Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18077

Biogeochemical aquifer changes driven by methane migration from leaking oil and gas wells: observations from laboratory to field

SAMUEL W SHAHEEN[1], TAO WEN[2], MAX LLOYD[1], CHRISTOPHER HOUSE[1], ERIC E RODEN[3] AND SUSAN L BRANTLEY[1]

[1]Pennsylvania State University

[2]Syracuse University

[3]University of Wisconsin-Madison

Presenting Author: sws41@psu.edu

One of the most cited environmental issues surrounding both historical and contemporary oil and gas exploration is the migration of methane (CH_4), the primary constituent of natural gas, into shallow groundwaters. However, the biogeochemical reactivity of leaked CH_4 upon reaching shallow groundwater is poorly understood. In this study, we investigated the biogeochemistry of aquifers impacted by leaking oil and gas wells using field, lab, and modeling-based observations.

In groundwaters where dissolved gas compositions suggest CH_4 migration from oil and gas activities in Pennsylvania (U.S.A.), we observe elevated concentrations of redox-active species (e.g., iron(II), sulfide) potentially indicative of anaerobic oxidation of CH_4 (AOM) coupled to iron and sulfate reduction. To understand the controls on CH_4 cycling, we compared results from two types of hydrologic settings: groundwaters discharging via artesian flow from leaking abandoned wellbores vs. groundwater seepages where CH_4 leaked from an oil and gas well must first migrate through shallow aquifers. At both types of sites, 16S rRNA gene sequencing supports the presence of microbial communities involved in both AOM and methanogenesis. Additionally, microcosm experiments indicate active AOM in groundwater incubations amended with goethite and/or sulfate. Based on these lab and field measurements, we constructed reactive transport models to investigate the role of electron acceptor availability along CH_4 migration pathways. From our results, we hypothesize that transport along more direct pathways (e.g., abandoned wellbores) vs. diffuse transport within an aquifer influences the associated impacts of CH_4 leakage on groundwater chemistry due to varying availability of electron acceptors for AOM. Redox reactions that consume CH_4 may in turn mobilize other, hazardous aqueous species (e.g., arsenic). This emphasizes the potential water quality risks associated with structurally deficient wells.