An Evaluation of the Chemtronics Superfund Site

Megan Brooks-Planck, Eden May, Michael Buttrick, Meng Yuan Li, Elizabeth Bonnell, Davis Jones, Rebecca Johnson, and Stephanie Williams

Warren Wilson College
What’s there?

• During the operation of Chemtronics Inc. a large number of chemicals passed through the site.
• For the most part these chemicals have been capped or neutralized.
• Contaminants that remain on site are currently undergoing treatment to prevent spread, and ultimately, to be removed.
• Currently, contaminants remain contained within the site.
Topics

- Risk Assessment Practices
- BZ
- CS and RDX
- Chlorinated Solvents
  - Chemistry
  - Air Stripping
- Perchlorates
- Remediation with Vegetable Oil
Reference

• Parts Per Billion (ppb) – One part in a billion or approximately 1 tablespoon of sugar in Lake Tomahawk

• Half Life – The time it takes for half of a substance to break down

• Precipitation – Formation of a solid within a solution or other solid

• Volatile – The tendency of a substance to vaporize

• Migration – Movement of a substance from the point of origin
Risk Assessment

Megan Brooks-Planck
Risk Assessment

• The EPA determines risk using a four step process.
  – Hazard Identification
  – Dose-Response Assessment
  – Exposure Assessment
  – Risk Characterization
CS and RDX

Eden May
What is CS?

• “Tear gas”
• Non-lethal, used as an aerosol
• Can damage lungs, heart and liver
• Present in soil at some sites
• Decomposes quickly in water
• Half life is 41 minutes
What is RDX?

- Produced as an explosive
- Can cause nausea, vomiting, confusion and amnesia
- EPA human health standard 103 micrograms/liter
- 220 micrograms/liter in one well
RDX Degradation and Remediation:

- In situ – anaerobic conditions - reduction
- Cannot be attributed to single biological or chemical process
- Similar explosives may also be removed by reductive processes

Conclusions
- Microbial and chemical processes play important roles in reducing RDX in the aquifer
- Reduction time took ~10 days for abiotic transformation
- Electron donors enhance rate
- *Rhodofex spp.* bacteria critical to in situ reduction in anoxic conditions
BZ

Michael Buttrick
What is BZ?

- 3-Quinuclidinyl benzilate
- Potent hallucinogen
- Tested and produced during 1960's and 70's
- Designed to be distributed as aerosol
- Never saw official use
- Exposure Limit
  - $\text{ID}_{50}$ (incapacitating dosage):
    - 0.00616 mg (direct i.v.)
Degradation of BZ

• No BZ detected in recent years
• Small amounts of Benzilic Acid decomposition product are present
  (less than 2 parts per million)
• Any BZ not removed during initial clean-up has turned to Benzilic acid
• Storage barrels of BZ were removed 25 years ago
• If any BZ was missed, its decomposition rate would indicate that
  less than .0000000005% remains
Current Levels of BZ

Preliminary Soil Concentration (1988):

Benzilic Acid: 56.9mg/kg of soil
BZ: 17.1mg/kg of soil

Chemtronics Site Data (2007):

Benzilic Acid:
Soil Concentration: 9.3mg/kg of soil
Groundwater Concentration: 1.4mg/L water

BZ:
Soil: Not Detected
Groundwater: Not Detected
Chlorinated Solvents

Meng Yuan Li
What are Chlorinated Solvents?

- Metal degreasing agents
- Are present at highest concentrations on site
- Found at high levels in some wells, not in other wells
- Common industrial pollutant
- Carcinogenic to humans exposed at work
  - Kidney, liver cancer
  - Non-Hodgkin lymphoma
- Neurobehavioral deficits
  - Long-term exposure to low concentration of TCE
- Evidence only from long term high level exposure
What are Chlorinated Solvents?

TCE  Trichlorethylene

TCA  Trichloroethane

Chloroform

EPA drinking water limits

5 micrograms/liter  200 micrograms/liter  70 micrograms/liter

All found in groundwater at levels exceeding EPA limits in some wells
EPA standard for TCE = 5 ppb

TCE in One Back Valley Shallow Well

Year

Concentration (ppb)

1993

2001

2011

EPA standard for TCE = 5 ppb
Perchlorates

Elizabeth Bonnell
What is perchlorate?

**Source:**
- Fireworks
- Warfare
- Some chemical processes
- Can form naturally

**Chemtronics Site Sources**
- Explosives
Health effects of perchlorate

- Competes with iodide in the thyroid gland
  - Only at high perchlorate levels
  - Some concern for pregnant women

- Not likely to cause cancer
Current Levels

• 2500 micrograms/liter in one Chemtronics well

• 6 micrograms/liter maximum permissible level in California

• Not travelling to off-site wells
What are they doing to clean it up?

• No previous methods at Chemtronics

• Possible Methods:
  – Anaerobic Degradation now being tested
    • Seems promising
  – Treatment through physical processes not likely now
Bioremediation:
Emulsified Vegetable Oil

Davis Jones
What does reduction mean?

- Reduction is the gain of electrons
- If something gains electrons (is reduced) something else has to lose the electrons (is oxidized)
- Some bacteria can speed up the reaction
- Vegetable oil is a possible source of electrons leading to reduction of pollutants
General Remediation

• July 2012 – Enhanced In situ Bioremediation (EISB) using food grade vegetable oil (EVO) approved by the EPA
  – Contractor
• Four sites tested in Front Valley
• Current activity: FSCT – Feasibility Screening/Candidate Testing
  – Microcosm testing – Bacterial strains
  – Shallow well test
General Remediation

- EVO provides underground emulsion to stimulate BOZ – biologically active zone
- BOZ stimulates bacterial growth
- Acts as electron donor to reduce chlorinated solvents
  
  \[
  \text{reduce} = \text{gaining an electron}
  \]
Contaminants Treated

Chemicals of Potential Concern

- VOC – volatile organic compounds (TCE, PCE, 1-2-DCA, CF)
- Nitroaromatics (RDX, HMX, 2,4,6- TNT)
- Perchlorate

Bioremediation can be effective for all three categories
Other Types of Remediation

Rebecca Johnson & Stephanie Williams
Remediation: Air Stripping

- Contaminated water enters at the top of the column as air enters at the bottom
- Packing provides increased surface area
- Chlorinated solvents enter the gas phase
- Treated water exits through the bottom of the column, solvents are off gassed
Reaction in air

• Light can cause removal of chlorinated solvents in air
• TCE breaks down into CO$_2$ and HCl
• The half life of TCE is 3.5 days
• After two weeks, TCE is essentially gone from air
Other Methods for removal of solvents

- **Natural attenuation**
  
  “Let nature take care of it” (bioremediation, dilution, etc)

- **Zero-Valence Iron**
  
  - Metal-water interface
  
  - Corrosion of iron

- **Bioremediation**
  
  - Bacteria remove Cl and replace with H
  
  - Final product is harmless
  
  - Currently being tested on-site