resultant of subsurface heterogeneity in DSC-MAR basin soils, with high temporal resolution. Typically, the acquisition of this type of data on solid phase mineralogical and distribution changes is done at the expense of simulating the test system with dynamic fluid flow, whereas planned work will include high-quality measurements of

a coupled flow-transport-reaction system. Determining the fundamental geochemistry and quantifying the extent of, and mechanisms controlling inadvertent metal release during DSC-MAR is essential in holistically evaluating this growing groundwater management strategy. Our study results have the potential to aid in methods development for reactor studies linking aqueous and solid phase data collection, as well as inform application decisions regarding basin design and implementation, and generate mechanistic knowledge to enhance the capacity of predictive modeling regarding the potential for inadvertent metals release in DSC-MAR systems.