In Situ Treatment of Chlorinated Solvents: Design and Monitoring of a 1,1,1-Trichloroethane Treatment System at CFB-Trenton
1,1,1-Trichloroethane

- Solvent, found in glues and paints
- Damages ozone layer, may affect nervous and circulatory systems
  - Use phased out due to ozone damage
- Not carcinogenic, but some degradation intermediates like 1,1-dichloroethene and vinyl chloride are
• Abiotic reduction of 1,1,1-TCA leads to VC
• Biotic reduction leads to ethane
• Several bacterial groups capable of reductive dehalogenation
• Reductive dehalogenators require anoxic, reducing conditions
CFB-Trenton
Building 151
- Active mechanical shop
- 2,400 L Underground Storage Tank (UST) removed in 1995 due to a leak
- Used to store chlorinated solvents
- Monitoring wells installed to delineate the plume, samples taken for lab scale optimization
Building 151

LEGEND

- Monitoring Wells (Installed this Study)
- Monitoring Wells (Previously Installed)
- Manhole pumps of the collection trench
- 1,1,1-Trichloroethane Concentration
- 1,1-Dichloroethene Concentration
- Vinyl chloride Concentration
- Dissolved 1,1,1-Trichloroethane Groundwater Plume 200 ug/L approximate contour MOEE guidelines (Table B)
- Dissolved 1,1-Dichloroethene Groundwater Plume 0.66 ug/L approximate contour MOEE guidelines (Table B)
- Dissolved Vinyl Chloride Groundwater Plume 0.5 ug/L approximate contour MOEE guidelines (Table B)
- Structures
- Fences

Underground Storage Tank

- MW106-2: 50.1 ppb
- MW104-2: 819 ppb
- MW111-3: 3 ppb
- MW103-2: 847 ppb
- MW108-2: 839 ppb
- MW112-3: 98.3 ppb
- MW110-2: 40.7 ppb
- MW114-3: 8 ppb
- MW115: 48.8 ppb
- MW21: 54.1 ppb
- MW107: 20.3 ppb
- MW109: 0.4 ppb
- MW113-3: 3 ppb
- MW116: 20.3 ppb

Dissolved 1,1,1-Trichloroethane Groundwater Plume
Approximate contour: 200 ug/L

Dissolved 1,1-Dichloroethene Groundwater Plume
Approximate contour: 0.66 ug/L

Dissolved Vinyl Chloride Groundwater Plume
Approximate contour: 0.5 ug/L

MOEE guidelines (Table B)
Biostimulation Optimization

• Biostimulation lab assays performed to determine optimal conditions
  – Molasses and nutrient amendments to reduce O$_2$ concentration and create reducing conditions
  – Effective degradation of 1,1,1-TCA

• Design of a pilot scale treatment system
  – Pulsed amendment addition to prevent clogging
  – System stopped several times - latest re-start September 2004
  – 1,1,1-TCA levels rose after each stoppage, dropped once system re-started
Installed
Biotreatment System

BULIDING 151

LEGEND
- Structures
- Previously installed monitoring well
- Injection well
- Pumping well
- New nested monitoring well
- Trenches

Groundwater flow
Overflow line
Air Stripper unit
Injection Box
Injection trench
Pumping trench

BIO-MW31
BIO-IW1
BIO-IW2
BIO-IW3
BIO-MW32B
BIO-MW32
BIO-MW31
BIO-MW34
BIO-PW2
BIO-PW1
BIO-MW33
Injection & Monitoring Wells

- Bentonite Seal
- Water Table ~ 1.5 m
- Filter pack (sand)
- PVC Screen
- Surface ~ 4.5 m
- Till ~ 6.5 m
- Bedrock
Pumping Wells & Air Stripper

- Bentonite Seal
- Filter pack (sand)
- PVC Screen
- Till
- Bedrock

Surface ~ 3.0 m
- ~ 7.5 m
1,1,1-Trichloroethane

TCA CONCENTRATION - ROC
2004, 18 AUGUST

TCA CONCENTRATION - ROC
2004, 17 DECEMBER

TCA CONCENTRATION - ROC
2005, 9 FEBRUARY

TCA CONCENTRATION - TILL
2004, 18 AUGUST

TCA CONCENTRATION - TILL
2004, 17 DECEMBER

TCA CONCENTRATION - TILL
2005, 9 FEBRUARY

LEGEND
- Structures
- Previously installed monitoring well
- Injection well
- Pumping well
- New nested monitoring well
Chloroethane
1,1,1-TCA & Intermediates

System re-start
Sept. 2004

MW33-1

Days

TCA
DCA
CA
Till vs. Bedrock

- Bedrock layer more permeable
  - Greater penetration and impact of nutrient amendment
    - 1,1,1-TCA disappearance, transient intermediates
  - 1,1,1-TCA concentrations remain higher longer in till layer
    - Requires more fractionation for improved removal
  - Currently exploring techniques to increase the porosity of the till
Presence of Dehalogenators

• Using molecular techniques (PCR):
  – Known dehalogenators present in the contamination plume (*Dehalococcoides, Dehalobacter, Desulfuromonas*) but not upgradient of the plume
  – Lower numbers/absent in till layer
**Bacterial Diversity**

- **Bacterial diversity not significantly impacted**
  - Either by 1,1,1-TCA or treatment system
- **Dynamic system**
  - Diversity profiles shifting
  - Possibly due to seasonal changes, release of 1,1,1-TCA from adsorbed substrates
Expanded Treatment System

**Legend**
- **New Injection wells**
- **New Pumping wells**
- **New Monitoring wells**

**Structures**
- Manhole pumps of the collection trench
- 1,1,1-Trichloroethane Concentration
- 1,1-Dichloroethene Concentration
- Vinyl chloride Concentration
- Dissolved 1,1,1-Trichloroethane Groundwater Plume
- 200 ug/L approximate contour
- MOEE guidelines (Table B)
- Dissolved 1,1-Dichloroethene Groundwater Plume
- 0.66 ug/L approximate contour
- MOEE guidelines (Table B)
- Dissolved Vinyl Chloride Groundwater Plume
- 0.5 ug/L approximate contour
- MOEE guidelines (Table B)
- **Fences**

**Monitoring Wells**
- MW23B
- MW13
- MW15
- MW104-2
- MW103-2
- MW102
- MW106-2
- MW110-2
- MW114-3
- MW112-3
- MW113-3
- MW17
- MW21
- MW22B
- MW21

**Scale**
- 0 m 5 m 10 m 20 m

**Dissolved 1,1,1-Trichloroethane**
- Groundwater Plume 200 ug/L approximate contour
- MOEE guidelines (Table B)

**Dissolved Vinyl Chloride**
- Groundwater Plume 0.5 ug/L approximate contour
- MOEE guidelines (Table B)
Summary

- Design and implementation of an effective 1,1,1-TCA treatment system
  - Significant reduction in 1,1,1-TCA concentration
  - Treating source in situ
  - Pulsed amendment addition
  - Biostimulation of indigenous bacteria by the creation of favourable environmental conditions
    - Aerobic, reducing conditions
    - Significantly reduced abiotic degradation intermediates
      - 1,1-DCE & VC
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MCEBR
Terrapex
Science at work for Canada