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Assessing biogeochemical processes influencing redox-sensitive elements: Batch and flow-through experiments with implications for managed recharge

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Managed aquifer recharge (MAR) can increase groundwater supply and improve water quality during surface water infiltration. Carbon-rich soil amendments, such as wood mulch or almond shells, can modify subsurface biogeochemistry and stimulate microbial processes. These processes have been demonstrated to increase denitrification and reduce N loading, while creating conditions favorable for mobilizing redox-sensitive elements, including trace metals. We are assessing the influence of a carbon amendment on the leaching potential of redox sensitive metals and nutrients in water with a series of batch and column experiments to determine the potential for changes in water chemistry during MAR in a groundwater basin in central coastal California, USA. An exploratory hole was drilled with continuous core recovery using sonic drilling technology, recovering eolian, estuarine, fluvial, and alluvial deposits. Sediment, which was collected every 0.21 m to 40 m below ground surface, was characterized by grain size analyses and XRF and split into four categories, listed from top (youngest) to bottom (oldest): sand, brown clay, gravel, blue clay. Flow through experiments were run using columns in series to emulate water flowing from the surface through an amendment and through the vadose zone (Figure 1). We tested residence times of 12 to 36 hours, staying at each rate for 18-22 days to establish dynamic steady-state flow conditions. Preliminary trace metal and carbon results show little change in a control column using native soils, but an increase of arsenic (As), manganese (Mn), and dissolved organic carbon (DOC) from influent to effluent for wood mulch (1.3 ug/L, 1100 ug/L, 4.7 mg/L) and almond shells (4.1 ug/L, 2720 ug/L, 22.9 mg/L). Nutrient and specific UV absorbance (SUVA) analyses are underway. Batch experiments will emulate water flowing from the vadose zone and perching on brown clay or blue clay in oxic and anoxic environments to help assess the potential fate of leached trace elements once in contact with clay layers. Sequential extractions and microbial analyses will be conducted using unaltered and reacted sediments, with and without soil amendments, to assess differences between treatments.

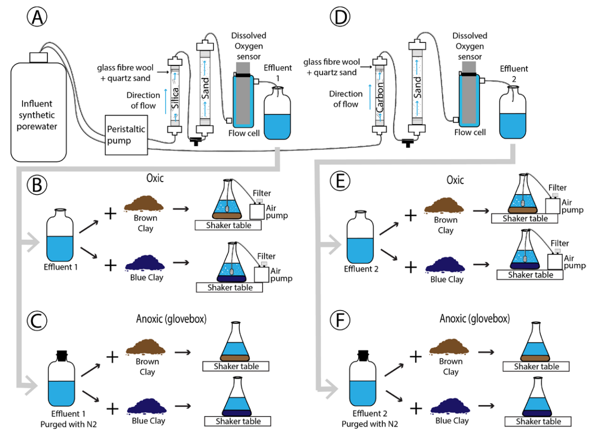

Figure 1. Flow-through and batch experimental configurations: (A) Control: Influent water flows through a sand column, dissolved oxygen (DO) is measured, and effluent 1 is collected (B) Effluent 1 is mixed with brown clay and blue clay aerobically (C) Effluent 1 is purged with N2 gas and is mixed with brown and blue clays within a glovebox to maintain anoxic conditions (D) Carbon amended: Influent water flows through a carbon amended column, to a sand column, DO is measured and effluent 2 is collected (E) Effluent 2 is mixed with brown and blue clays aerobically (F) Effluent 2 is purged and mixed with brown and blue clays under anoxic conditions.