Foams vs. Solutions To Mobilize Pollutants And Vectorize Reagents In Soils: A State Of The Art

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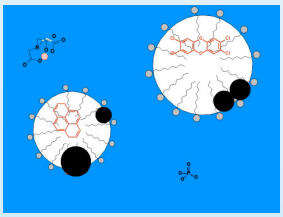
Introduction

Intensive treatments of contaminated soils often use fluids to extract pollutants or vectorize reagents. This approach has been largely recognized, but is still in development because of the complexity and heterogeneity of pollutions. For example, the removal of Non Aqueous Phase Liquid (NAPL) is still an intense field of research (EPA). Surfactants have been used for 2 decades for soil remediation due to their ability to reduce the interfacial tension between pollutants and the injected fluid (Parish, 2008). They are usually used in water solution and form various assembled structures driven by their amphiphilic character; among them micelles are well-known for their ability to dissolve hydrophobic particles in water. Therefore, in the 90's, some researchers have proposed to use foams to extract contaminants in soil remediation (Roy et al., 1995; Chowdiah et al., 1998). Foams are a dispersion of gaz bubbles in a liquid. In water, air bubbles may be stabilized by surfactants. Depending on their water/surfactant ratio, they are called 'wet' or 'dry'. Wet foams are obtained at low surfactant concentration, but above their CMC.

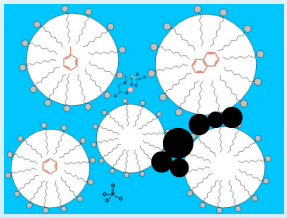
Here we present and discuss some aspects of these two fluids to extract pollutants or vectorize reactants in soil remediation.

How is the transport for solutions and for foams ?



Solutions (d ~ 1)

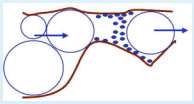
In-situ test LNAPL extraction (Lee et al., 2005)
TCE degradation with metallic particles and surfactants (Harenda et Vipulanandan, 2008)



Foams (d = 0,01- 0,7)

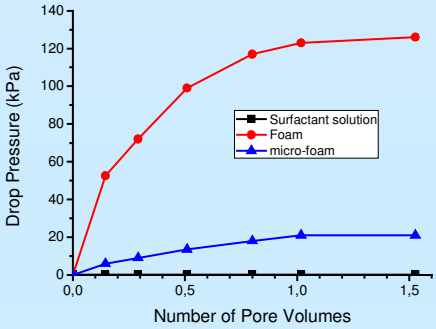
ZVIN delivery (Zhong et al., 2009)

Foam propagation:



Deformation-breackage-reformation
⇒ A better mechanical friction

Comparison of pressure drops in a porous soil
(from Couto et al., 2009)

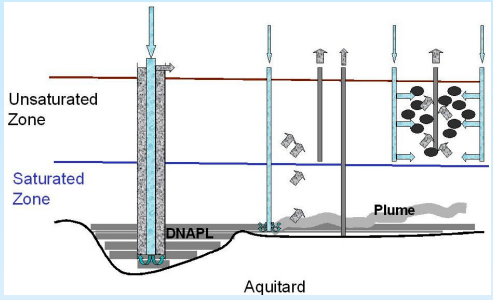


Drop pressure increases with bubble size/pore size ratio

How are the treatment ?

Foams can be made:
- ex-situ *(reactant delivery: Shen et al., 2011)*
- in-situ *(H_2 dispersion in DNAPL Hirasaki et al., 2005)*

In-situ

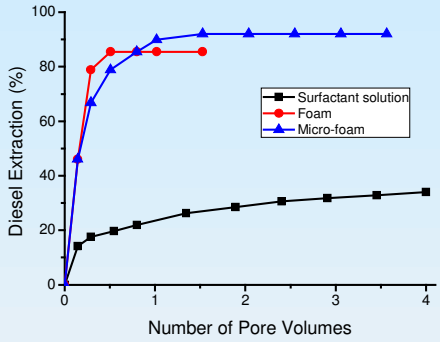


- Foams can be laterally headed through the UZ,
- lower risks for groundwater

On-site

Separation of macro-pollutants is possible:
- flottation with foams *(metal sulfurs:Horozov, 2008; Mouton et al., 2009)*
- sedimentation with solutions *(metals and oxides)*

Comparison of removal efficiencies



Different mechanisms for OC extraction (Mulligan et al., 2003)

Conclusion

Foams better:
- disperse gazeous reactants
- extract organic contaminants
- extract contaminants from silt than solutions,
- prevent contaminant dispersion

Solutions give:
- shorter and cheaper treatments,
- lower drop pressure in soils

References

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