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Using Branching Fungus to Remediate NAPLs Trapped in Hard-to-reach Areas in Fractured Porous Media

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Non-aqueous phase liquid (NAPL) trapped in stagnant or low permeability regions, such as a dead-end fracture or rock matrices, are hard to remediate because they are mostly inaccessible by groundwater flow. In this study, we utilize branching fungus to remediate NAPLs immobilized in low permeability regions. Hyphae of fungi are known to generate tremendous turgor pressure on their tips [1] and produce surfactants [2] that allow them to navigate through small pores and air pockets in porous media and even penetrate rock matrix [3]. However, to the best of our knowledge, there has been no direct visualization of fungal hyphal penetration into oil-water interfaces, and its implication on the remediation of NAPL has been unclear.

This study reports the active removal of NAPL by fungi using microfluidic experiments. We isolated naphthalene-degrading colonies from a local coal-tar-contaminated site, and through the microbiome analysis, we identified and selected the fungal colony which constituted the major fungal populations in biofilms sampled from the site. The fungi were suspended in a minimal salt medium, and the solution was injected into a PDMS microfluidic chip with a flow channel surrounded by NAPL-saturated low porosity regions (Figure A). Vegetable oil with 10 g/L of naphthalene was used as the model NAPL. The fungal growth and the change of oil-water interfaces were recorded through a scientific CMOS camera at the pore scale. Our results showed the active removal of NAPL by fungi over 65 hours. We observed that clogging of the preferential flow path by fungi induced flow instability which led to a fingering-like displacement of trapped NAPL (Figure B). Moreover, fungal hyphae effectively penetrated water-oil interfaces and significantly enhanced the oil removal from low porosity regions (Figure C). In this contribution, we will further discuss the mechanisms behind the effective removal of NAPL by fungi.

Participation

In-Person

References

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Primary author: LEE, Sang

Co-authors: MOURA, Marcel (PoreLab - University of Oslo); Dr SRIVASTAVA, Shreya (University of Minnesota); Prof. SANTELLI, Cara (University of Minnesota); KANG, Peter (University of Minnesota)

Presenter: LEE, Sang

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