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Impact of renewable natural gas (biomethane) in a deep aquifer storage in the Paris Basin: multiphase reactive transport modeling of H2S reactivity

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The increasing integration of renewable natural gas (biomethane) into natural gas grids has gained significant attention due to its potential to reduce greenhouse gas emissions and contribute to the transition to cleaner energy sources. The growing share of biomethane in transportation grids also means that the underground gas storage facilities, including those in deep saline aquifers, are cycling a growing fraction of biomethane gas. Unlike conventional natural gas, biomethane often contains up to 10000 ppm of oxygen gas (O2) due to industrial oxidative desulfurization processes. O2 reactivity can impact the integrity of the reservoir, as well as groundwater and gas quality [1]. Hydrogen sulfide H2S gas can also be present in the injected gas or produced through microbial sulfate reduction during injection/withdrawal cycles.

Field data from a sandstone aquifer gas storage site in the Paris Basin (France) indicate the evolution of H2S content in the stored gas over several years. Additionally, the influence of co-injecting O2 into the gas reservoir is revealed for the first time. A modeling study is proposed to investigate the geochemical impacts of the injection of natural gas and biomethane blend in the reservoir, focusing on O2 and H2S reactivity during successive cycles of injection and withdrawal. Multiphase reactive transport simulations are performed using the HYTEC software [2] under 1D and 2D axisymmetric configurations. Microbial kinetic models are implemented mainly on H2S production by sulfate- reducing bacteria (SRB) but also on H2S consumption by O2.

The key findings show that the H2S content decreases in response to different O2 levels and pH conditions within the reservoir close to the injection wells. The significant role of SRB in controlling long-term H2S levels deeper in the whole storage is demonstrated. These findings emphasize the importance of integrating microbial processes into multiphase reactive transport models to improve predictions of reservoir behavior and gas quality. More generally, the insights gained from this study contribute to a better understanding of the risks and resilience properties of storage facilities associated with biomethane in deep saline aquifers.

[1] Banc et al., 2024 https://doi.org/10.1016/j.jgsce.2024.205381

[2] Sin et al., 2017 https://doi.org/10.1016/j.advwatres.2016.11.014