Chemical Reduction of PCE by Zero Valent Iron Colloids – Batch and Column Experiments

NAPASAN nano-particles for groundwater remediation

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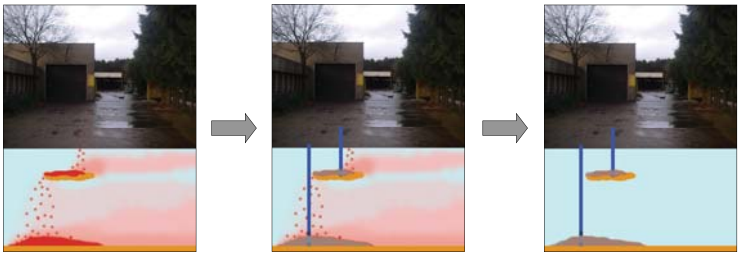
Motivation



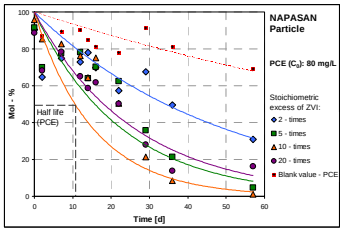
- Permeable reactive walls using iron filings state of the art for plume treatment
- Injectable nano-scaled zero valent iron particles (nZVI) have potential advantages:
  - Reactivity of nZVI much higher than iron filings (specific surface)
  - Economical application also in greater depth and underneath buildings
  - Applicable to large range of contaminants (chlorinated hydrocarbons, heavy metals, pesticides etc.)

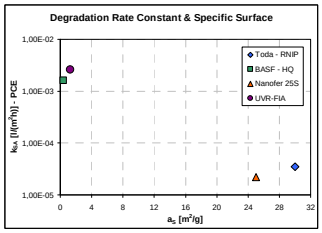
Goals

- Assessment of chemical reactivity of different nZVI particles towards degradation of PCE as model contaminant
- Investigation of degradation potential of nZVI particles in column tests: experimental simulation of plume vs. source remediation
- Transfer of results for planned field application

Batch-Tests

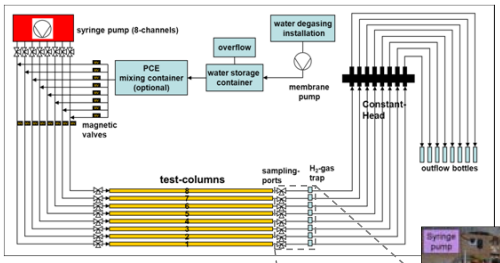
- Facilitates comparison of different nZVI particles



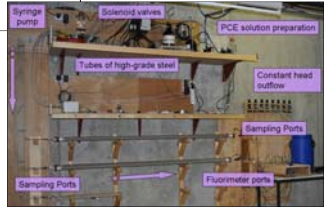


- In batch the pH quickly increases due to corrosion → self inhibition
  → Column Tests necessary!

Experimental Setup – Columns



- Flow control using syringe pumps
- Q=175 ml/d
  → v=0.5 m/d
- Hydrogen gas-trap to quantify potential hydrogen production



- 8 columns in parallel
  L=200 cm, ID=3 cm
- Porous media: sand
- n ~ 0.36, 1 PV ~ 700 cm³

Column-Tests: Plume Remediation

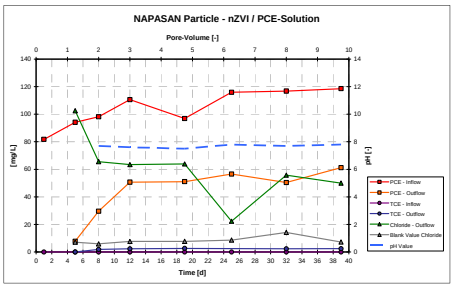
NAPASAN-Particle

Flakes

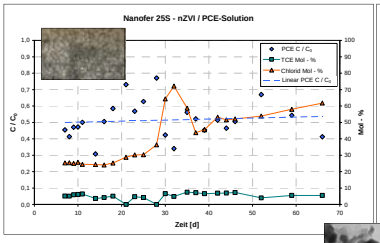
D_{50} = 900 nm

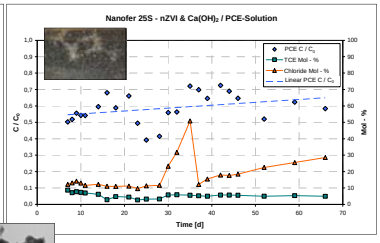
a_S = 1.3 m²/g

Thickness ~ 70 nm

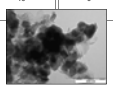


- Undesired side reaction between nZVI and water: anaerobic corrosion
  → Loss of nZVI and production of H_2





No preconditioning of columns:
→ reactive for more than 60 days

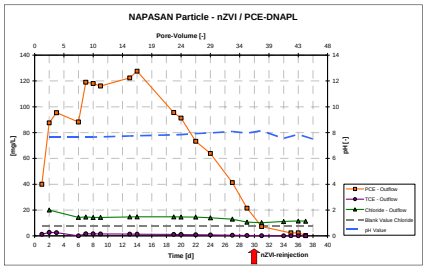


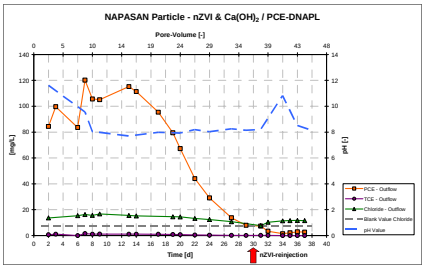
With preconditioning of columns:
→ less reactive, but more stable

- H_2-gas production in long term column experiments was significantly reduced by adding solid $Ca(OH)_2$ (pH increase to 11) to the iron suspension

Column-Tests: Source Remediation

- Simulation of a PCE source remediation
- PCE-saturation in source zone: S_{PCE} = 6 %
- Injection of nZVI at 2-fold stoichiometric excess for efficient PCE-degradation
- Reinjection of nZVI after 30 days





- PCE-degradation from a maximum concentration of 120 mg/l to less than 0.5 mg/l
- Significant increase of pH after $Ca(OH)_2$ injection
- nZVI-reinjection induced recovery of PCE-degradation (increase of chloride concentration)

Conclusion / Outlook

- Chemical behavior in batch experiments differs significantly from column experiments. Hence, column experiments necessary to predict field application
- Column experiments showed proper degradation results for both plume and source remediation
- Conclusions for field application:
  - Control of anaerobic corrosion necessary (pre-conditioning of aquifer)
  - Further investigations of source treatment by nZVI necessary

Partners

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