Understanding the fate of hydrogen in subsurface and anoxic storage reservoirs

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Hydrogen (H_2) storage supports the decarbonization of society by enabling the use of green hydrogen produced from renewable energy sources. Subsurface reservoirs like deep aquifers (AQ), (depleted) hydrocarbon reservoirs (HR), and salt caverns (SC) provide large-scale and long-term storage solutions that help balance supply and demand. These anoxic environments host diverse microbial communities that can consume H_2 for their metabolisms. This microbial H_2 consumption poses risks, such as the loss of stored H_2, lower quality due to the production of other gases (H_2S, CH_4) and alterations in the physicochemical properties of the reservoirs. Yet, the general presence (taxonomy and occurrence), activities and metabolism rates of the microbial communities are insufficiently explored. To better understand the potential fate of H_2 in the different storage types, 25 sampling and microbial enrichments were performed to characterize the natural microbial communities and monitor H_2 concentration changes over time, using natural underground water samples. For each sample, initial microbial communities were identified using 16S rRNA amplicon sequencing. Enrichments were set up under various conditions: with H_2 or N_2 input, with or without nutrients addition, at field or standard (30°C) temperature. Negative controls were also carried out under the following conditions: autoclaved brine solution with H_2, brine solution with N_2, and anoxic distilled water with H2. Gas concentration and pH were monitored over time. As expected, the first results highlight a high diversity of the natural microbial communities and metabolisms. However, enrichment tests results show that H_2 consumption is only present in a few samples. H_2 consumption is more significant in HR compared to SC and AQ. Methanogenesis was recognized as the key microbial metabolism responsible for the observed hydrogen loss. Production of CH_4 together with the presence of methanogenic archea was observed in the brine during incubation. These preliminary findings underscore the importance of characterizing microbial communities in potential H_2 storage sites and to determine the associated risks for each site.