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Biofilms can retain sub-micron fine particles migrating in porous media: toward enhancing durability of bioclogging in soils

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With the increasing demands for sustainable and eco-friendly soil improvement methods, utilization of microbial activities in subsurface has received increasing attention as an way to modify and control the mechanical and hydraulic properties of soils. Many bacteria can produce biofilms, which are matrices of organic materials consisting of microbial cells and extracellular polymeric substances (EPS). The formation of biofilms in soil can cause pore clogging, hence reduce the permeability by several orders of magnitude. Therefore, stimulating the biofilm formation has been proposed as a method to seal cracks and leakage in earth structures, such as embankments, dams, and levees. However, because of the possibility of biofilm removal or degradation over time, the durability of biofilms over a long period has been questioned, and this has been hampering the implementation of biofilms in field-scale engineering practices.
Herein, we explored the feasibility of using submicron fine particles to maintain or even enhance the clogging and permeability reduction in coarse sands. It was hypothesized that biofilms could trap and retain fine particles in their matrices, and this is expected to increase the durability of the induced clogging. To test this hypothesis, we performed the control test and the bentonite slurry injection test. Bacillus subtilis were chosen as model bacteria. In the control test, B. sutilis were cultured and stimulated to form biofilms formation in a clean sand-pack while monitoring the permeability. The permeability was reduced by ~50% after 1–2 weeks of experiments, and de-ionized water was injected to test the possible degradation and removal of biofilms. In the slurry injection test, upon the biofilm formation and ~50% permeability reduction following the control test, 1% bentonite slurry was injected. It was found that the injected bentonite particles were effectively attached or retained in biofilm matrices, resulting in slight but additional reductions in permeability. Upon the completion of slurry injection, de-ionized water was again injected to examine the durability of the clogging. This study showed that the biofilms is effective in retaining sub-micron fine solid particles in an aqueous phase, and this provides a valuable basis in biofilm utilization in many civil engineering practices.

References

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