# Evaluating the Effectiveness of Commercial Bioremediation Products on Petroleum- and Chlorinated- Hydrocarbons in Soil Under Sequential Aerobic–Anaerobic Conditions


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# Background

## Rachel Graham

- Bachelor of Environmental Science from Concordia University of Edmonton
- Master's candidate for Remediation and Soil Science from the University of Alberta
- Born and raised in Fort Chipewyan, Alberta
- Environmental Manager for Mikisew Cree First Nation, Government and Industry Relations

# Background

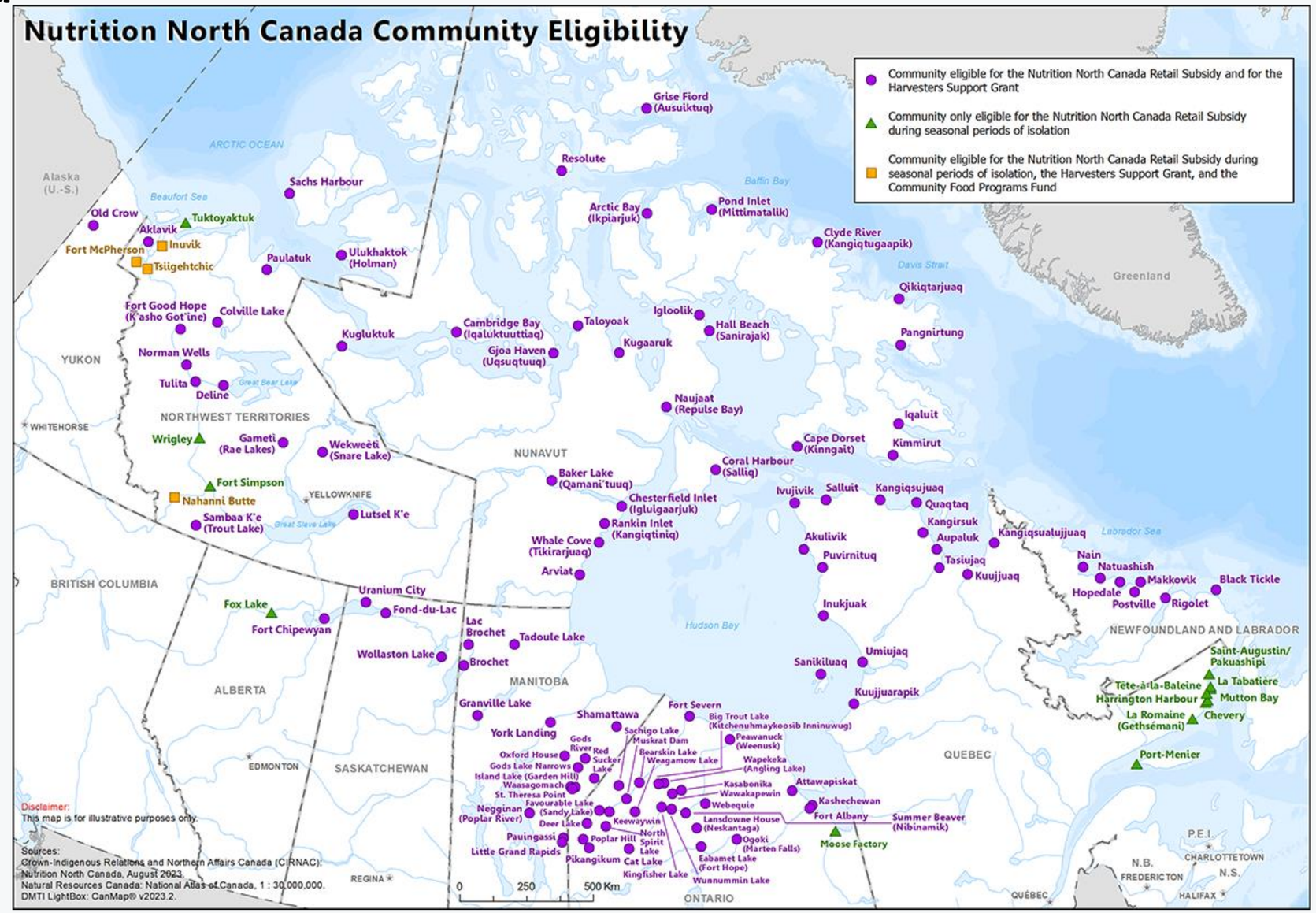


Photo from Nutrition North - https://www.nutritionnorthcanada.gc.ca/eng/1415540731169/1415540791407



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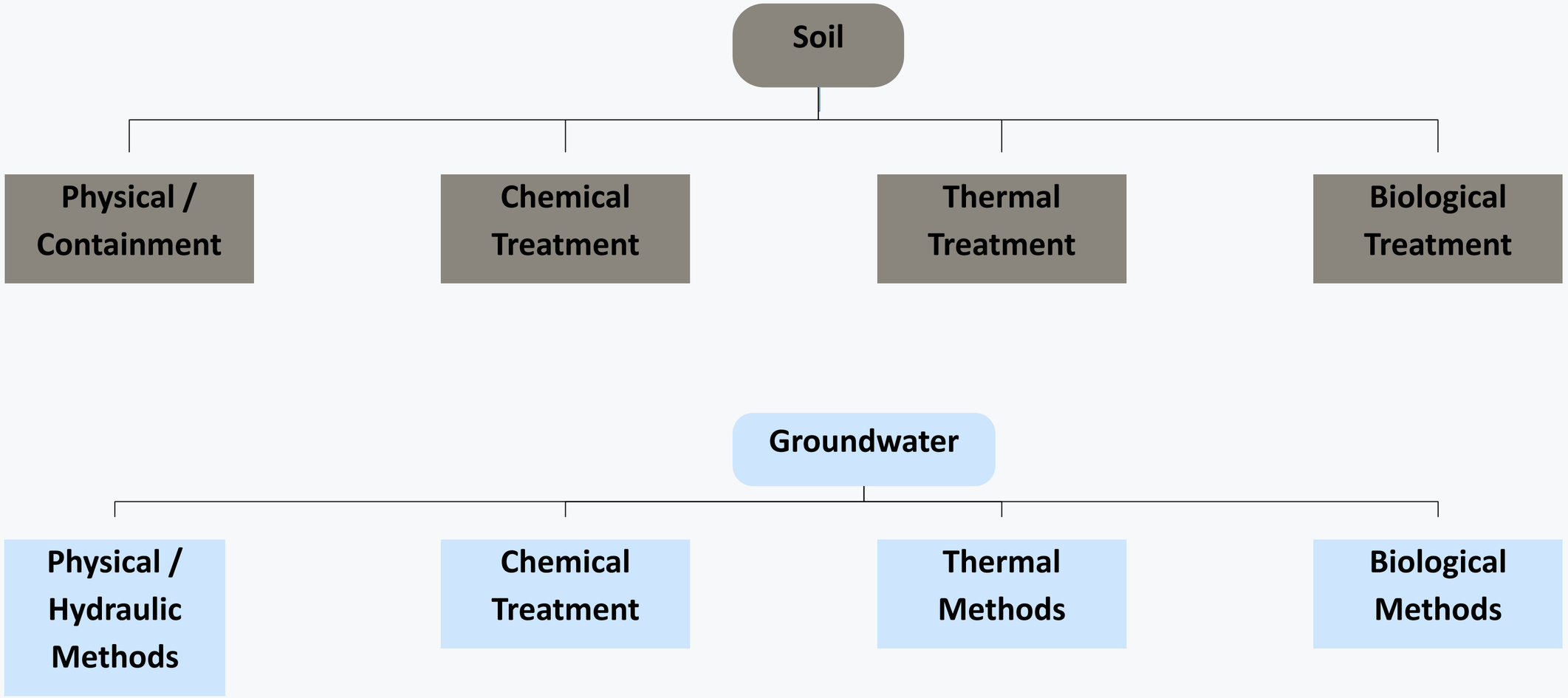
# Remediation Options



# Remediation Options

## Soil

### Physical / Containment
- Excavation & Disposal
- Capping / Isolation
- Soil Washing
- Solidification/Stabilization

### Chemical Treatment
- Soil Flushing
- Chemical Oxidation
- Chemical Reduction
- pH Adjustment / Precipitation

### Thermal Treatment
- Incineration
- Thermal Desorption
- Vitrification

### Biological Treatment
- Bioremediation
- Phytoremediation
- Natural Attenuation

## Groundwater

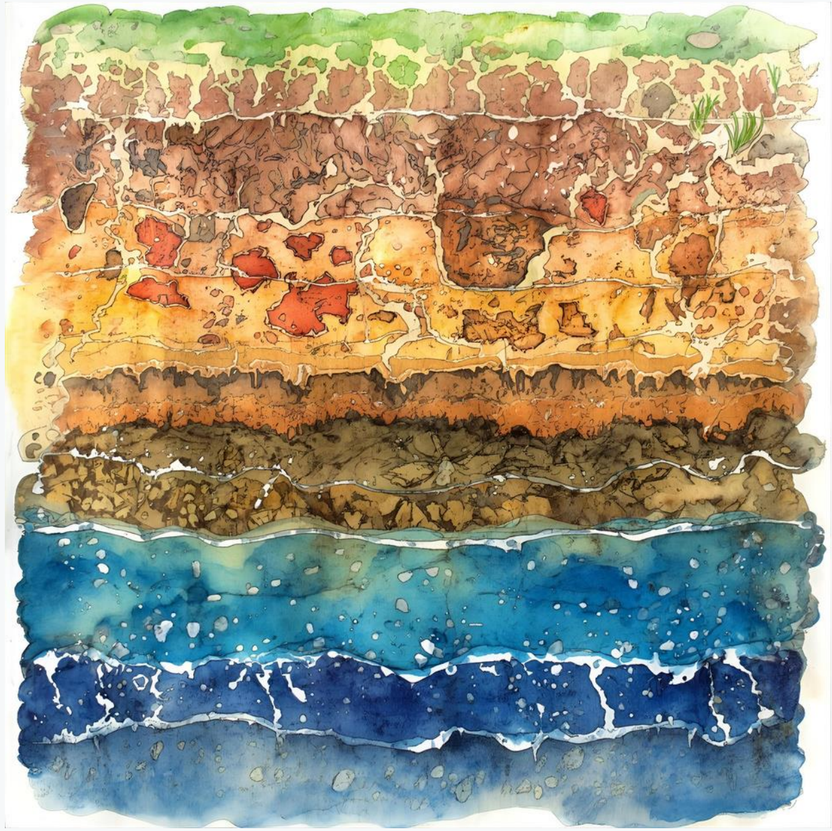
### Physical / Hydraulic Methods
- Pump-and-Treat
- Containment / Hydraulic Barriers
- Air Sparging
- Permeable Reactive Barriers

### Chemical Treatment
- In-Situ Chemical Oxidation
- In-Situ Chemical Reduction
- pH Adjustment / Precipitation

### Thermal Methods
- Electrical Resistance Heating
- Steam Injection / Hot Water Flushing
- Thermal Conduction Heating

### Biological Methods
- Bioremediation
- Enhanced Reductive Dechlorination
- Natural Attenuation

# Bioremediation



# Why Is This Research Needed?

**01** Commercially available products do not have scientific evidence to support their claims

**02** When commercial products had the evidence to support their product, the results were inconsistent or unreplicated

**03** Many tests focused on singular analysis for the contamination.

**04** Redox sequencing

# Two Urban Edmonton Study Sites

**Industrial**

**Commercial**

**Benzene**

**Toluene**

**Tetrachloroethylene (PCE)**

**Trichloroethylene (DCE)**

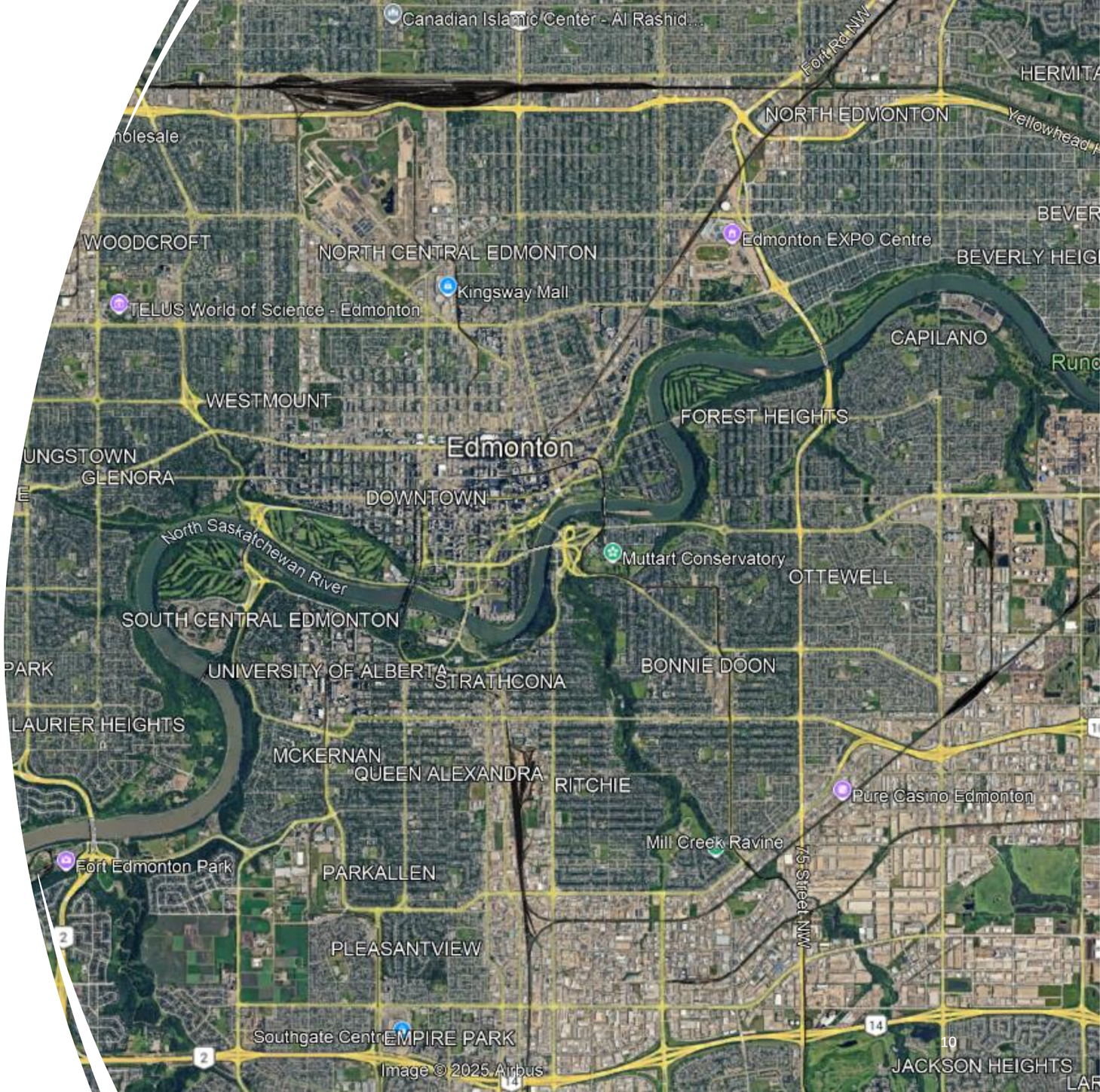
**Dichloroethylene (DCE)**

**Vinyl Chloride**

# BioRemediation Amendments Commercial Products

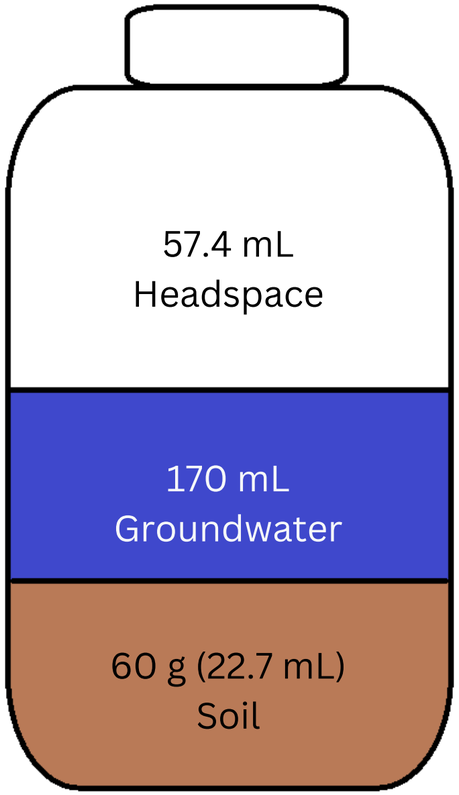
1. BioLogix – Delta Remediation - Bioaugmentation focused on petroleum hydrocarbons in aerobic conditions
2. TPHENHANCED – Terra Styke - Biostimulant focused on petroleum hydrocarbons
3. ERDENHANCED – Terra Stryke - Biostimulant focused on chlorinated hydrocarbons in anaerobic conditions


# How effective are aerobic and anaerobic commercial bioremediation products at removing petroleum- and chlorinated - hydrocarbons?



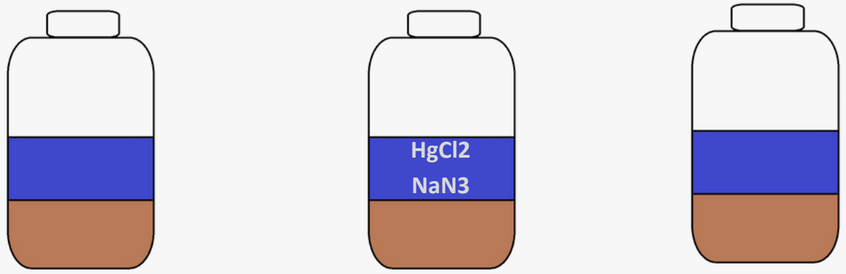
# Materials

The experiment was replicated with both spiked and unspiked bottles. 20 mg/L Benzene, Toluene, & PCE added



## Controls

### Aerobic Phase (4 Months)




X2
Control 1
Non-sterilized control

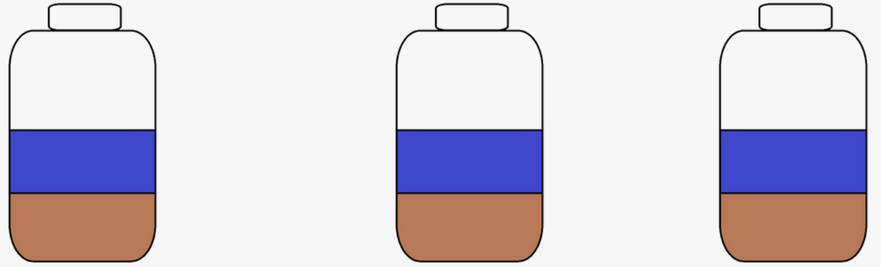
X2
Control 2
Chemically Sterile

X2
Control 3
Killed BioLogix

## Treatments

### Aerobic Phase (4 Months)

Oxygen maintained at 20%



X3
Treatment 1
BioLogix

X3
Treatment 2
TPHENHANCED

X3
Treatment 3
TPHENHANCED & BioLogix

**Anaerobic Phase (12 Months)**
**ERDENHANCED Added**

Bottles flushed with helium gas at start of anaerobic phase

**Anaerobic Phase (12 Months)**
**ERDENHANCED Added**

# Chemical Analysis

GC Headspace analysis for benzene, toluene and PCE monthly

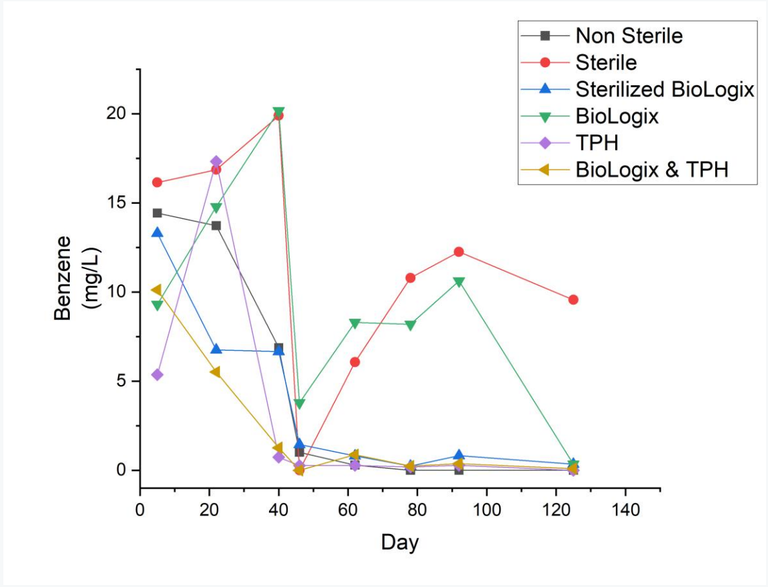
pH, EC, anions and cations from liquid fraction monthly

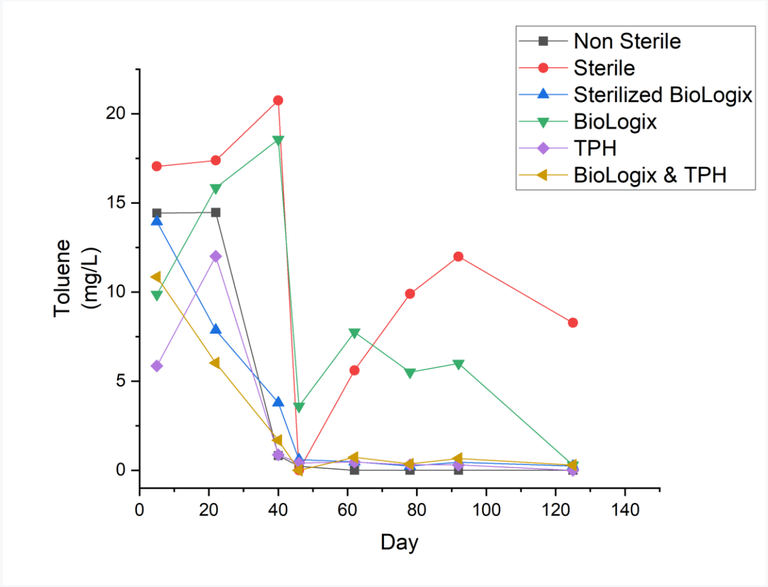
Headspace for CO2, CH4, 02 and C2H6 monthly

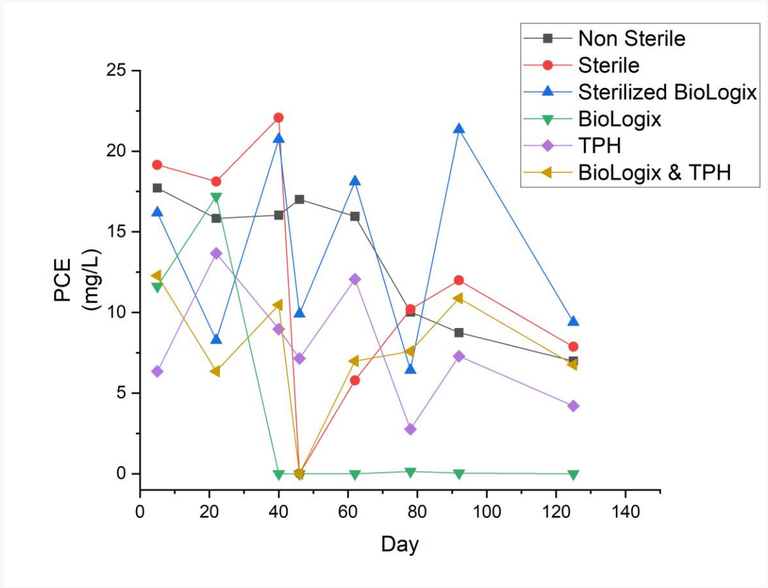
# Industrial Site Data

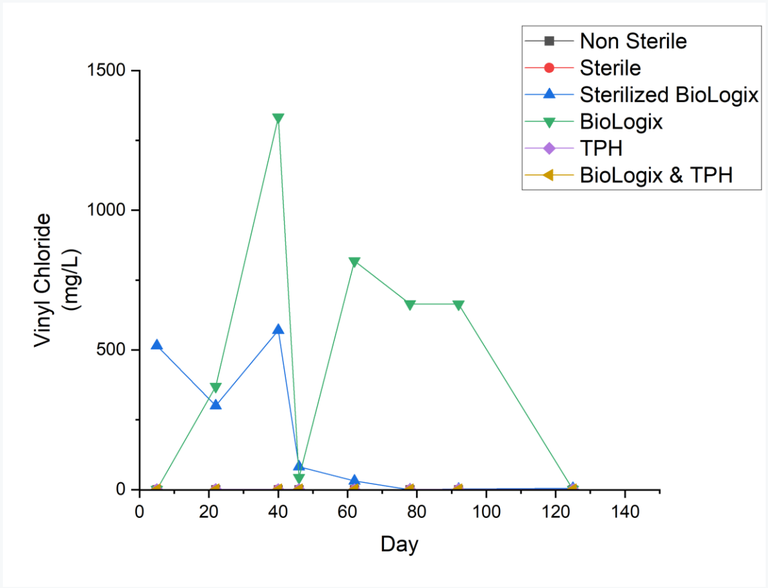
- Spiked to 20mg/L with Benzene, Toluene, and PCE
- Gas chromatography analysis for benzene, toluene, PCE, and vinyl chloride.
- TCE and DCE measurements were taken, but the two daughter products don’t show significant changes

# Industrial



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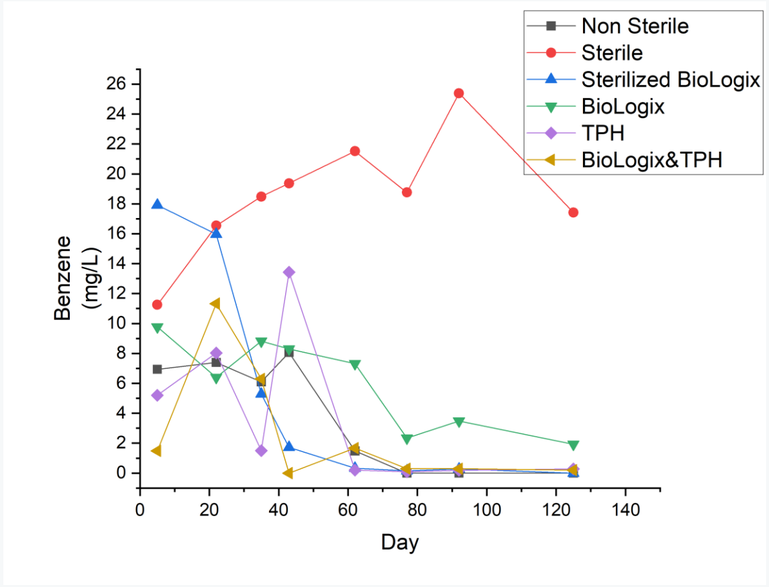


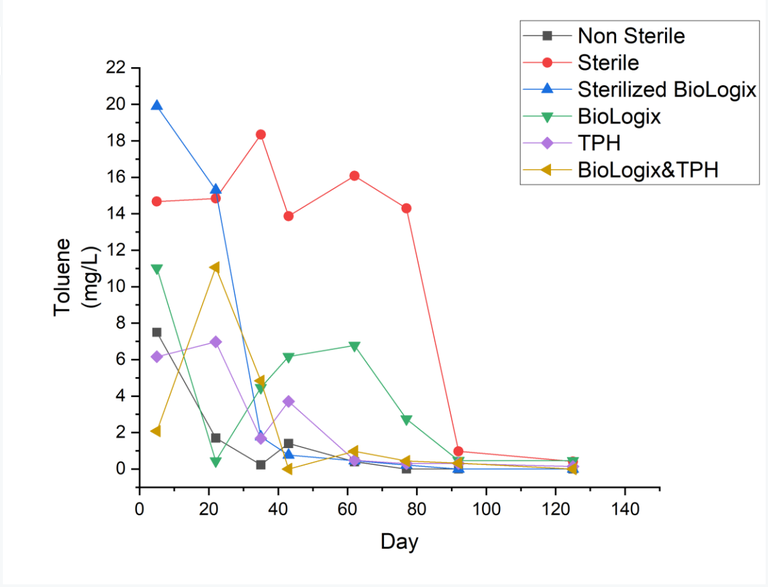


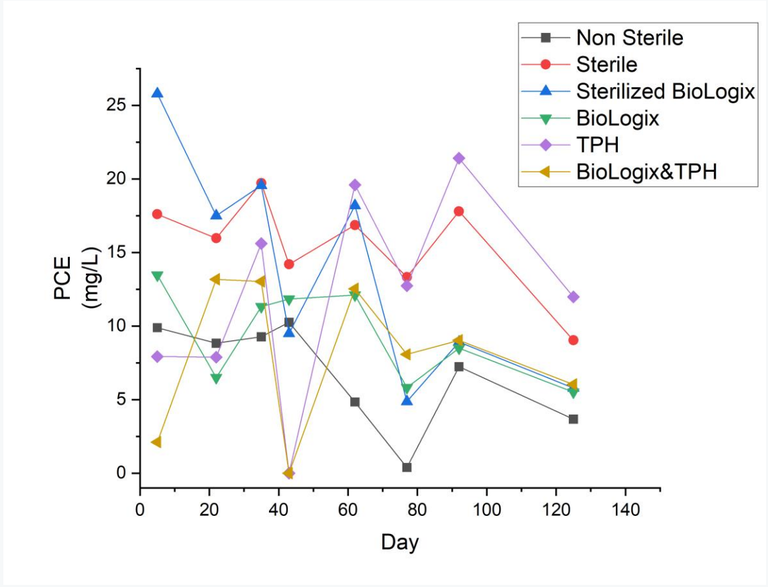


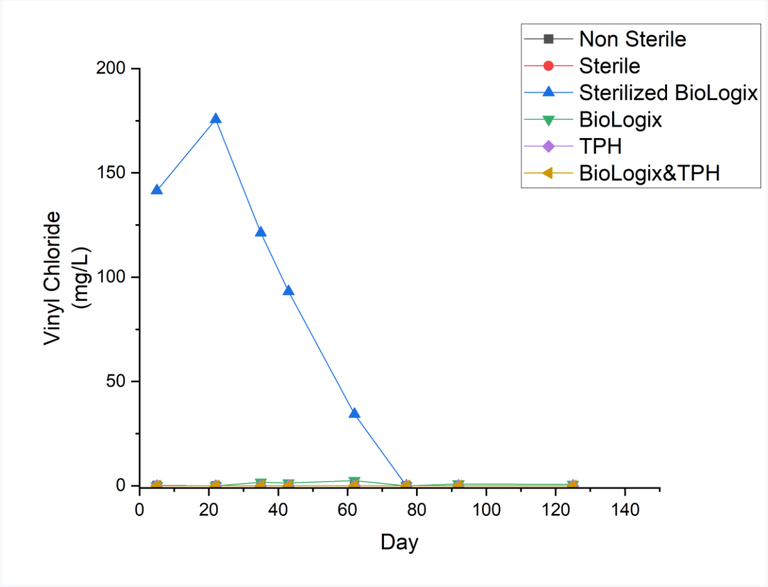

# Conclusions

- The patterns in both spiked and unspiked bottles show a decline in petroleum hydrocarbons in the aerobic phase, a slight decline in PCE, and an increase in VC after the bottles entered the anaerobic phase.
- The small concentrations of the chemicals in the unspiked bottles do not have a dramatic decline as opposed to the spiked bottles.
- Data showed the treatments as being effective in removing the petroleum hydrocarbons sooner than the untreated.
- The treatments have not been shown to remove PCE and its daughter products in the aerobic phase, but the treatments for PCE work best in anaerobic conditions.

# Next Steps

- Monthly monitoring of anaerobic phase
- qPCR to identify microbial community contributing to degradation
- Statistics and data analysis (calculate half life)
- Findings will support the design of Clear-Site Solutions Remediation in-situ remediation systems to optimize injections of commercial products

# Acknowledgements