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Site Selection Tool for Hydrogen Storage in Porous Media

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Zero carbon energy generation from renewable sources can reduce climate change by mitigating carbon emissions. A major challenge of renewable energy generation is the imbalance between supply and demand. Subsurface hydrogen storage in porous media is suggested as a large-scale and economic means to overcome these energy imbalances. However, hydrogen is an electron donor for many subsurface microbial processes which may have important implications for hydrogen recovery, gas injectivity and corrosion.

We reviewed the state-of-the-art literature on the controls on the three major hydrogen-consuming processes in the subsurface: methanogenesis, homoacetogenesis, and sulphate reduction, as a basis to develop a hydrogen storage site selection tool. Sites with low temperature (<70°C), zero to moderate salinity (0-0.6 M) and close to neutral pH values provide the best growth conditions for most of the hydrogen-consuming methanogens, homoacetogens and sulphate reducers. Conversely, fewer strains are adapted to more extreme conditions (high temperature and pressure, increased salinity and acidic or alkaline pH), favouring hydrogen storage in these sites.

Testing our tool on 42 depleted gas and oil fields of the British and Norwegian North Sea and the Irish Sea showed that seven of the fields may be considered sterile with respect to hydrogen-consuming microorganisms due to either temperatures >122 °C or salinities >5 M NaCl. Only three fields can sustain all of the major hydrogen-consuming processes, due to either temperature, salinity or pressure constraints in the remaining fields. We calculated a potential microbial growth in the order of 1-17*10^7 cells ml^{-1} for these fields. The associated hydrogen consumption is negligible to small (<0.01-3.2 % of the stored hydrogen). Our results will advance a faster transition to a lower carbon energy supply by helping inform decisions about where hydrogen can be stored in the future.