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# Recent insights on the coupled processes and potential applications of microbially induced desaturation and precipitation by nitrate-reducing bacteria

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Microbially induced desaturation and precipitation (MIDP) is investigated for several engineering applications in porous media. The MIDP process involves injecting a nutrient solution containing calcium acetate and calcium nitrate in the subsurface, which stimulates indigenous nitrate-reducing bacteria to convert these substrates into three main products: biogenic gas (mainly nitrogen and some carbon dioxide), biomass and calcium carbonate biominerals. Each of these products affects the hydraulic and mechanical properties of porous media. Biogenic gas desaturates the soil, which increases the compressibility of the pore fluid, which dampens pore pressure build up during cyclic loading of loose granular soils and can therefor be used to mitigate earthquake-induced liquefaction. Precipitation of calcium carbonate minerals increases strength, stiffness and dilatancy precipitation of unconsolidated sediments; and all three phases, biogenic gas, biominerals and biomass fill up the pore space and reduce the hydraulic conductivity. This contribution highlights recent studies, which demonstrated how the distribution, migration and permanence of biogenically formed gas is affected by the reaction rate, the grain- or pore size distribution and pore connectivity and at a larger scale by overburden pressure and soil stratification. Lab tests demonstrated that only a 10% reduction in degree of saturation is sufficient to significantly increase the undrained cyclic shear resistance of loose sands, while field tests demonstrated that MIDP treated sediments remained desaturated for more than 3 years. A simplified numerical model was developed and used to simulate the biochemical conversion and predict its affect on the hydraulic and mechanical properties. The model was fitted on experimental data and simulations suggested that the coupled interaction between the different phases resulted in very efficient clogging showing a permeability reduction of two orders of magnitude with only 1 wt% of calcium carbonate. When multiple treatment cycles are applied or multiple pore volumes are injected, local changes in hydraulic conductivity affect the distribution of substrates and products, particularly during the first few cycles.

## Participation

In-Person

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