1,4 – Dioxane Bioaugmentation During and After Anaerobic Degradation

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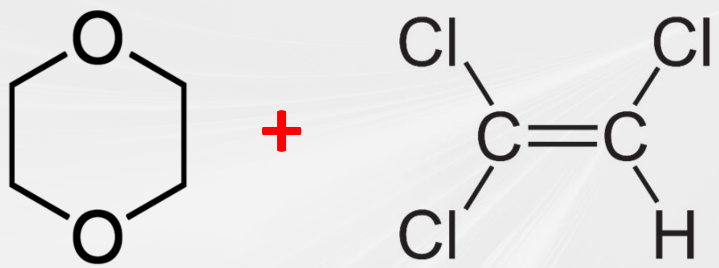
Overview

- Objective
- Background
- Bench Scale Studies
  - Anaerobic Study
  - Transition from Anaerobic to Aerobic
  - Aerobic Study
- Conclusions and Implications

Objective

- Assess impact on 1,4-dioxane during active anaerobic degradation for chlorinated solvents
  - Laboratory microcosm study
  - Assess feasibility for field implementation
- Impact on 1,4-dioxane after anaerobic degradation
  - Aerobic degradation
  - Residual TOC impact
  - Residual CVOC impact

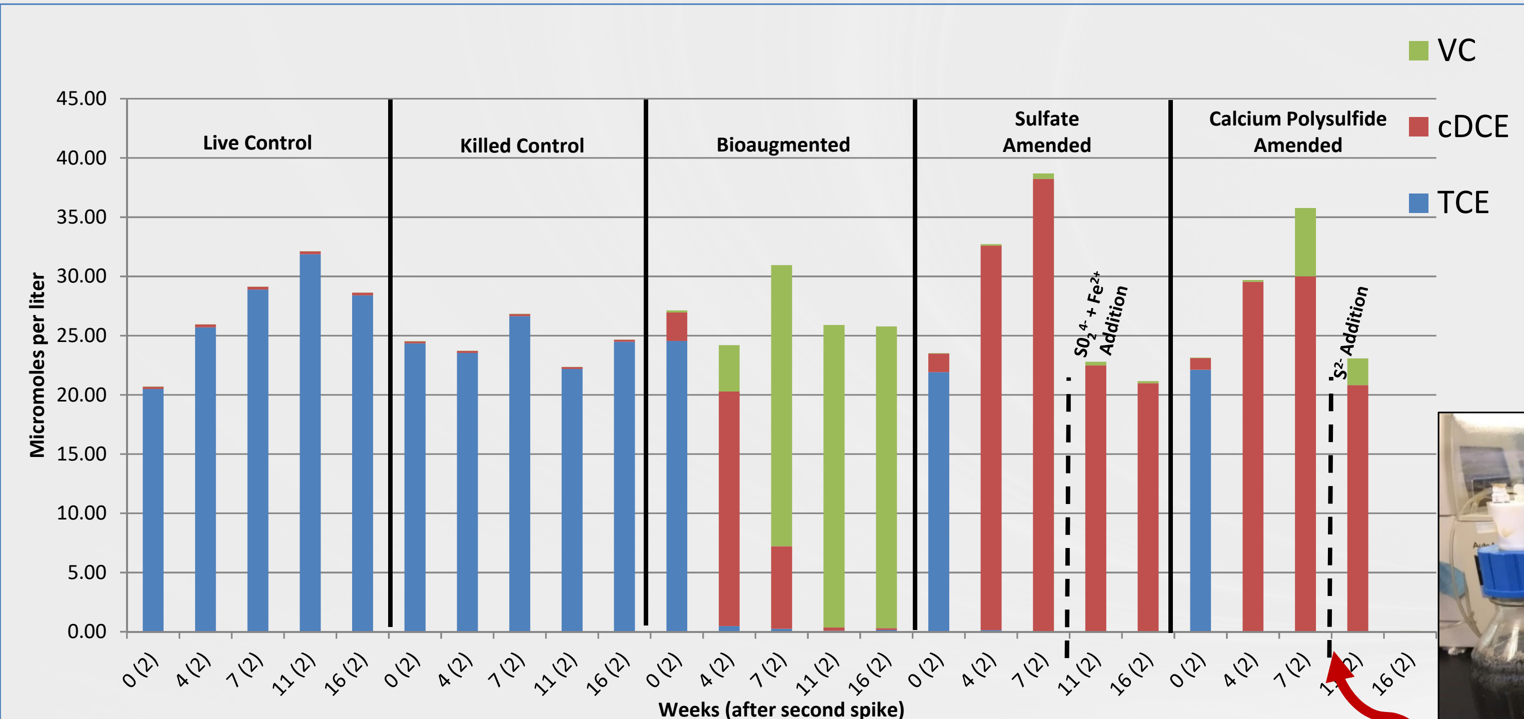


Site Background

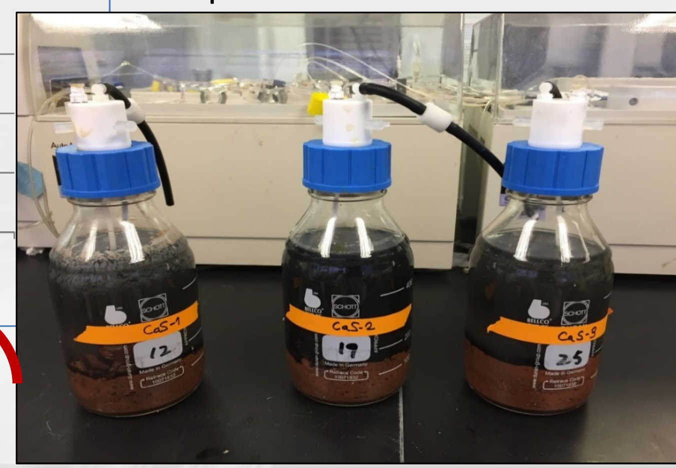
- CVOCs and 1,4-dioxane in a Passaic Formation Bedrock aquifer
- Successful anaerobic bioremediation pilot study performed at the site in 2015
  - Excessive iron production
  - Slower kinetics for chlorinated ethenes versus chlorinated methanes
  - Increases of 1,4-dioxane in the bioremediation area
  - Consequently, we recommended
    - Investigation of anaerobic degradation using iron sulfide via a bench-scale study
    - 1,4-dioxane treatment following anaerobic degradation

Sample of iron/biomass from bedrock – post pilot study →

Anaerobic Treatability Study

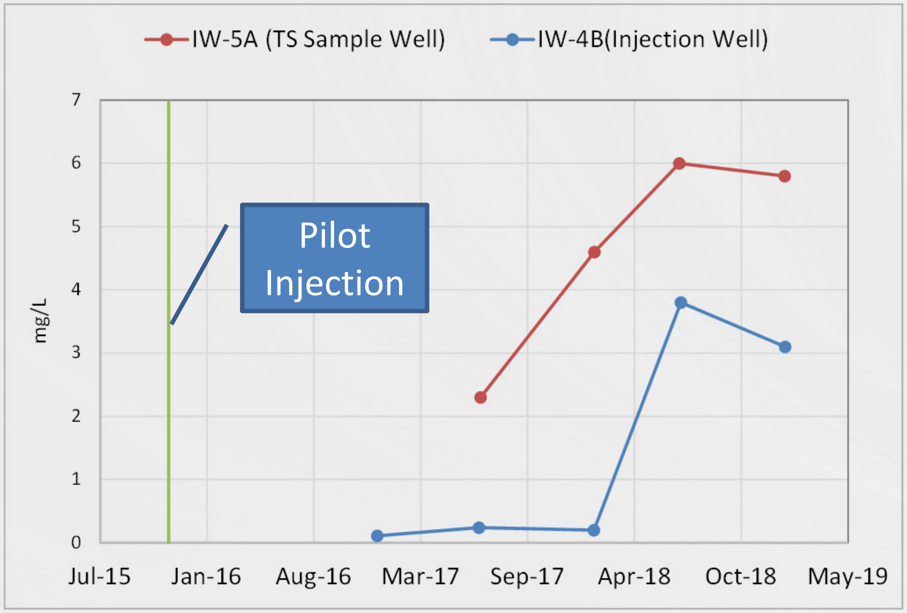


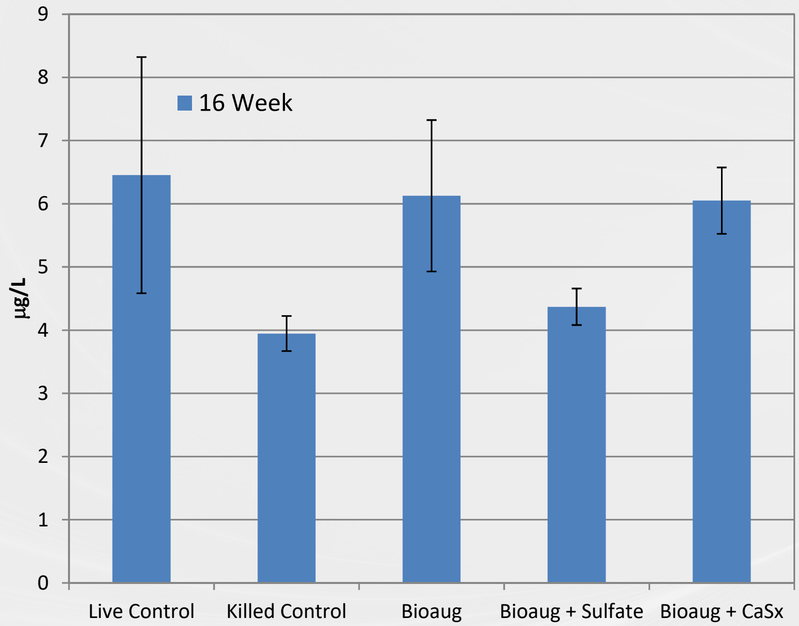
FeS formation resulted in rapid reduction of TCE parent compound.



- Rapid reduction of cis-1,2-DCE without VC generation

1,4-Dioxane During Anaerobic Treatment

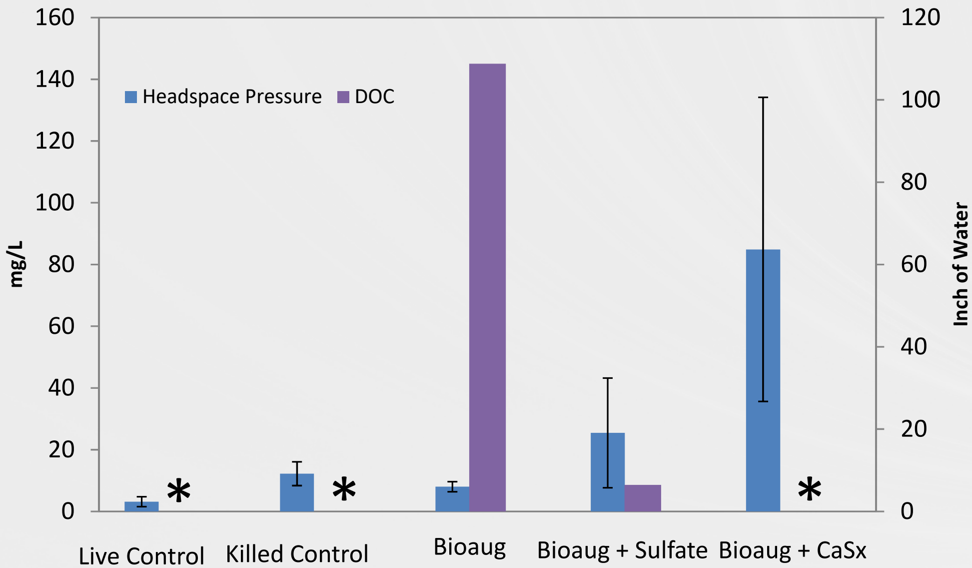




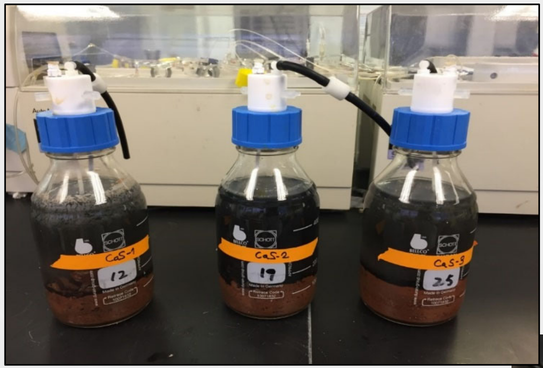
- 1,4-dioxane concentrations increased during and after anaerobic treatment for CVOCs both in the lab and field.

Transition from Anaerobic to Aerobic Study

- Vented methane and increased DO to saturation



*data is not available



Disappearance of FeS

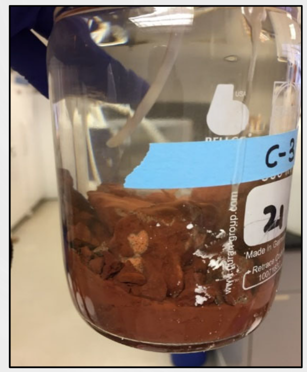
More rapid consumption of TOC and methane generation with sulfate or sulfide additions

Aerobic Setup

Two sets of aerobic tests - bioaugmented and bioaugmented + sulfate

- Bioaugmented NJIT DD-4 culture
- No additional oxygen
- Total propane
  - 600 ng for bioaugmented
  - 900 ng for bioaug + sulfate

Triplicate bottles for anaerobic treatments



Combined all triplicate bottles into one to reach DO saturation

Divided composite sample into 4 triplicates
- Killed
- Live
- DD4 Only
- DD4+ Propane

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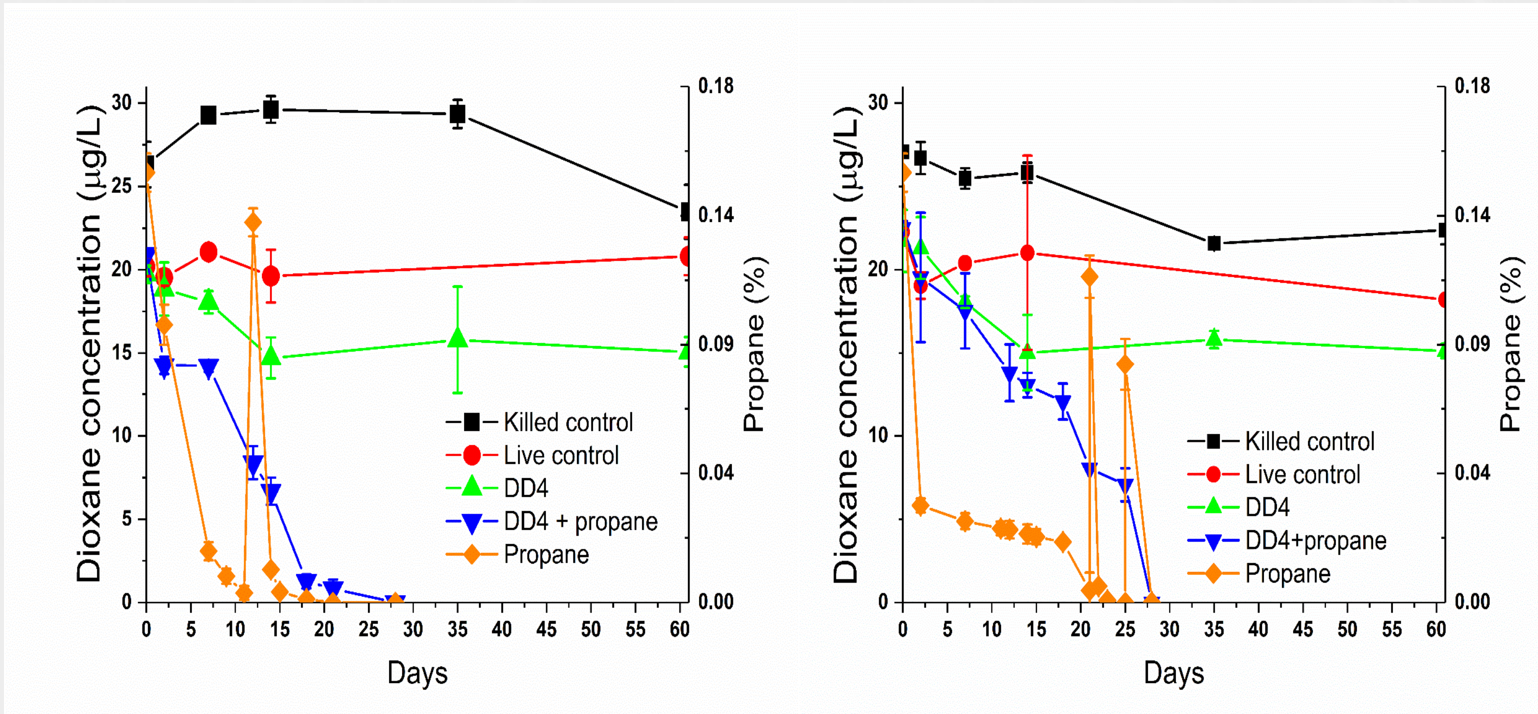
1,4-Dioxane Results

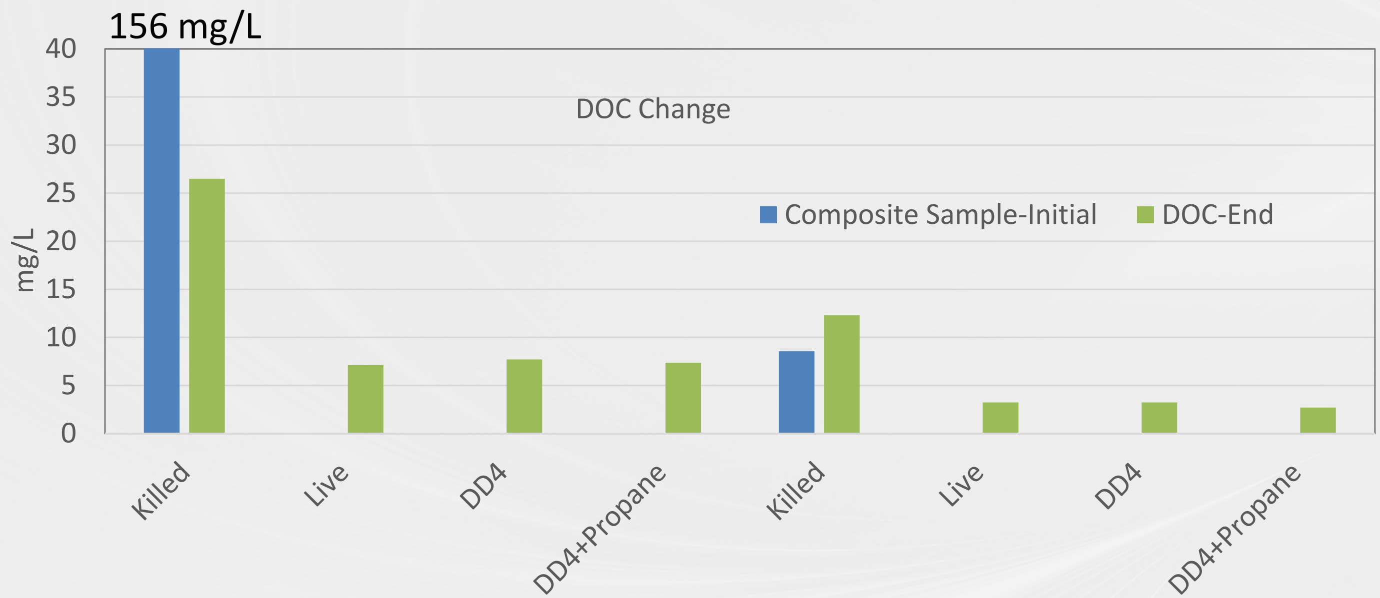
- DOC as carbon source for DD-4 reduced 1,4-dioxane by 25%
- DD4 + propane showed best results
- Consider
  - DOC and sulfate concentration different in two treatments
  - CVOC were different



Bioaugmented | Bioaugmented+Sulfate

Geochemical Changes During Aerobic Study

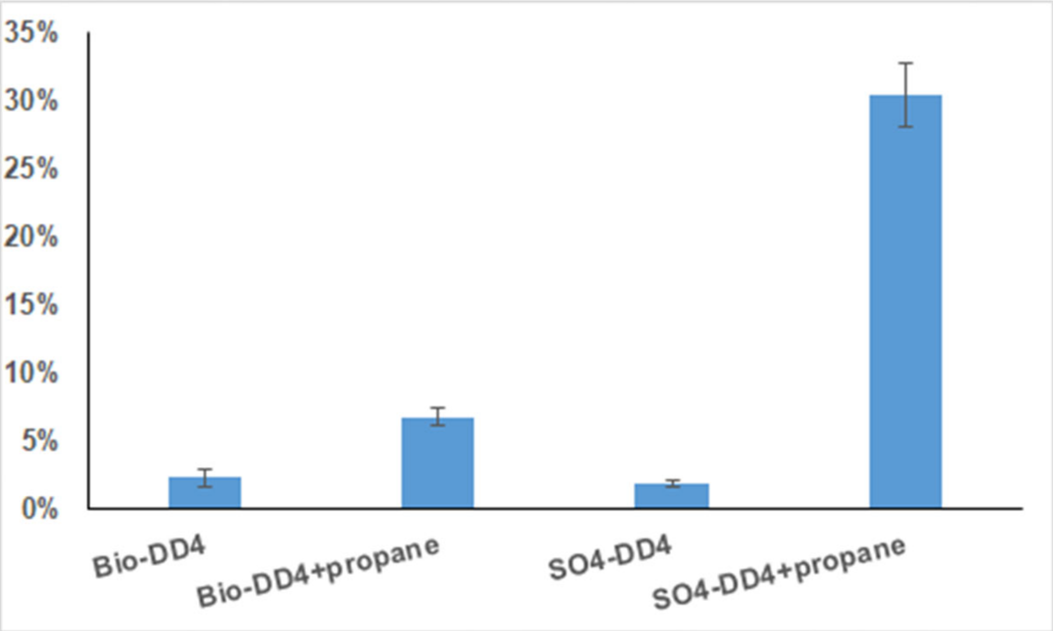
- No difference in end-point dissolved organic carbon (DOC) among different treatments
- Oxygen was sufficient to maintain aerobic condition.



O_2:DOC:Propane = 31.5 mg (21% in headspace): 1.35mg (26 mg/L): 0.9 mg = 35:1.5:1

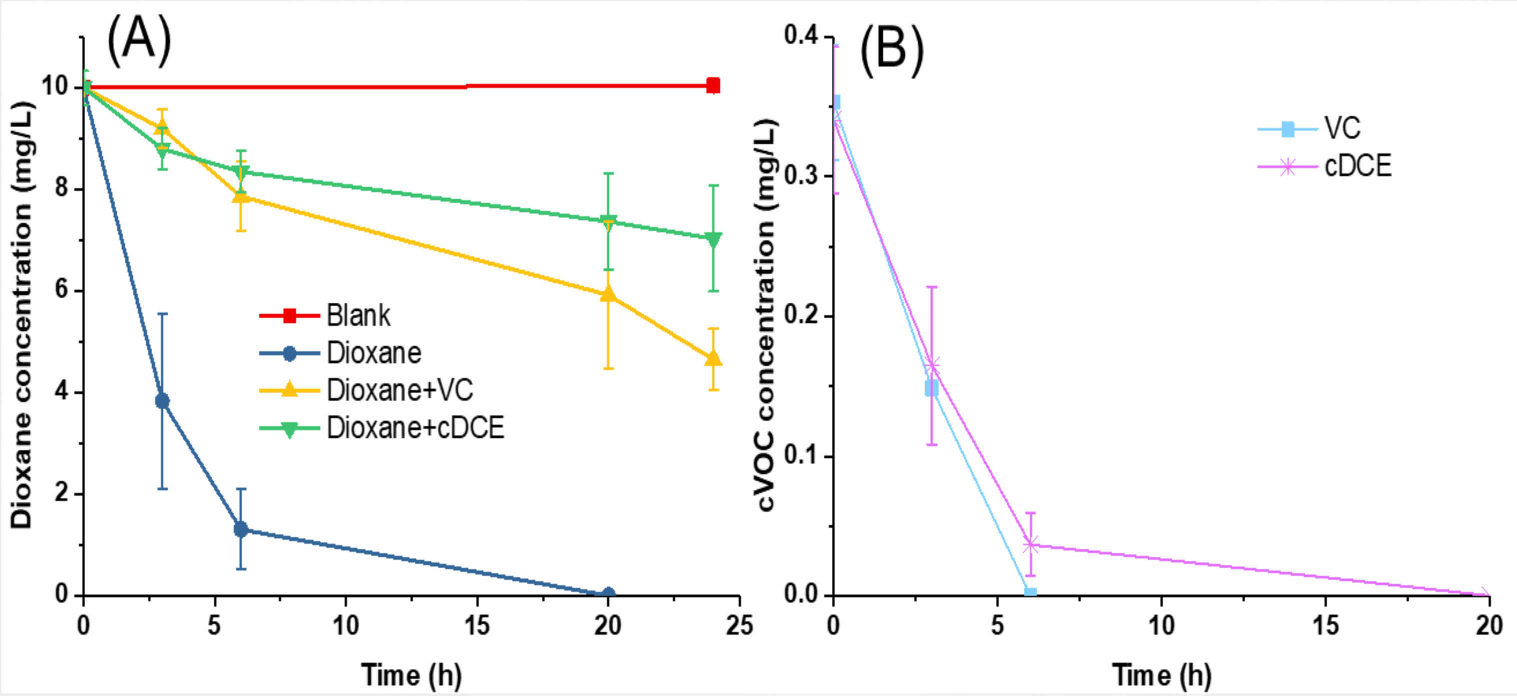
Microbial Population

- DD-4 survived without propane.
- Propane enhanced microbial population significantly



Co-Contaminant Inhibition and Degradation

- VC and DCE can be degraded with 1,4-Dioxane
- VC and DCE appear to interfere with 1,4-Dioxane degradation



Conclusions

- Combined remedy is feasible for 1,4-dioxane
  - 1,4-dioxane degradation was not observed under anaerobic condition.
  - Bioaugmentation with DD-4 and propane additions at low concentration (15 mg/L) was effective for 1,4-dioxane removal.
  - DD-4 can remove CVOCs via co-metabolic degradation.
  - Multiple factors could affect 1,4-dioxane degradation via DD-4
  - Without propane, DD-4 could survive on carbon content remained from EVO fermentation.

Implications for Site Remediation

- Consider sequential remediation at the site

CVOCs
- Complete anaerobic remediation
- Carbon source and bioaugmentation

1,4-Dioxane
- Wait for TOC to decline to <50 mg/L and DO is back to baseline
- Bioaugmentation with DD-4

1,4-dioxane
- 1,4-dioxane standard can not be reached within the time frame
- Implement propane infusion as a contingency

Acknowledgements

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