Influence of a carbon amendment on nutrient and metal concentrations at a managed aquifer recharge site

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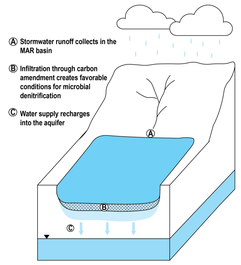
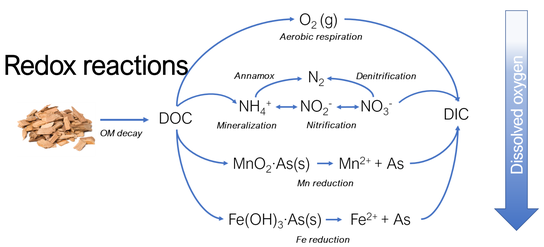
Introduction

Managed Aquifer Recharge (MAR) sites can increase groundwater supply and, under the right conditions, improve water quality. Recent work has focused on using soil carbon amendments (e.g., wood chips) in MAR basins to improve water quality by increasing denitrification potential during infiltration. Other redox sensitive contaminants may be mobilized during infiltration in these carbon-rich MAR basins though.

In this study, we explore the leaching potential of metals from the vadose zone during infiltration at a MAR field site.



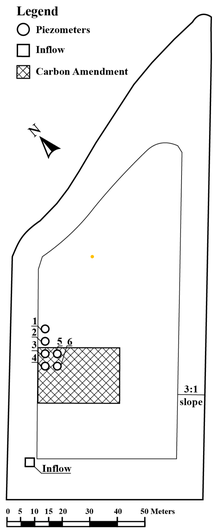
Redox reactions



Field site

- An active MAR site (15,000 m^2) had 300 m^2 of a carbon amendment, woodchips, disked into the top 40-50 cm of the basin

- 6 piezometers were installed at 30 cm depth to collect subsurface water samples (4 within and 2 adjacent to the amendment)



-Additional water samples were collected at the inflow and surface of the basin

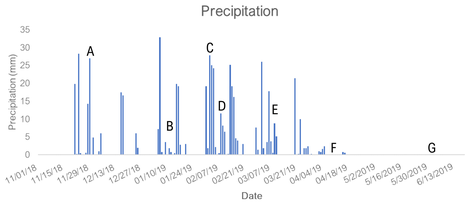
- Samples were collected from 7 field sampling events and analyzed for nutrients (NO_x, NH_4^+, Si and PO_4^{3-}), DOC, DIC, and metals (As, Mn, and Fe)

Located in central coastal California

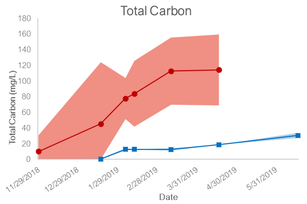
Results

Precipitation measured at the field site during WY19 in millimeters.

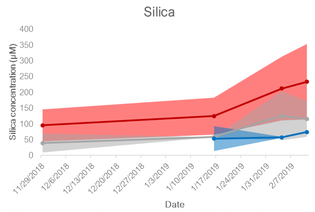
Field sampling events are labeled A-G



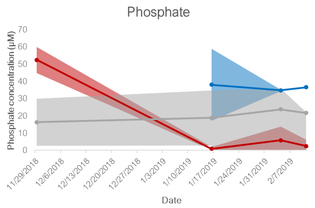
Concentrations of carbon, select nutrients, and metals for water samples collected during events A-G:



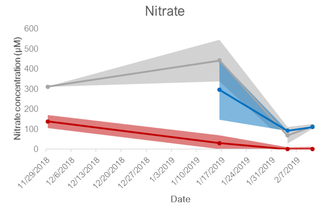
Carbon concentrations were elevated in the subsurface, with a positive and increasing trend through time. Surface water had low carbon content, and inflowing water had negligible carbon content. The carbon amendment, woodchips, appear to be releasing carbon throughout the season.



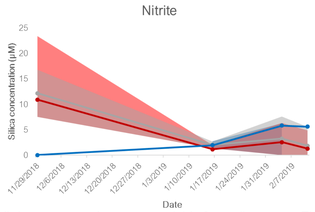
Silica concentrations were elevated in the subsurface followed by the inflow, while the surface water had the lowest silica content. This is to be expected since silica can be leached from sediments and the subsurface, and inflow had the most active contact with soils.



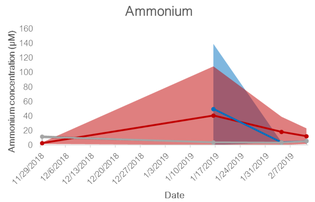
Phosphate concentrations were initially elevated in the subsurface. By the end of the sampling period, phosphate concentrations were consistently lower than the inflow and surface water though. The first rain event of the season likely flushed all excess phosphate from the nearby area.



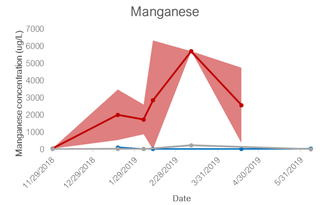
Nitrate concentrations were elevated in the inflow and surface water, while subsurface nitrate concentrations were consistently lower. Denitrification appears to be occurring in the subsurface.



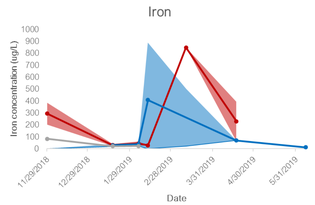
Nitrite concentrations were variable from all sources. This is to be expected since it is highly reactive resulting in dynamic activity.



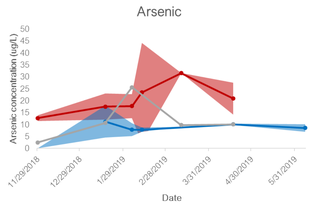
Ammonium concentrations were variable but elevated in the subsurface and surface water relative to the inflow. Ammonium is likely being actively used/produced by microbes, with some fraction also generated directly from dissimilatory nitrate reduction to ammonium.



Manganese concentrations in the subsurface were consistently higher in when compared to the inflow and surface. Subsurface redox conditions triggered the release of manganese from naturally occurring sediments.



Iron concentrations were dynamic in the subsurface and surface. This is to be expected since iron is highly particle reactive, accordingly while iron may be released, with changing redox conditions, it can quickly be re-adsorbed onto sediment surfaces.



While arsenic concentrations were elevated in all samples, the subsurface samples were on average higher than inflow and surface. Subsurface redox conditions triggered the release of arsenic from naturally occurring sediments.

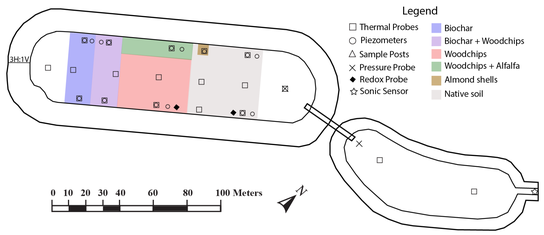
Conclusions

Results show that water infiltrating through the carbon amendment had: (1) a reduction in nitrate concentrations, (2) an increase in arsenic, manganese, and dissolved organic carbon concentrations, and (3) dynamic responses in iron, nitrite, and ammonium concentrations. Infiltrating water is likely to pass through a thick vadose zone at this site before reaching the primary aquifer, and additional reactions and processing may occur. We are completing laboratory microcosm and leaching experiments to better understand the influence of soil carbon amendments on the transport and fate of trace metals during MAR. We also plan to expand monitoring of the field site to better understand impacts on groundwater quality over time.

Future Work

Field work

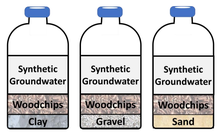
- Another MAR site has been constructed (Sep. 2019); aims are to improve water supply in the area as well as test a variety of carbon amendments during infiltration

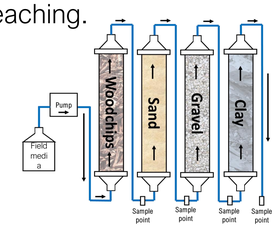


-Water samples are being collected during rain events from piezometers (two depths: 30 cm, 55 cm), surface water, inflowing water and a local shallow aquifer well

Lab work

A series of microcosm and column experiments are being devised to consider the effect of a carbon source on trace metal leaching as well as how oxygenation through the vadose zone can reduce or mitigate any leaching.





Acknowledgments

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