In Situ Groundwater Remediation by Activated Carbon (AC) Based Amendments at Contaminated Sites Managed by Federal Programs

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The 11th International Conference on Chlorinated Solvents and Recalcitrant Compounds
Session: Activated carbon based amendment

Disclaimer

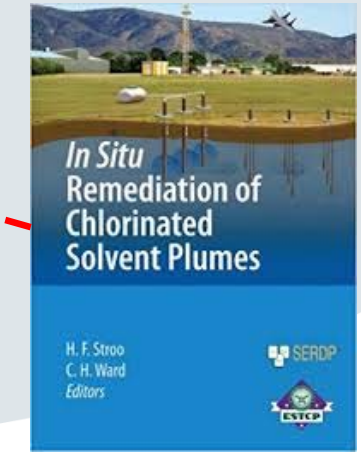
- The content presented here only reflects my research outcome while at EPA and does not represent the official view of EPA.
- The names of the companies and products included in this presentation do not constitute any form of endorsement.

Outline

- Review critical information for technology evaluation
  - Degradation evidence
  - Long term performance
- Overview of applications at Federal sites
  - NPL, RCRA, and non-NPL Federal Facility sites
  - Rationale for selecting AC-based remedy
  - Treatment performance to date
- Identify key questions that need to be addressed in the future

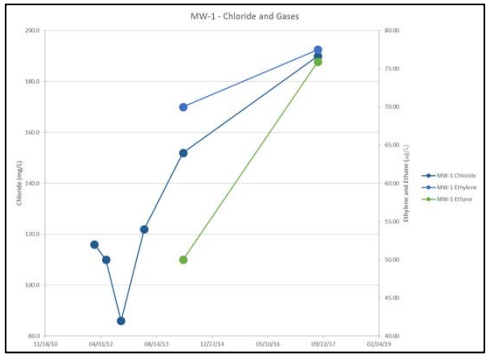
What is the Bigger Universe?

In Situ Subsurface
AC + Amendment



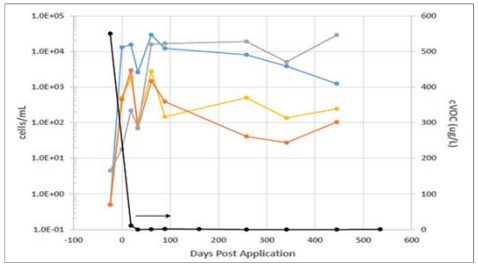
Progress on Evaluation of Degradation

Productions of Cl, ethene ethane



-AST Environmental, 2017

DHC populations & functional genes



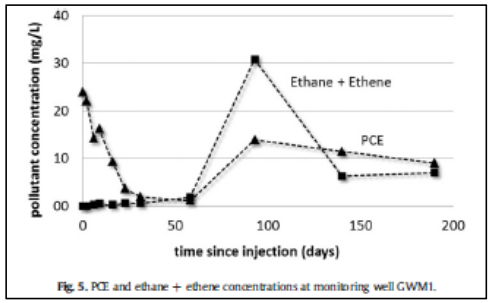
-Regenesis, 2015

Parent Compounds

Degradation Products

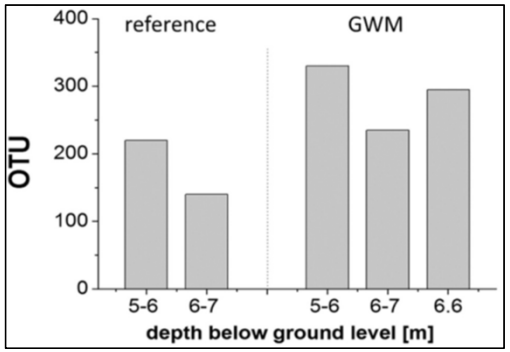
Environmental Molecular Indicators

Productions of ethene & ethane



-Mackenzie et al. 2016

Microbial Diversity



-Vogel et al. 2018

Vogel et al. 2018: Pilot Injection of Carbo-Iron to Treat PCE

Combined chemical and microbiological degradation of tetrachloroethene during the application of Carbo-Iron at a contaminated field site

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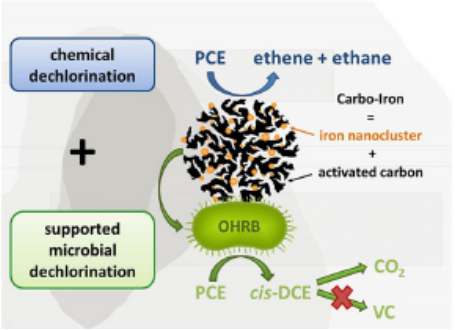
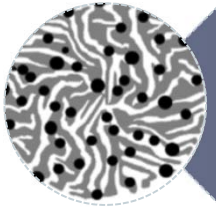
HIGHLIGHTS

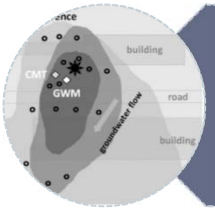
- Successful combination of chemical and microbial degradation of PCE at a field site
- Carbo-Iron improves the aquifer conditions for microbial dechlorination for months.
- No vinyl chloride formation due to sequential reduction and oxidation processes.

GRAPHICAL ABSTRACT

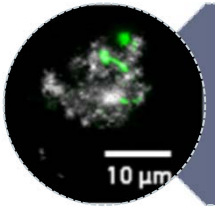




Colloidal AC impregnated by nZVI and stabilized by CMC



Injection in a source area with PCE concentration up to ~100 ppm

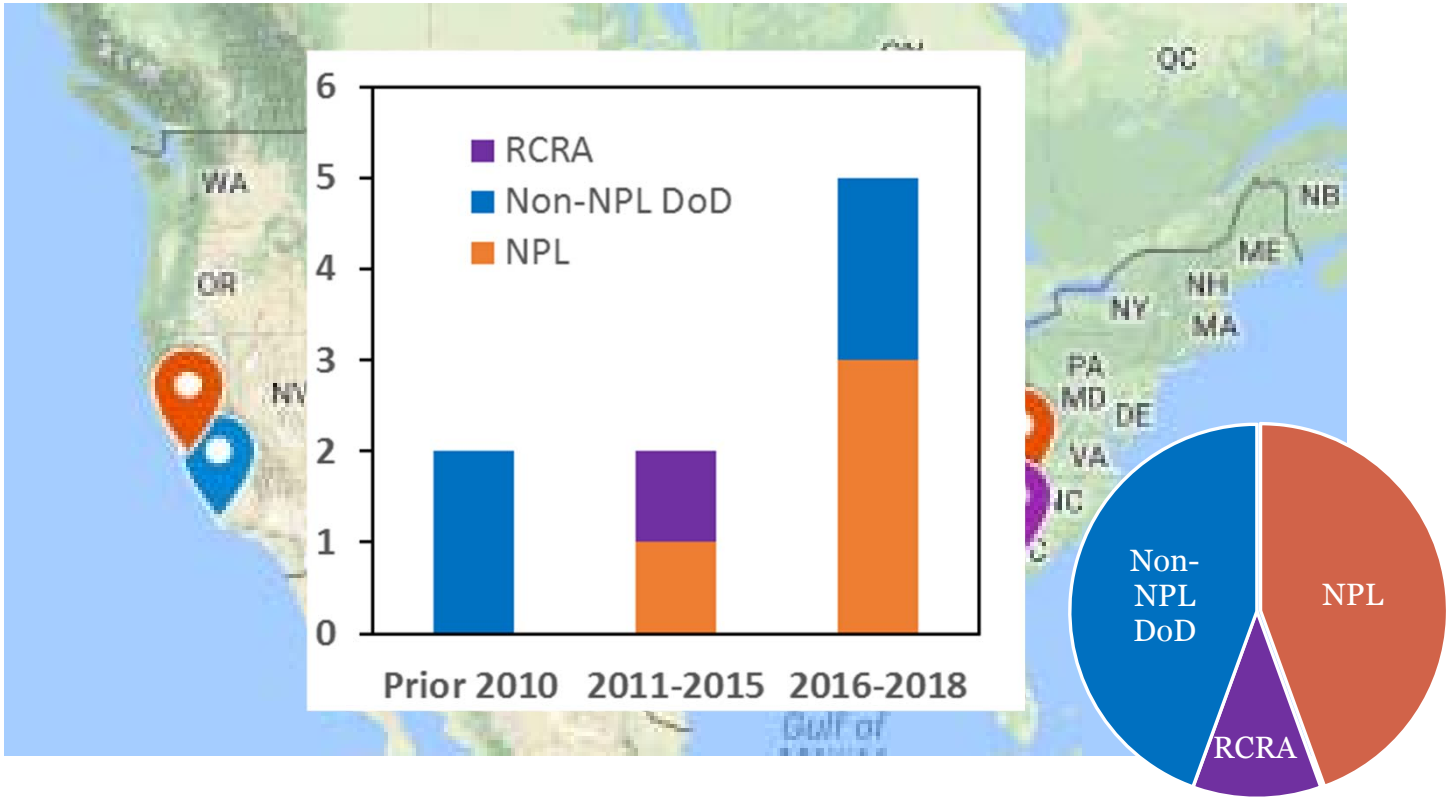


3 yr monitoring of contaminant and microbial community under different redox conditions

What is the Long-term Performance?

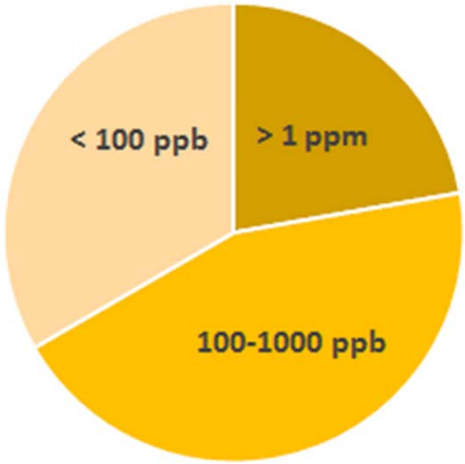
- Lack of long-term monitoring data
  - Many early UST applications do not require long-term monitoring data.
  - Recent cVOC sites yet have long-term data.
- No quantitative information regarding contributions between degradation and adsorption.
- Several cVOC sites have shown promising results.
- Sediment sites using AC only for more hydrophobic compounds also showed long-term effectiveness.

Application at Federal Sites

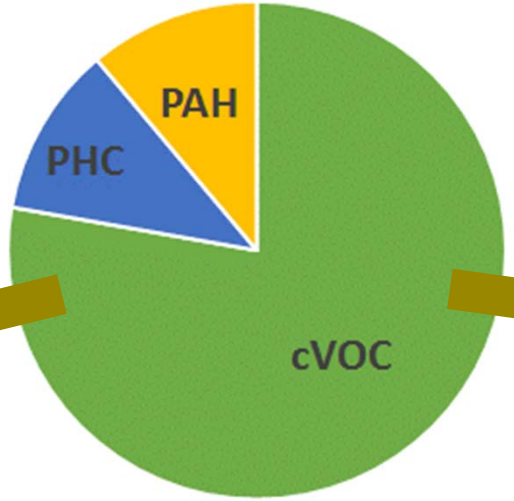


Overview of Site Conditions

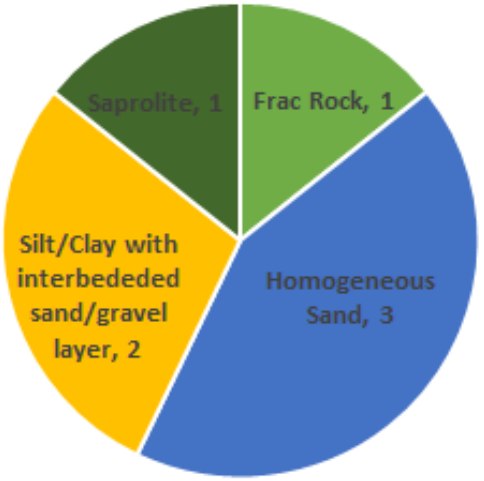
Concentration Range



Contaminant of Concern (9 sites)

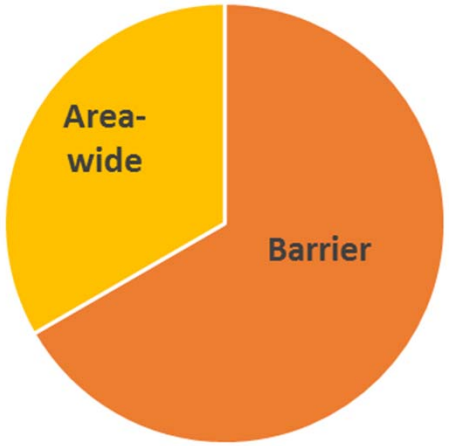


Geological Conditions



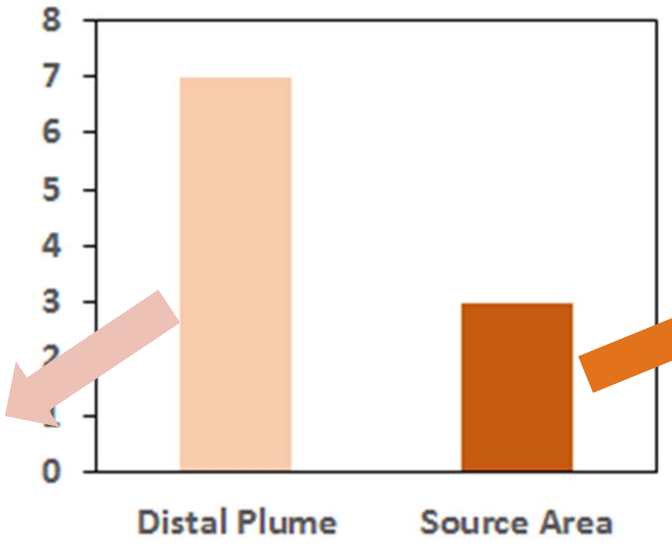
Overview of Technology Applications

Treatment Configuration



Two sites applied AC w/o reactive amendments to prevent (1) VC and (2) remob of Mn and As

Treatment Area



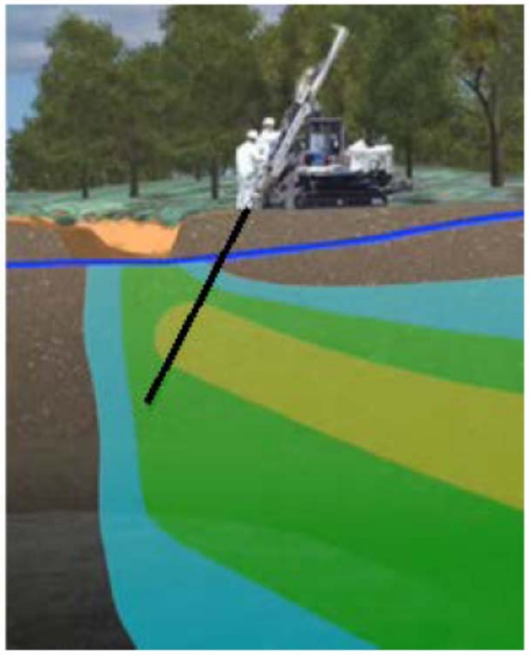
Two sites coupled with more aggressive source remedies

Overview of Technology Applications

Source zone treatment coupling AC and SVE

-Malott, EPA R6

PRB to limit plume migration to surface water

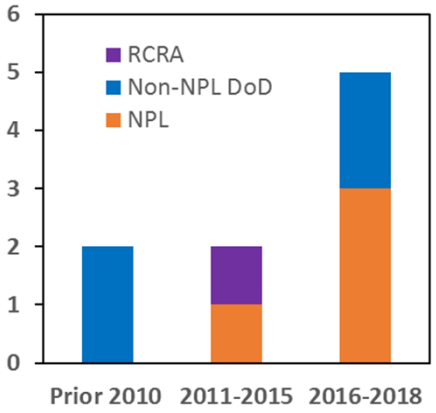


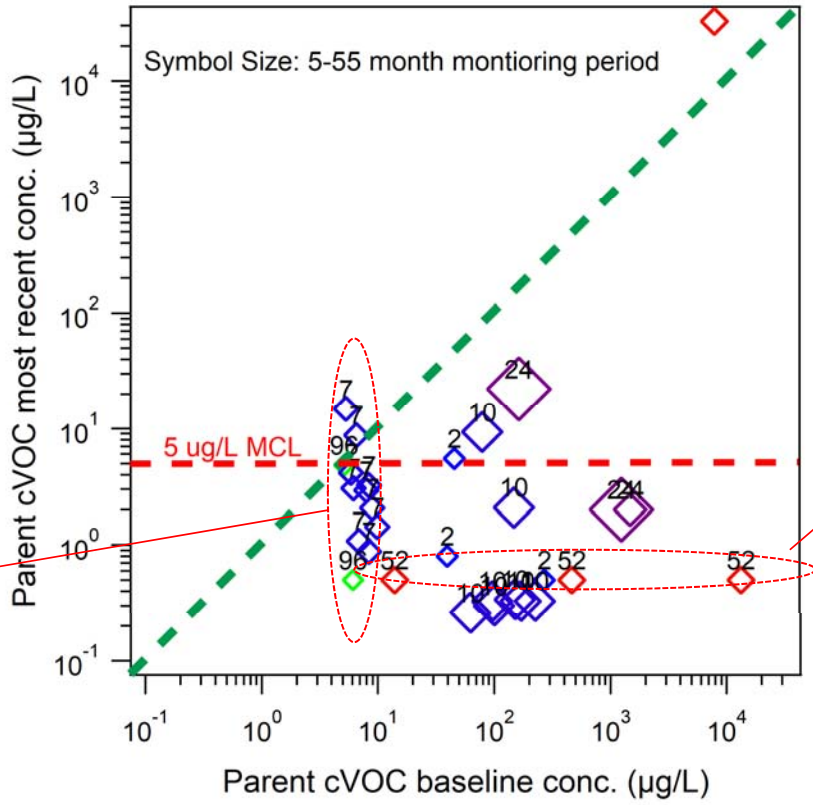
-Krouse, AECOM

Rationale for Selecting AC-based Technology

- Technologies could not achieve remediation goal or determined to be not applicable:
  - At the former Lowry AFB, addition of alkaline-activated persulfate resulted 70%CT concentration reduction in bedrock aquifer after injection but showed rebound after 6 month.
  - At the former Intel SC3 facility NPL in R9, multiple attempts have been tried to reduce TCE concentrations below MCL in all monitoring wells in the tailing part of the plume, including ISCO, MNA and P&T. One well is resistant to all treatments.
  - At the East 67th Street NPL in R6, injection of EVO for bio impacts water quality and requires ongoing maintenance due to biofouling of injection wells. P&T limited by property access.
  - At Vandenburg AFB and FCX NPL site, production of VC and high groundwater velocity adjacent to surface water are concerns that prevent selection of bio or ISCO.

Overview of Treatment Performance





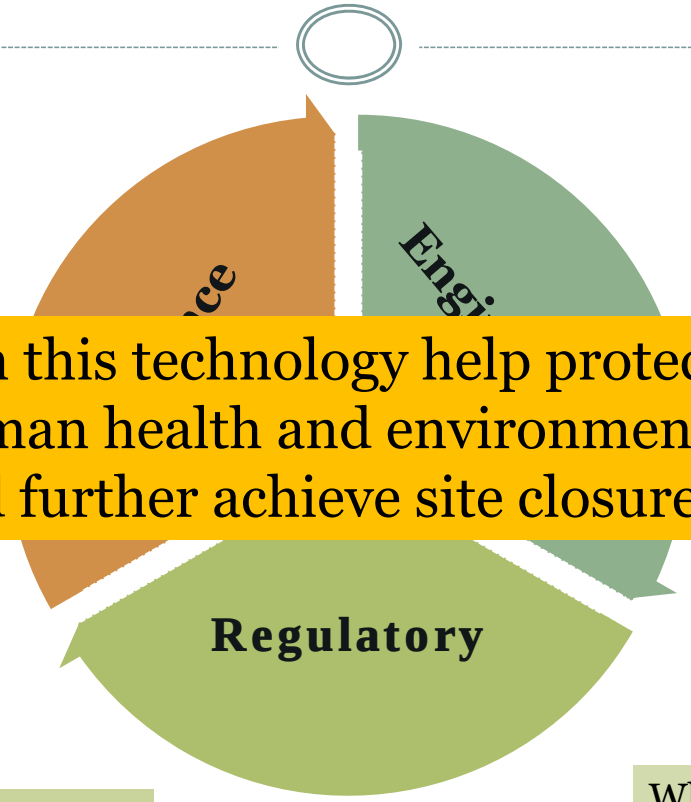
Two sites that applied AC only without adding reactive amendments

A site AC-based amendments applied at multiple areas

Key Questions to Future Applications

Biogeochemical processes involving AC:

- Electric properties of carbonaceous material for contaminant degradation
- Interactions between AC and microorganisms and the resulting effects on contaminant degradation
- Desorption kinetics/risks



Can this technology help protect human health and environment and further achieve site closure?

Evaluation and optimization of long-term performance

- How to differentiate contributions between adsorption and degradation?
- How to optimize the persistence of degradation in long term?
- How to couple with other technologies?

How to categorize the technology?

What monitoring frequency and parameters are needed?

Conclusions

- Increasing amount of evidence has confirmed the occurrence of degradation and potential benefits of AC on degradation processes.
- Long-term performance, especially the contribution and completeness of degradation, remains to be further evaluated when data becomes available.
- Technology has been selected at Federal sites when
  - Immediate risk to receptors needs to be mitigated.
  - Mass flux out of source area needs to be controlled.
- Science, engineering, and regulatory fronts all need to be advanced to better evaluate & use this technology.

Acknowledgement

- Various EPA and State RPMs
- Consultants/Vendors/Contractors
- Oak Ridge Institute for Science and Education