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# **Bioaugmentation Approaches for Effective Bioremediation of Mixed Contaminant Sites**

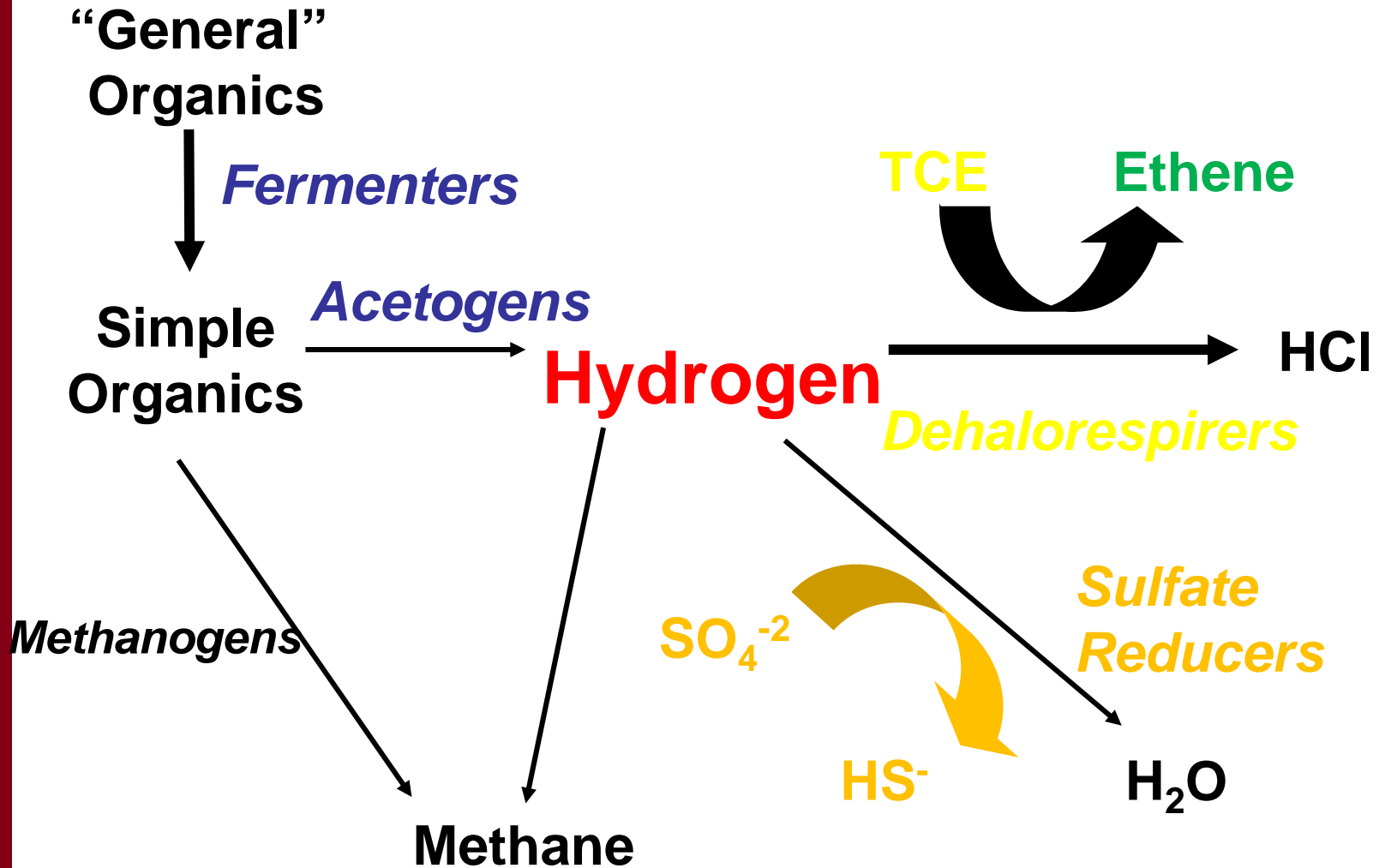
**Sandra Dworatzek, Jeff Roberts and Phil Dennis**

**SIREM, Guelph, ON, Canada**

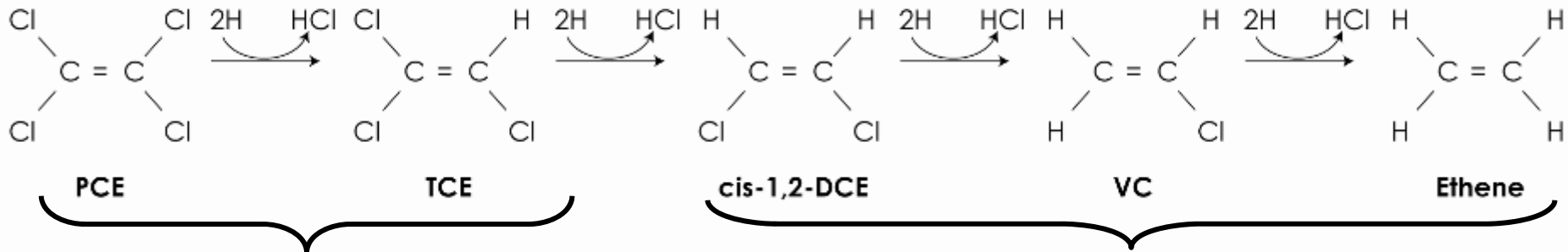
**Southeastern In Situ Remediation Conference**

**24 February 2010**

# Microbial Communities involved in anaerobic reductive dechlorination

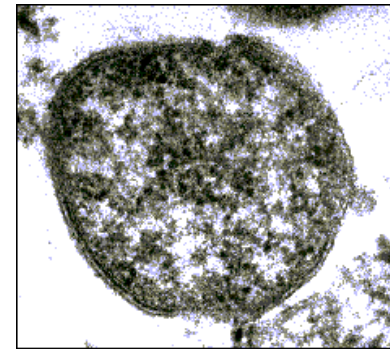


# Dehalococcoides (DHC)



*Dehalobacter*  
*Dehalospirillum*  
*Desulfitobacterium*  
*Desulfuromonas*  
 + *Dehalococcoides*

*Dehalococcoides*



# Chloroethene Degradation Pathways

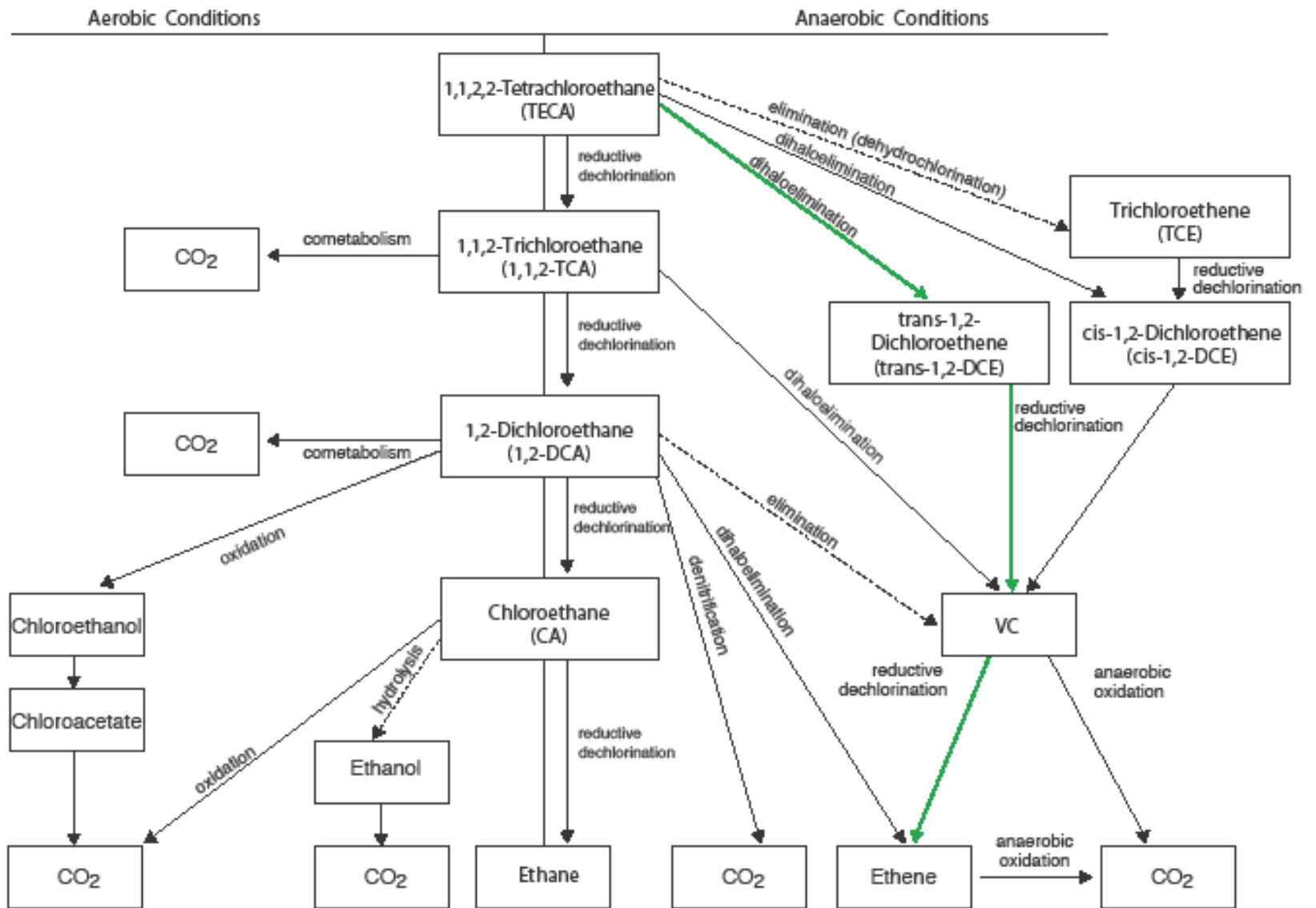
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- Established track record – degradation pathways well understood
- BUT.....
  - What happens when other contaminants are present?
    - Multiple contaminant mixtures?
    - Complex degradation pathways?

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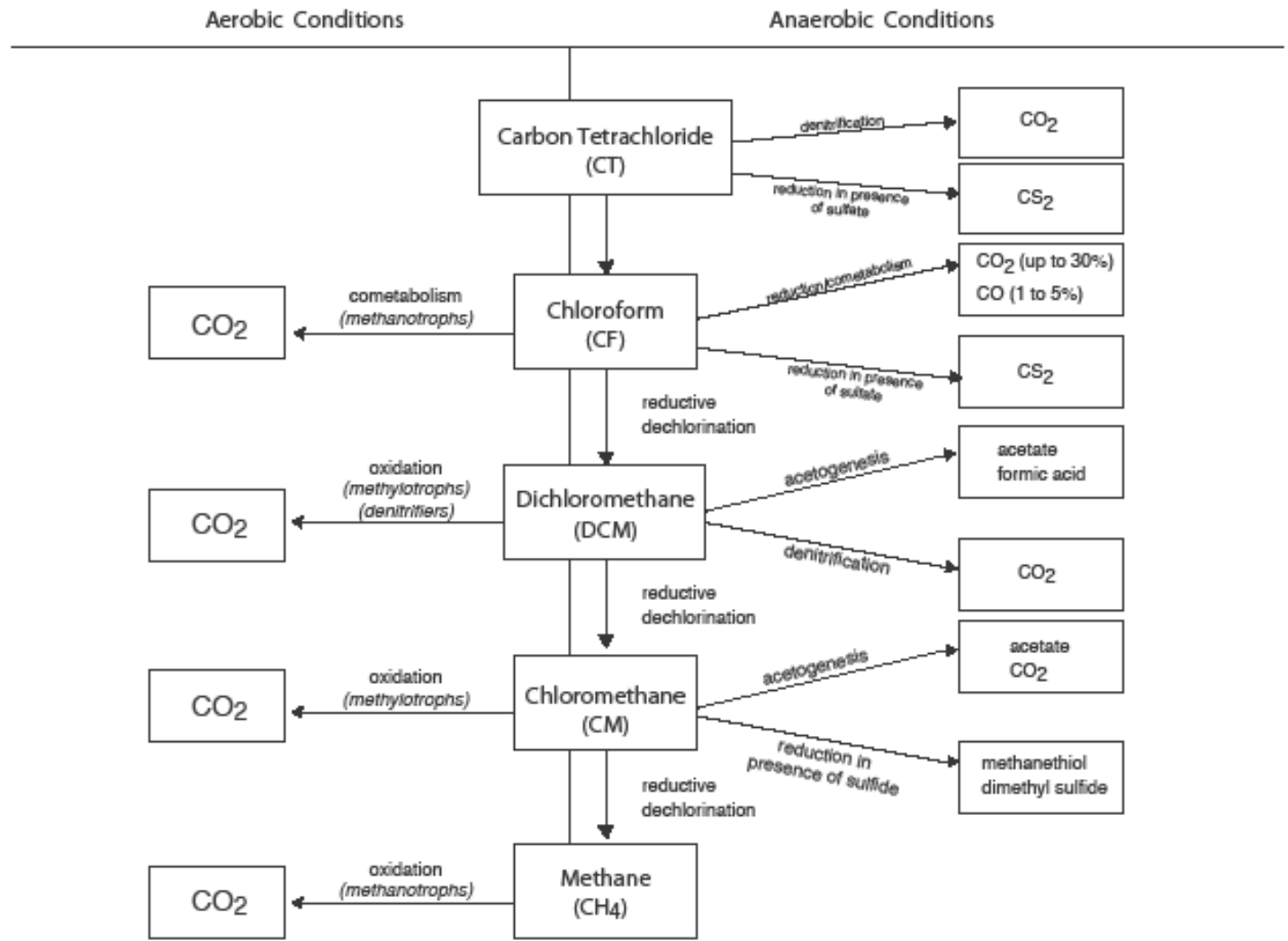
Multiple/complex degradation pathways.

# MULTIPLE DEGRADATION PATHWAYS



- > biological reaction
- - -> abiotic reaction
- > primary TECA biodegradation pathway observed

Pathways for the Degradation Of Chlorinated Ethanes and Ethenes

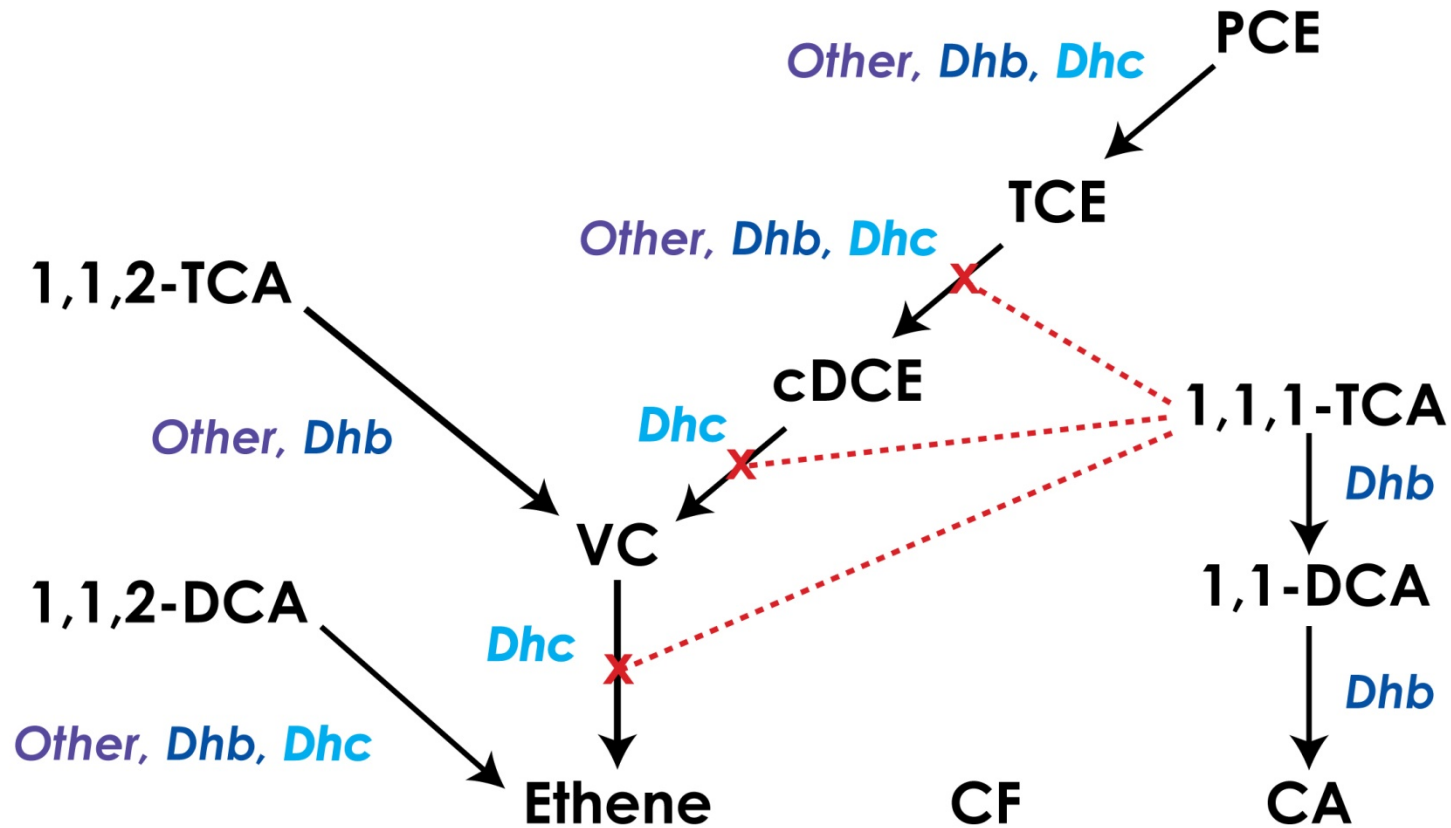


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# Contaminant Mixtures



# TCA Inhibition



**Dhc** = *Dehalococcoides*

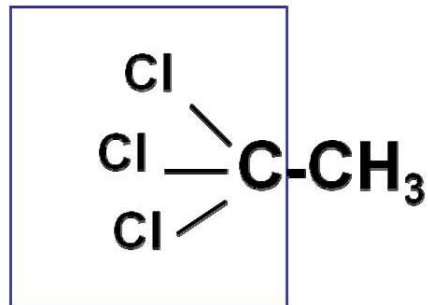
**Dhb** = *Dehalobacter*

**Other** = *Desulfitobacterium, Sulfurospirillum, Clostridium*

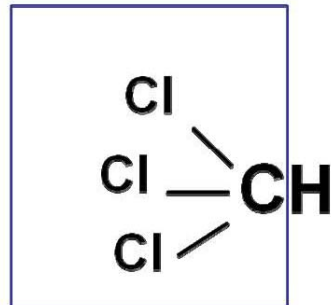
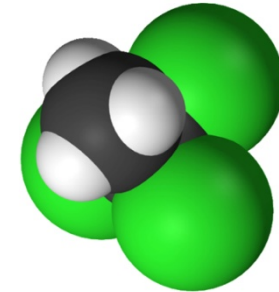
**-----X** = Inhibition



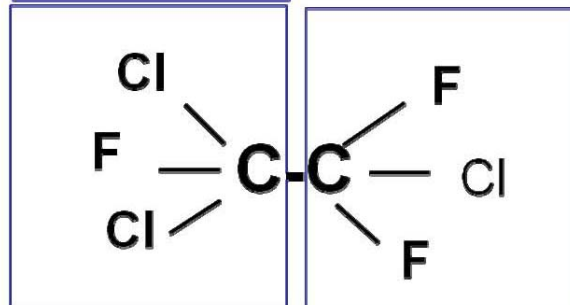
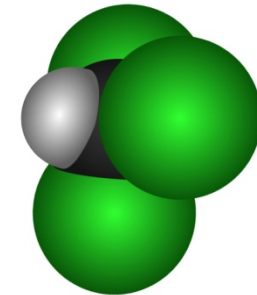
# Compounds Inhibitory to Chloroethene Degradation



1,1,1-TCA



Chloroform



CFC 113

Many Dhc inhibitory compounds contain tri-halogenated carbons

# Dehalobacter (Dhb) to the Rescue

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- **Dhb initially found to degrade 1,1,1-TCA**
- **Recent research (Grostern et al)**
  - **Dhb strain with specific affinity to trihalogenated carbon atoms**
- **Implications for remediation of similar trihalogenated contaminants (DDT, CFCs and other ozone-depleting substances, and drinking water disinfection by-products).**

Grostern, A., M. Duhamel, S. Dworatzek and E.A. Edwards, 2010. Chloroform respiration to dichloromethane by a *Dehalobacter* Population. *Environmental Microbiology*. In Press.

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# Treatability Testing Results with KB-1 Plus

# KB-1<sup>®</sup> Plus

- ***Dehalobacter***
- ***Dehalococcoides***
- ***Geobacter***
- Fermenters
- Methanogens

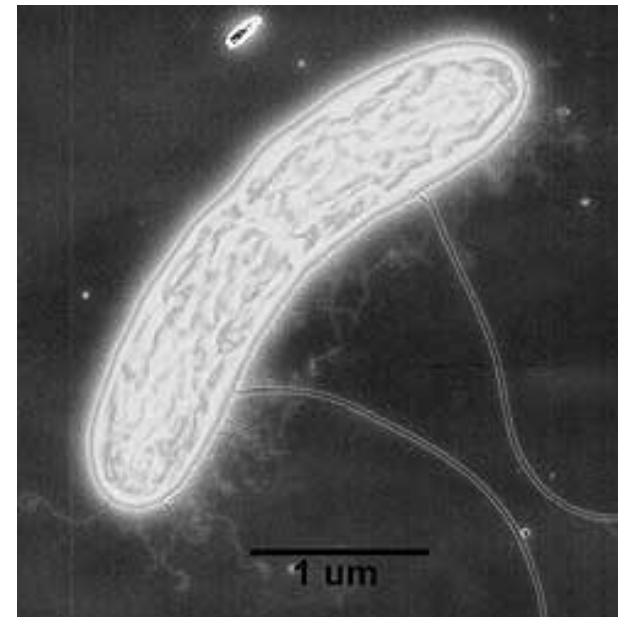
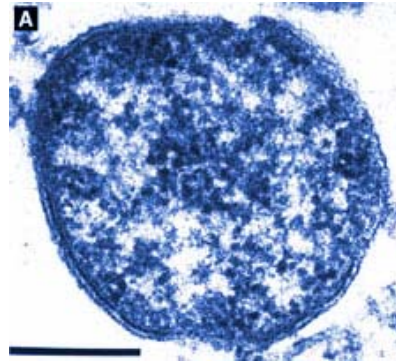
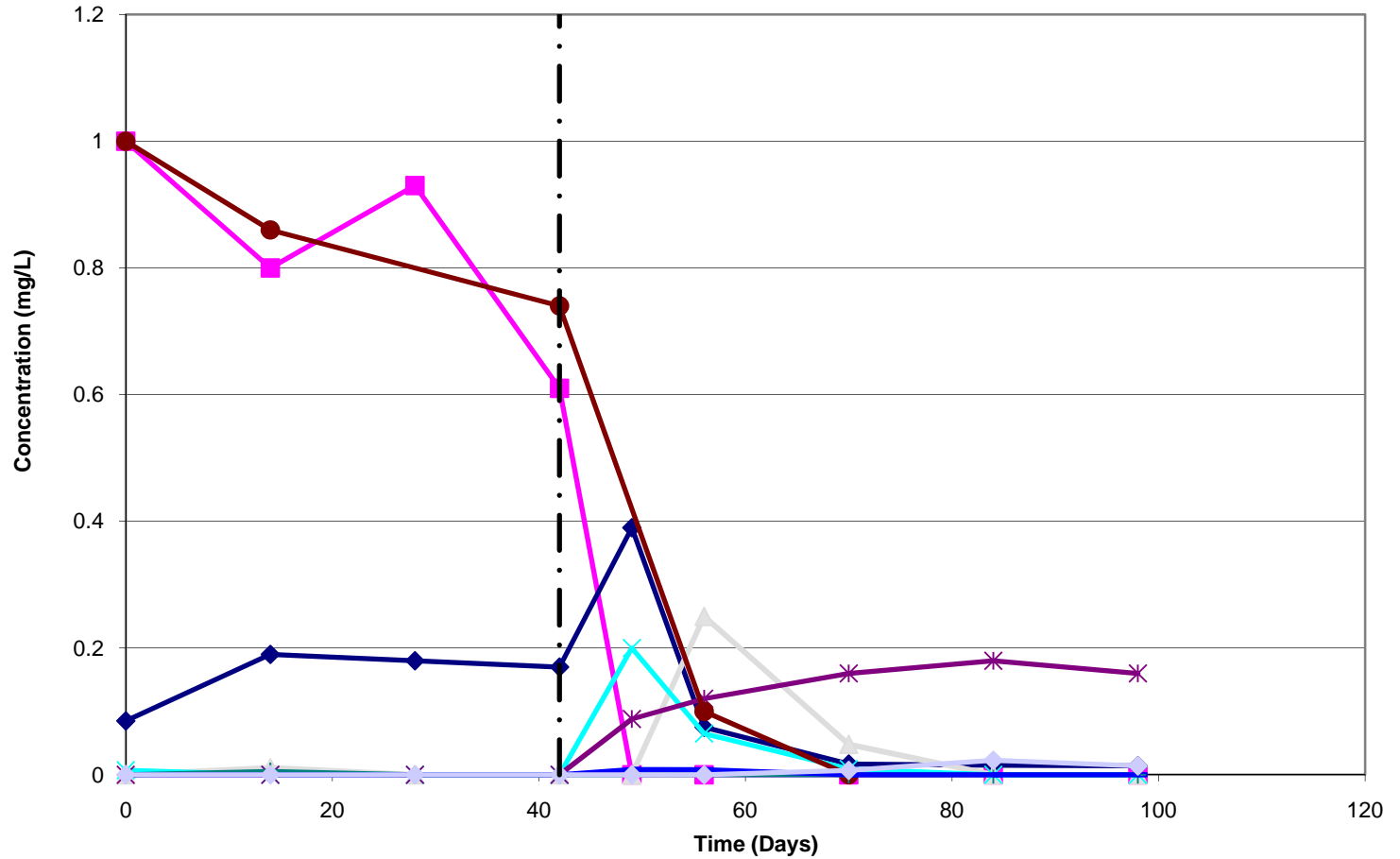


Photo credits: SiREM,  
Sun et al., 2002 *Science*  
298: 1023-1025 and

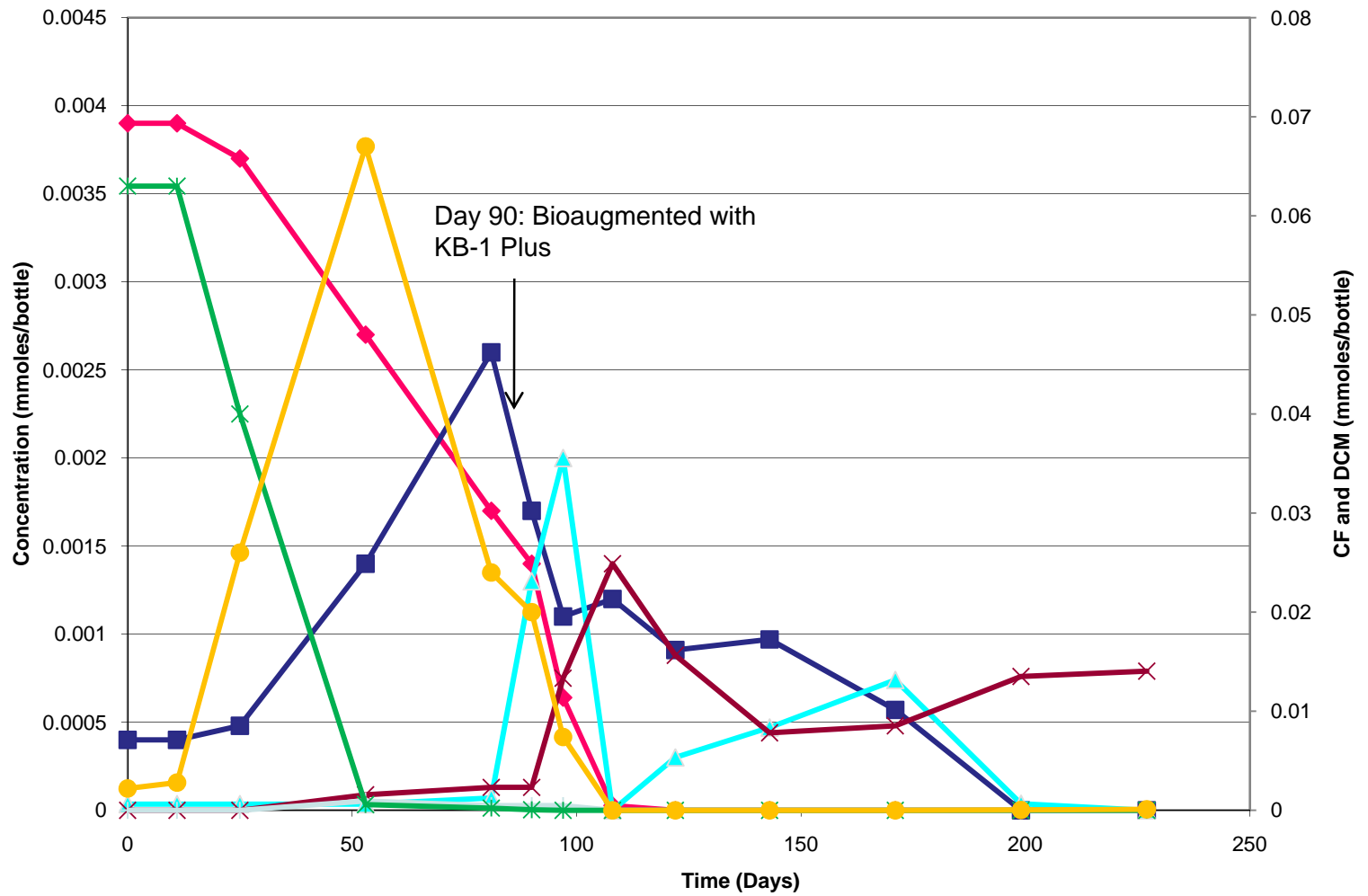
[http://science.nasa.gov/headlines/y2004/18may\\_wastenot.ht](http://science.nasa.gov/headlines/y2004/18may_wastenot.ht)

# Biotreatability testing results: 1122TECA + TCE



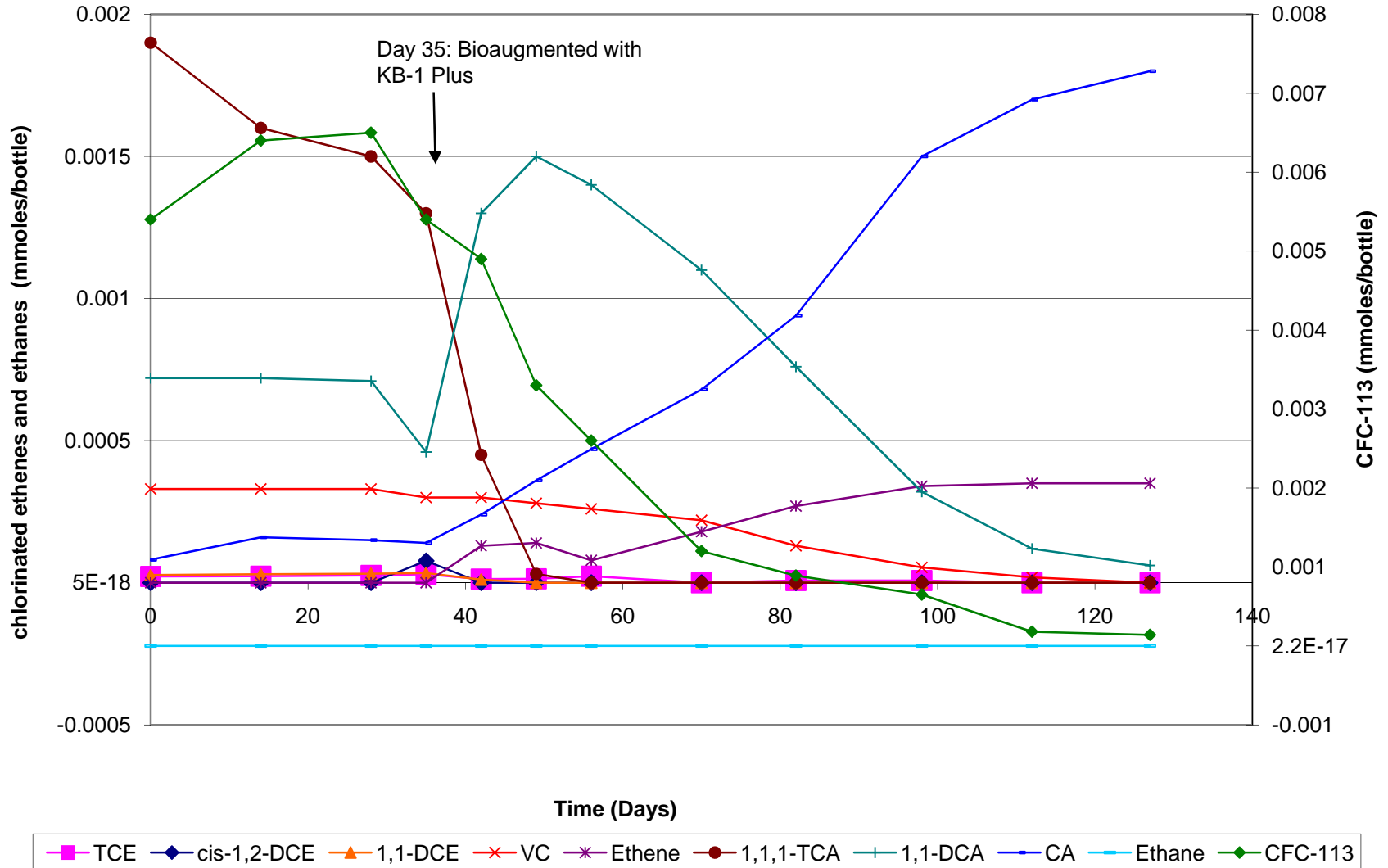
- TCE
- ▲ tDCE
- ✱ Ethene
- + 1,1,2-TCA
- ◆ CA
- ◆ cDCE
- ✱ VC
- 1,1,2,2-TECA
- 1,2-DCA
- · - Bioaugmented with KB-1® Plus

# Biotreatability Testing Results: CF (40 mg/L) and TCE (2 mg/L)

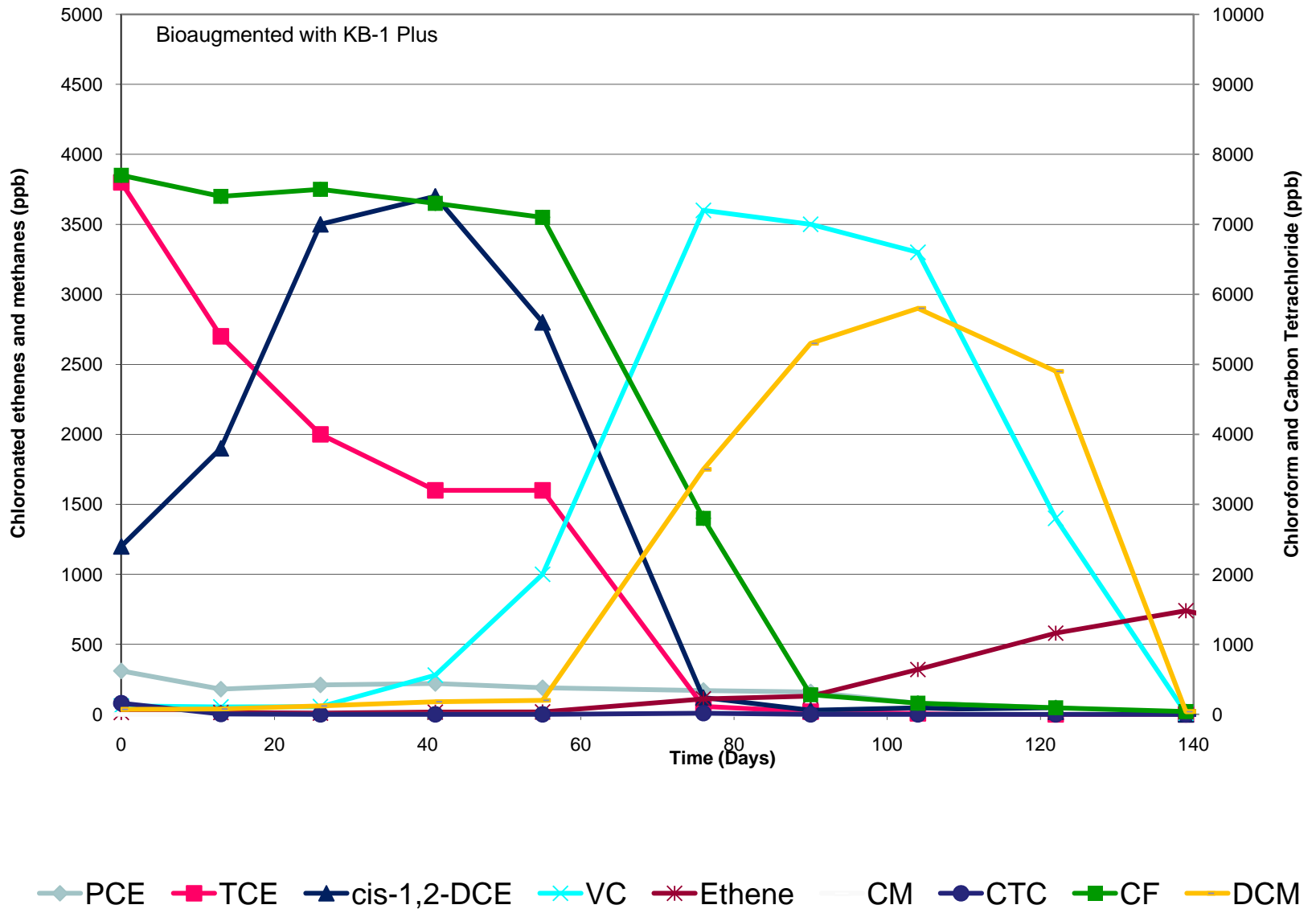


◆ TCE    ■ cis-1,2-DCE    ▲ VC    × Ethene    ▲ CM    \* CF    ● DCM

# Biotreatability Testing: 1,1,1-TCA and CFC-113



# Biotreatability Study Results: 3.8 mg/L TCE and 7.7 mg/L CF



# Summary

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- Potential Dhc inhibitory compounds include TCA, CF and CFCs
- Mixed cultures containing both Dhc and Dhb effective
- Treatability testing important evaluation tool
- Future work: field demonstrations

# Questions/Comments?...

**Further Information...**

**[www.siremlab.com](http://www.siremlab.com) Toll Free: 1-866-251-1747**

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