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Re-Evaluating Nitrate Treatment as a Mitigation Strategy for Microbial Reservoir Souring

ALI MAHMOODI[1] AND HAMIDREZA M. NICK[2]

[1]Technical University of Denmark

[2]Danish Offshore Technology Centre, Technical University of Denmark

Presenting Author: alimhm@dtu.dk

The injection of seawater into a hydrocarbon reservoir (seawater flooding), as an oil recovery method, triggers microbial reservoir souring, through which Sulfate Reducing Bacteria (SRB) consume Dissolved Organic Carbon (DOC) and sulfate ions to produce hydrogen sulfide, which is hazardous, corrosive, and detrimental to the environment if enters production wells. A strategy to mitigate this problem is to add nitrate or nitrite to the injection seawater, also known as nitrate or nitrite treatment.

This study aims to reevaluate the efficiency of nitrate treatment in a sector of a hydrocarbon reservoir in the Danish North Sea. The field observations together with the developed non-isothermal multi-phase multi-component bio-chemical model in the field scale enables the study of different nitrate treatment scenarios. The common expectation, usually based on lab experiments, is that the higher the concentration of nitrate or nitrite in the injection seawater the less hydrogen sulfide production.

However, the results of this study show that slowing down the microorganisms (or mitigation through nitrate treatment) may cause higher hydrogen sulfide production from production wells, despite lower total amount of generated hydrogen sulfide inside the reservoir. Put differently, not only the total amount of hydrogen sulfide generated inside the reservoir matters, but also the location of the generation zone and its distance from production wells matter. It is possible that insufficient amounts of nitrate (a sub-optimal nitrate treatment) only cause the generation zone to move away from injection wells toward the production wells. Hence, more hydrogen sulfide is produced from production wells during the lifetime of the reservoir. Moreover, it has been observed that the effective microbial growth rates in a large-scale model are significantly lower than laboratory measurements. Due to the coupled effect of multi-physics processes under in-situ conditions, neglecting the effect of bioavailability and mixing in the porous media in field-scale simulations may result in unrealistic conclusions. On the other hand, the addition of excessive amounts of nitrate in the injection seawater may result in the presence of unconsumed nitrate and nitrite in the produced water, which poses risks to marine ecology if discharged into the sea.