# Bio-traps and Site Assessment Strategies for Groundwater Impacted by Chlorinated Hydrocarbons

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Microbial Insights, Inc

THE UNIVERSITY of TULSA

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# What Are Bio-Trap® Samplers?

Passive sampling tool for microbes

Collects **active** microbes

Integrated sample vs. "snapshot"

Analyzed using molecular biological tools, analytical chemistry, and stable isotope analysis


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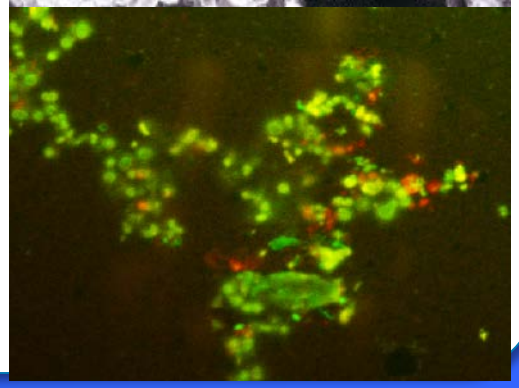
# How Do Bio-Traps Work?

## Properties of Bio-Sep Beads

- 3-4 mm in diameter
- 25% Nomex and 75% PAC
- 74% porosity
- 600 $m^2$ of surface area/g
- Heat sterilized 270 $^oC$
- Colonized by **active** microbes





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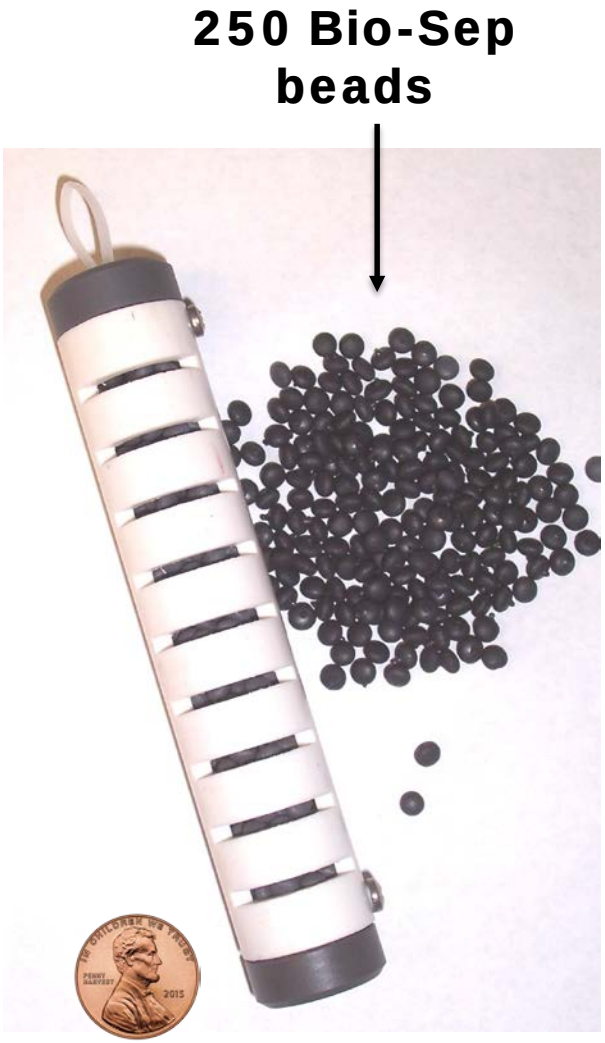
# Types of Bio-Trap Samplers

## Standard Bio-Trap

- Basic design
- Sampling groundwater, surface waters, sediments, soils
- Compatible with all MBTs, analytical chemistry, and stable isotope techniques

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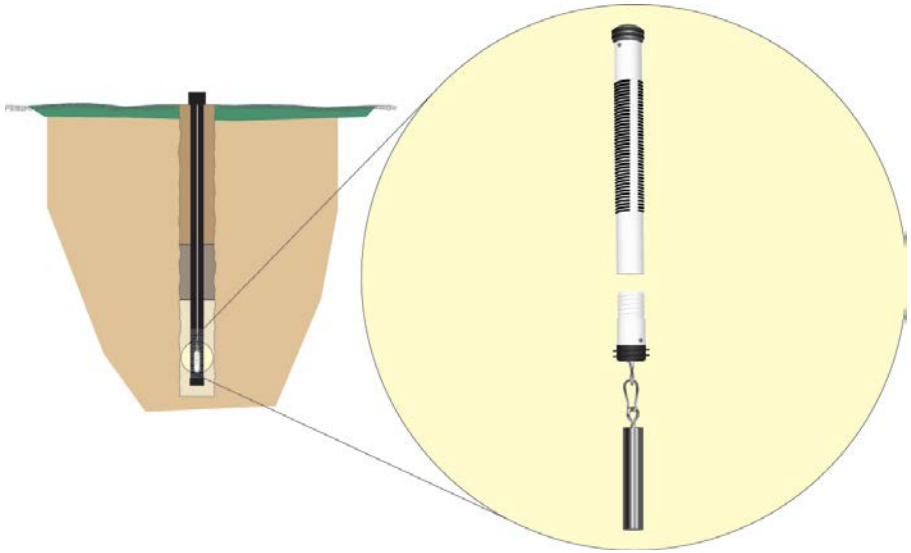
# *In Situ* Microcosm Unit Samplers



Supplier

COC

MICRO
(Bio-Trap)

GEO

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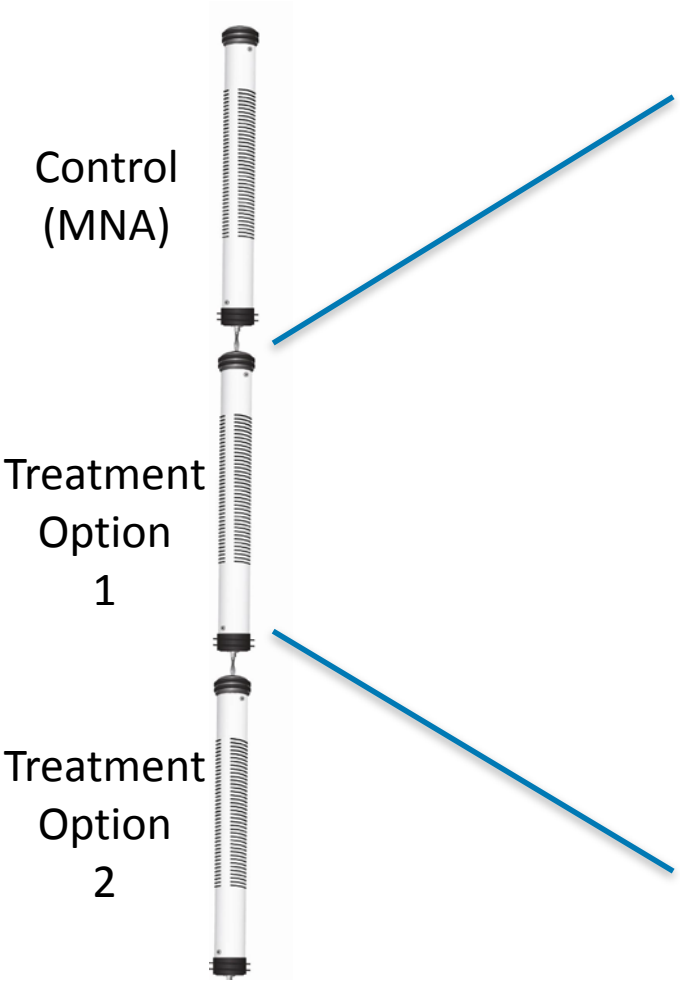
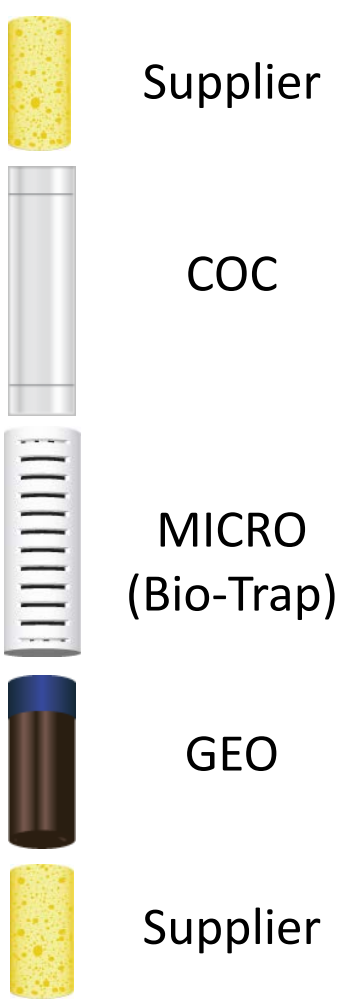
# Assembly




# Unit

# Samplers

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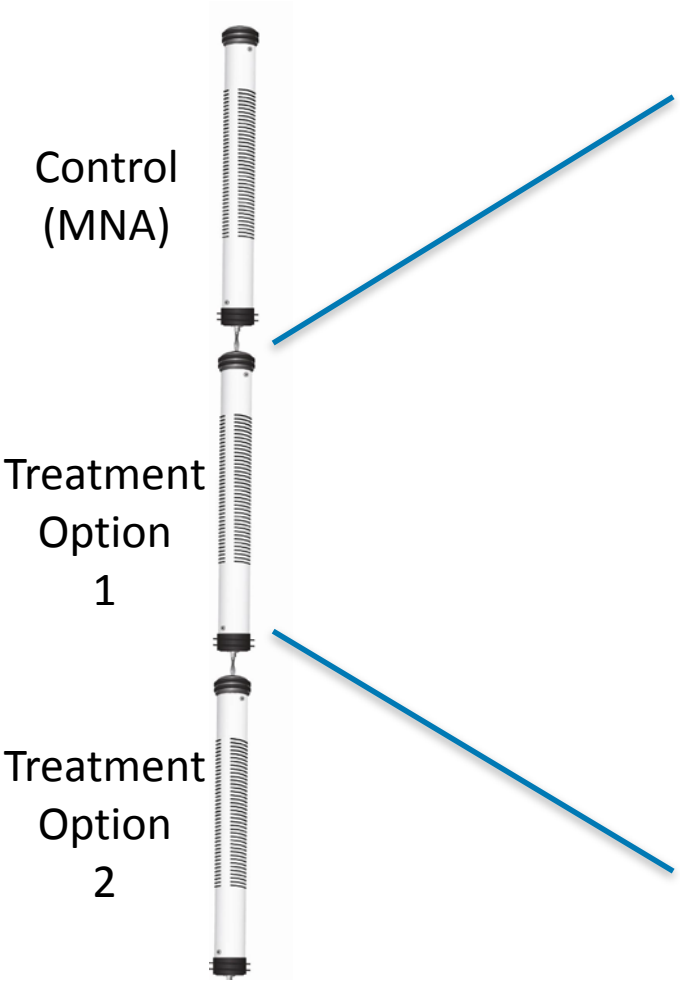


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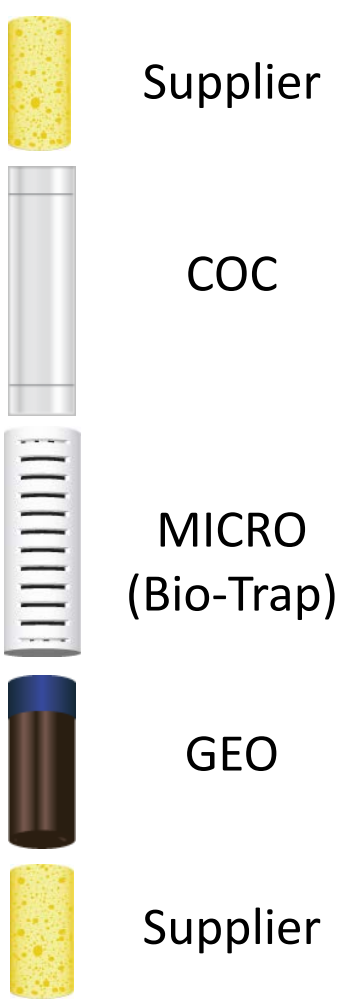


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# Amendments Include:

## Electron Donors

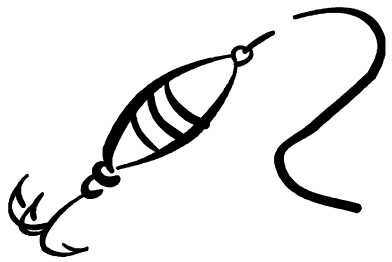
- Vegetable oil
- Molasses
- HRC
- EOS
- Lactate
- And more

## Electron Acceptors

- Oxygen (PermeOx, ORC)
- Nitrate
- Iron (III)
- Sulfate
- And more

## Stable Isotope Compounds ($^{13}C$)

- Benzene
- Toluene
- p-Xylene
- MTBE
- TBA
- Naphthalene
- Chlorobenzene
- 1,4-Dioxane
- Sulfolane
- And more



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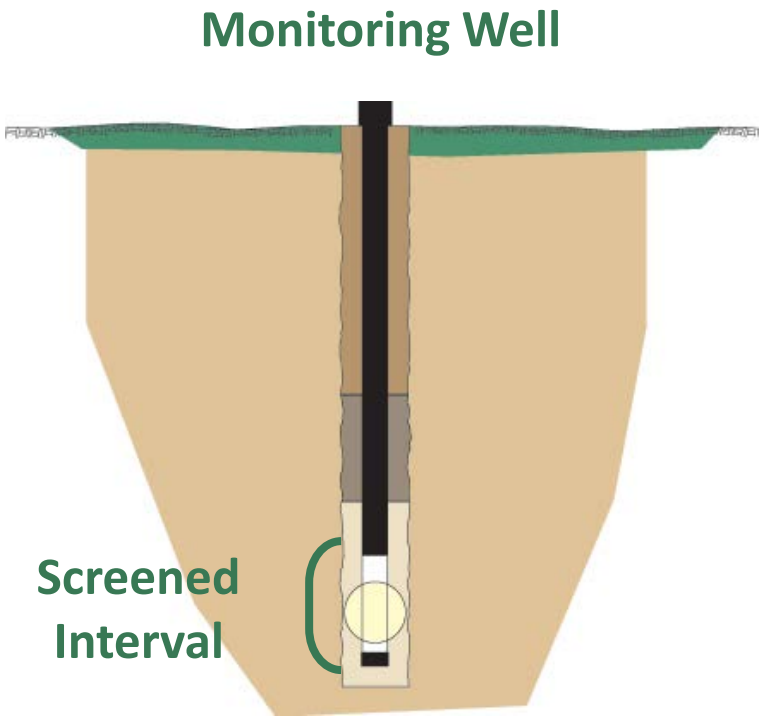
# How Are Bio-Trap Samplers Deployed?

Purge monitoring well

Suspend from top of casing

Deploy within the screened interval at depths of interest.

If large fluctuations in the water level are anticipated suspended from a float.

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# How Are Bio-Trap Samplers Analyzed:

## Molecular Biological Tools

- PLFA
- CENSUS (qPCR)
- QuantArrays
- DGGE
- Stable Isotope Probing (SIP)

## Chemical Analysis

- Compound specific isotope analysis (CSIA)
- Dissolved Inorganic Carbon (DIC)
- Contaminant Concentrations

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# What Can I Do With a Bio-Trap Sampler?

- Determine if known degraders of a COC are present
- Evaluate monitored natural attenuation versus enhanced bioremediation
- Compare effectiveness of amendments designed to stimulate bioremediation
- Prove that bioremediation of a specific compound is occurring

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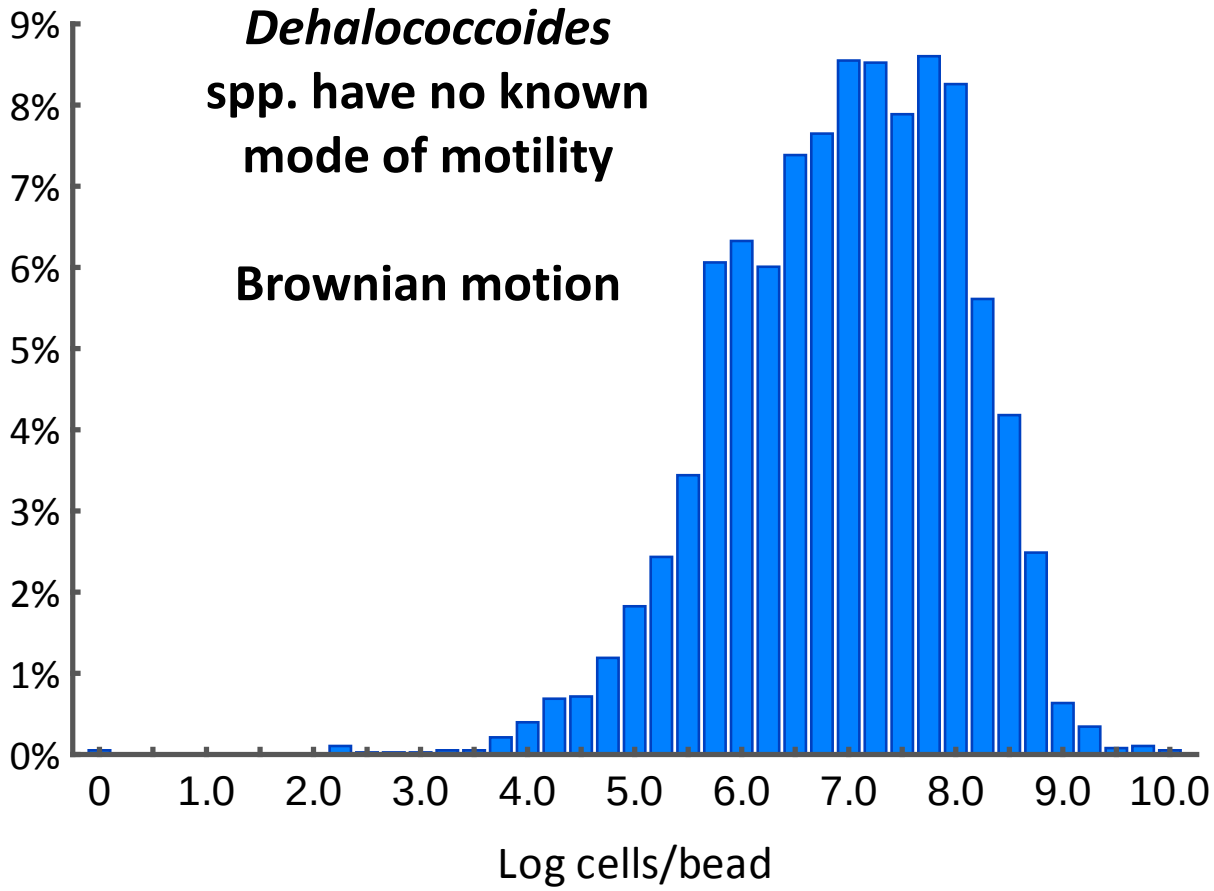
# Microbial Insights Database - *Dehalococcoides*

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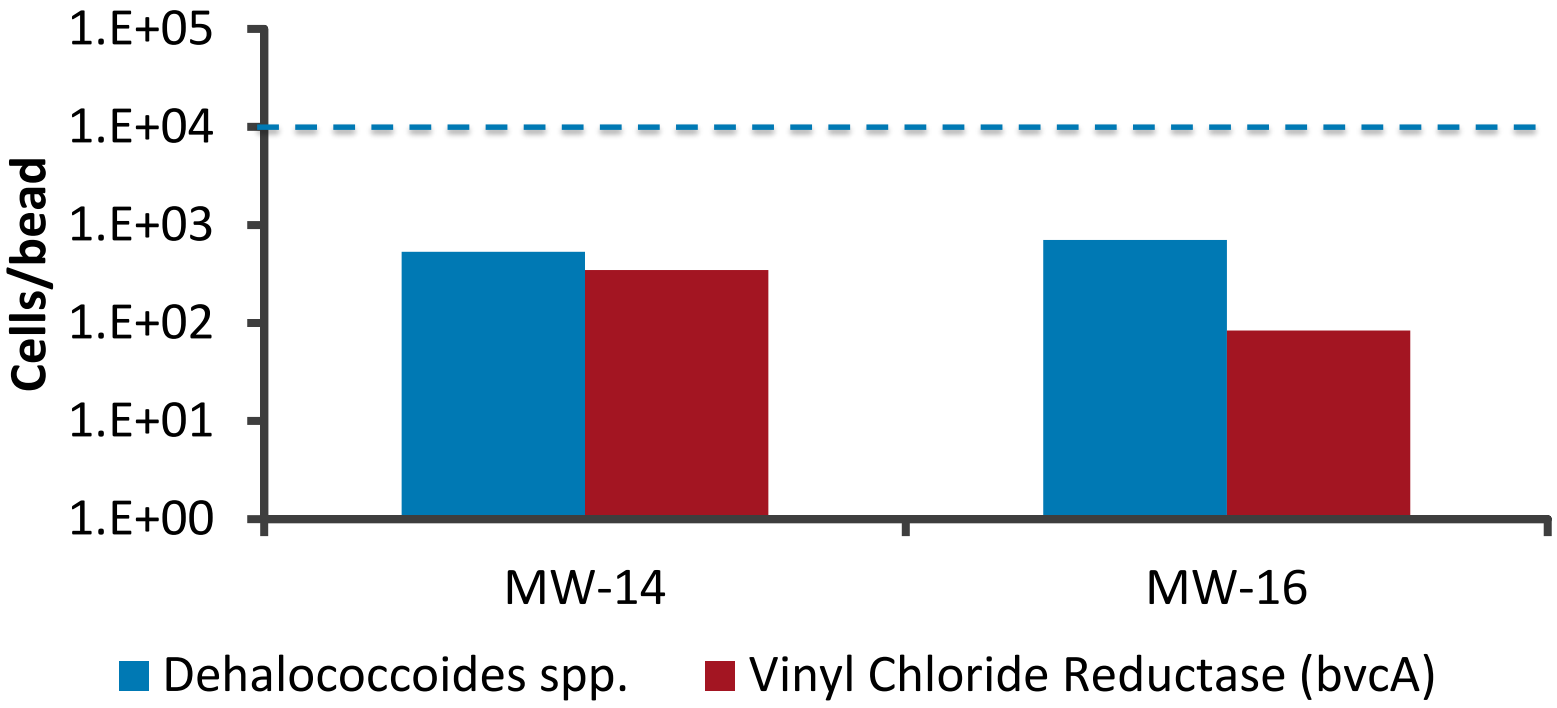
# Determine If Known Degraders Are Present




CENSUS® - *Dehalococcoides* populations indicate the potential for complete reductive dechlorination of PCE to ethene but stimulation needed

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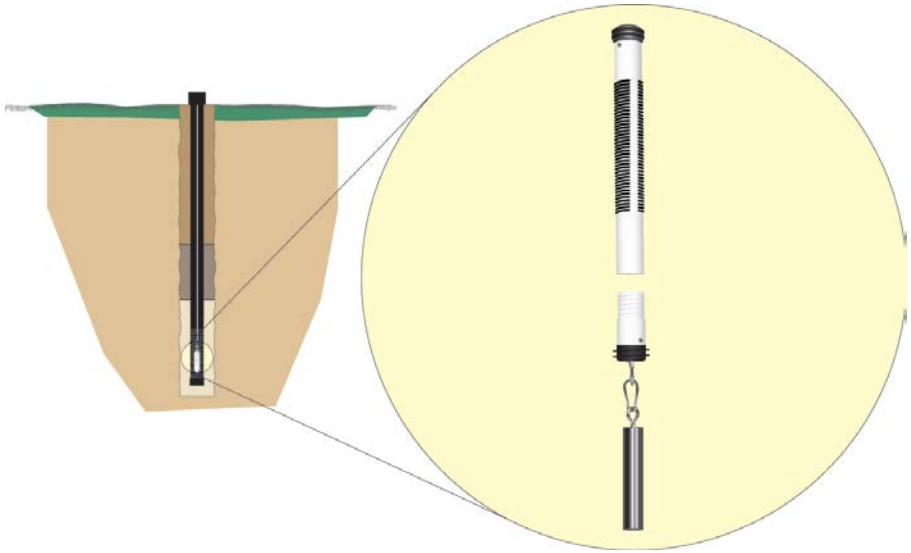

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| Samplers | Analysis | Lines of Evidence |
|---|---|---|
| COC | VOCs | • Contaminant concentrations<br>• Daughter product formation |
| MICRO (Bio-Trap) | CENSUS® | • Quantify specific microbial populations and processes |
| | SIP | • Prove biodegradation<br>• Compare relative rates<br>• Compare degree of contaminant incorporation |
| GEO | Anions | • Redox conditions |
| | Dissolved Gases | • Ethene & Ethane production |
| Supplier | | |

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# Screening Remediation Options: Chlorinated hydrocarbon impacted site

**Control (MNA)**

**Control Unit**

- Evaluate MNA as treatment alternative
- Baseline for enhanced remediation options

**BioStim (Electron Donor)**

**BioStim Unit – Electron Donor Addition**

- Enhanced anaerobic bioremediation
- Lactate, HRC, EOS

**BioAug (Electron donor + culture)**

**BioAug Unit – Culture and Electron Donor**

- Bioaugmentation (culture impregnated in beads in the bio-trap)

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# Case Study:  Amended ISMs

Chlorinated Solvent Site

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# Site Background

- Shallow aquifer impacted by chlorinated solvents, primarily trichloroethene (TCE).
- Daughter product *cis*-1,2 dichloroethene (DCE) has been detected.
- DCE appears to be accumulating with no observed production of vinyl chloride or ethene ("DCE stall").
- Biostimulation (electron donor addition) and bioaugmentation (donor and culture) were being considered as remediation strategies.

# Site Specific Questions

## Microbiology

Are organisms capable of complete reductive dechlorination of TCE to ethene (*Dehalococcoides*) present under MNA conditions?

Will addition of an electron donor stimulate growth of these key dechlorinating bacteria?

Will a bioaugmentation culture survive?

Is bioaugmentation necessary?

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# Site Specific Questions

## Chemistry

Will electron donor addition promote daughter product formation and stimulate complete reductive dechlorination?

Will bioaugmentation + biostimulation more effectively stimulate reductive dechlorination than biostimulation alone?

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# Study Design

## Assembly

Control (MNA)

BioStim

BioAug

## Unit

## Samplers

Supplier

COC

MICRO (Bio-Trap)

GEO

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## Potential Lines of Evidence

**VOCs:** Differences in TCE and daughter product concentrations

**CENSUS:** *Dehalococcoides* and vinyl chloride reductase genes

**Dissolved Gases:** Ethene production

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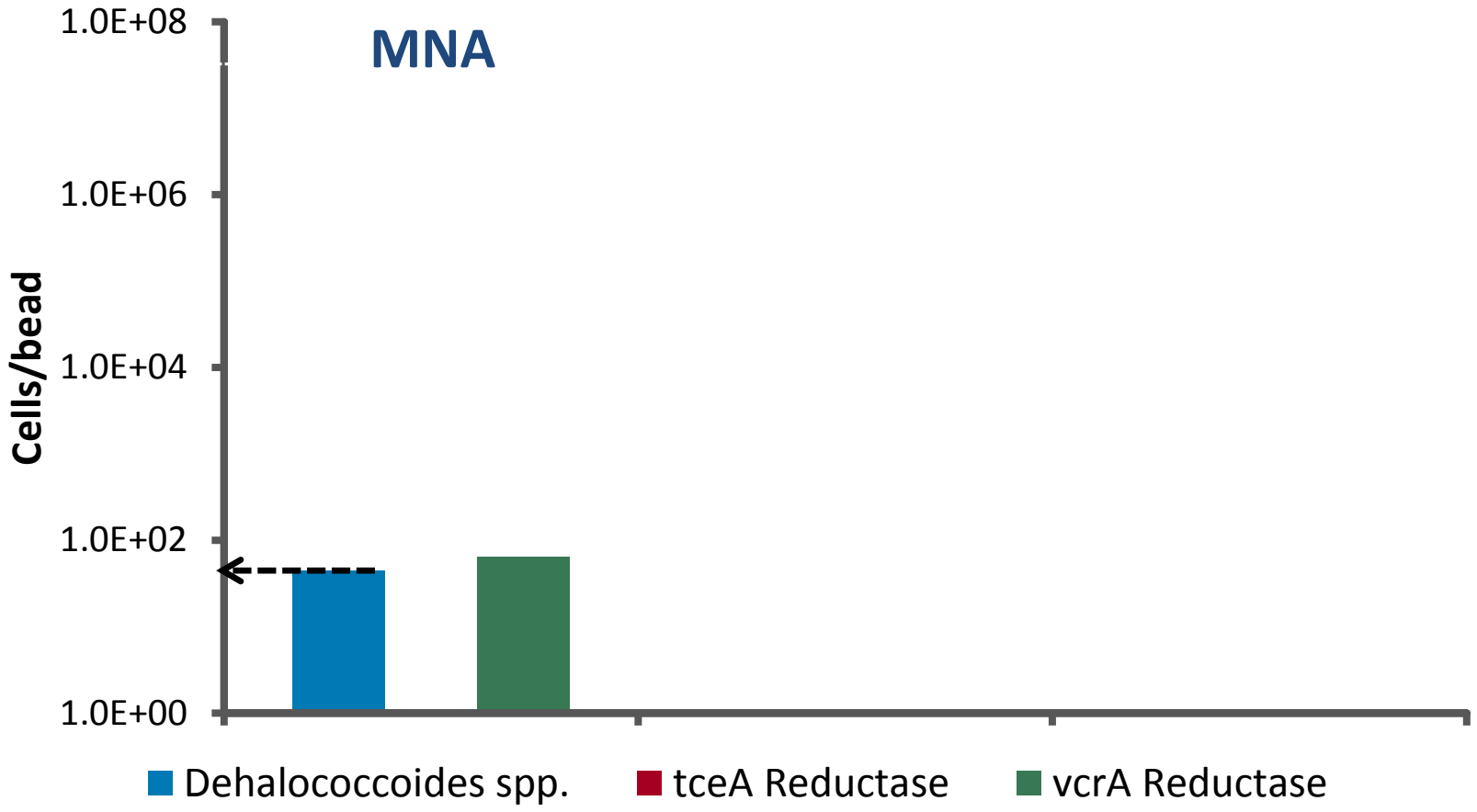
# Control (MNA) Unit – CENSUS® qPCR Results

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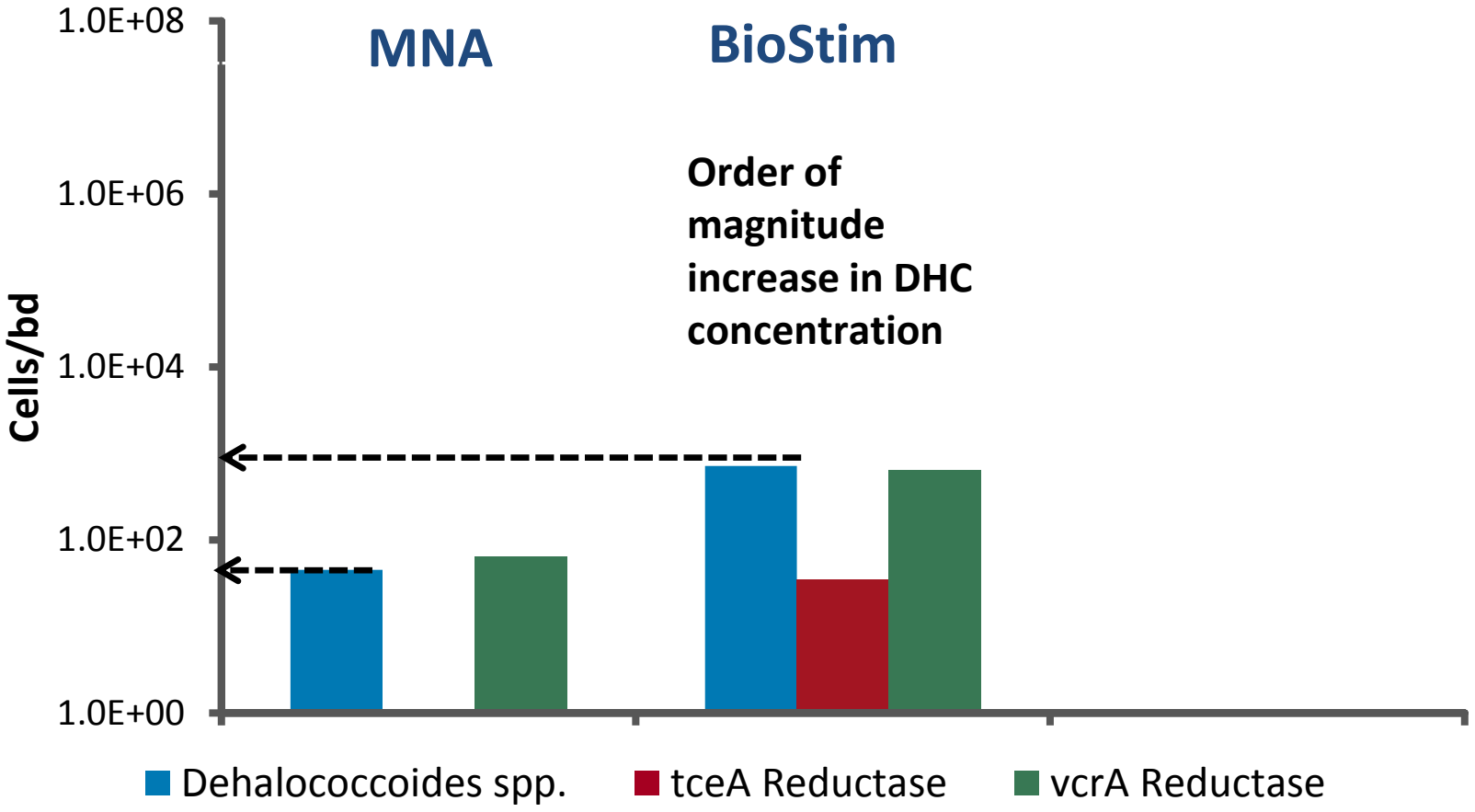
# MNA vs BioStim

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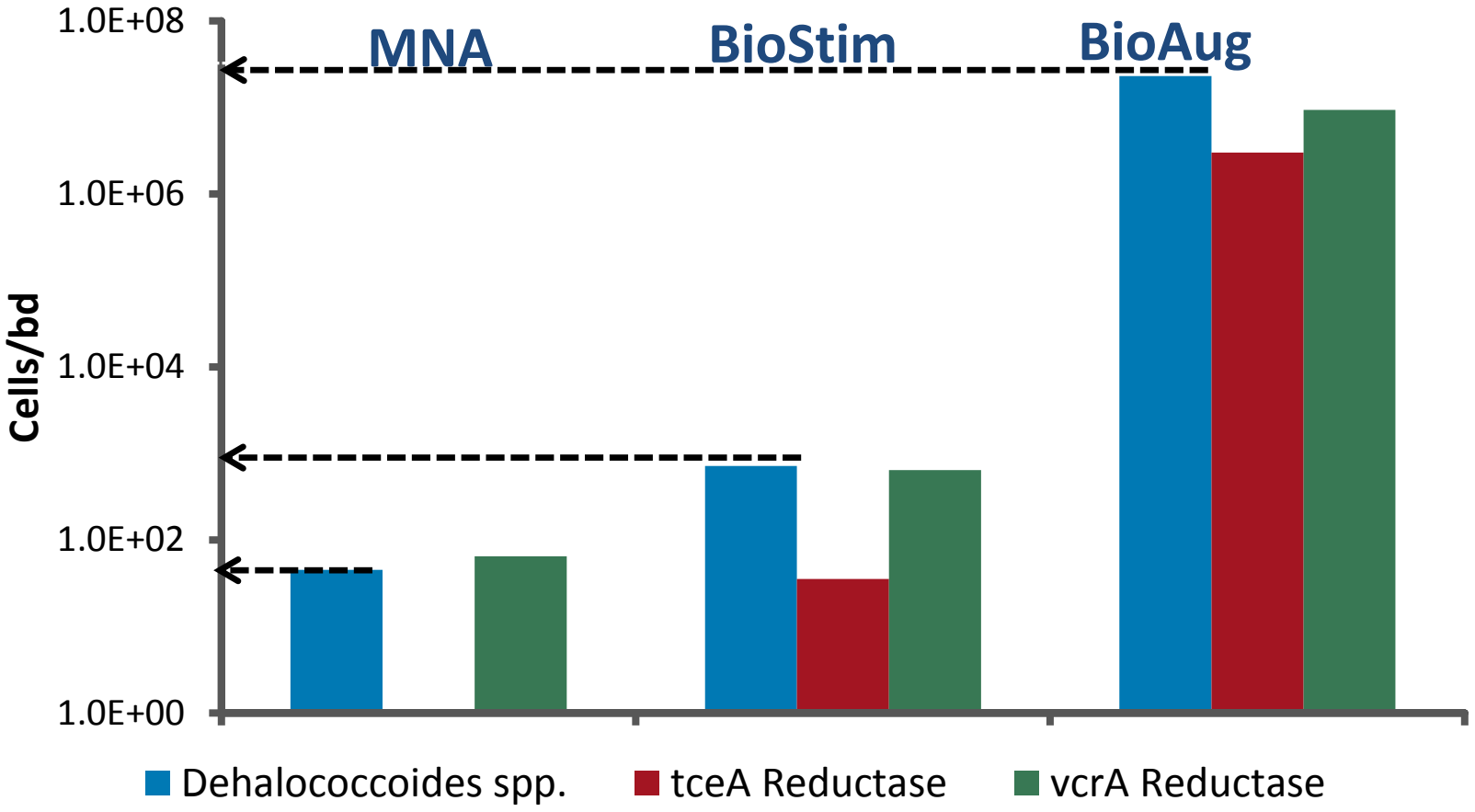
# MNA vs BioStim vs BioAug

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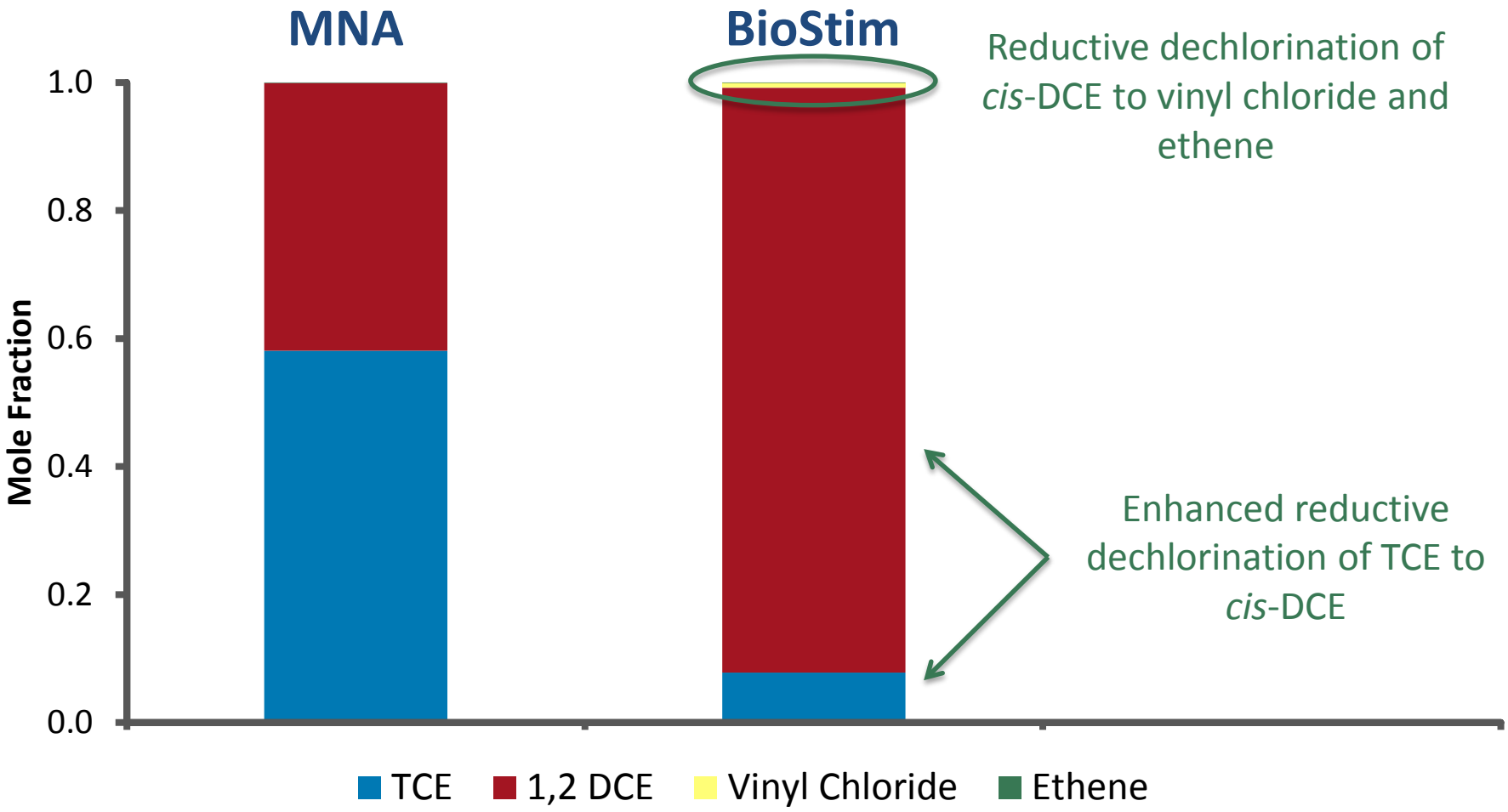
# Control vs. BioStim – Impact on COCs

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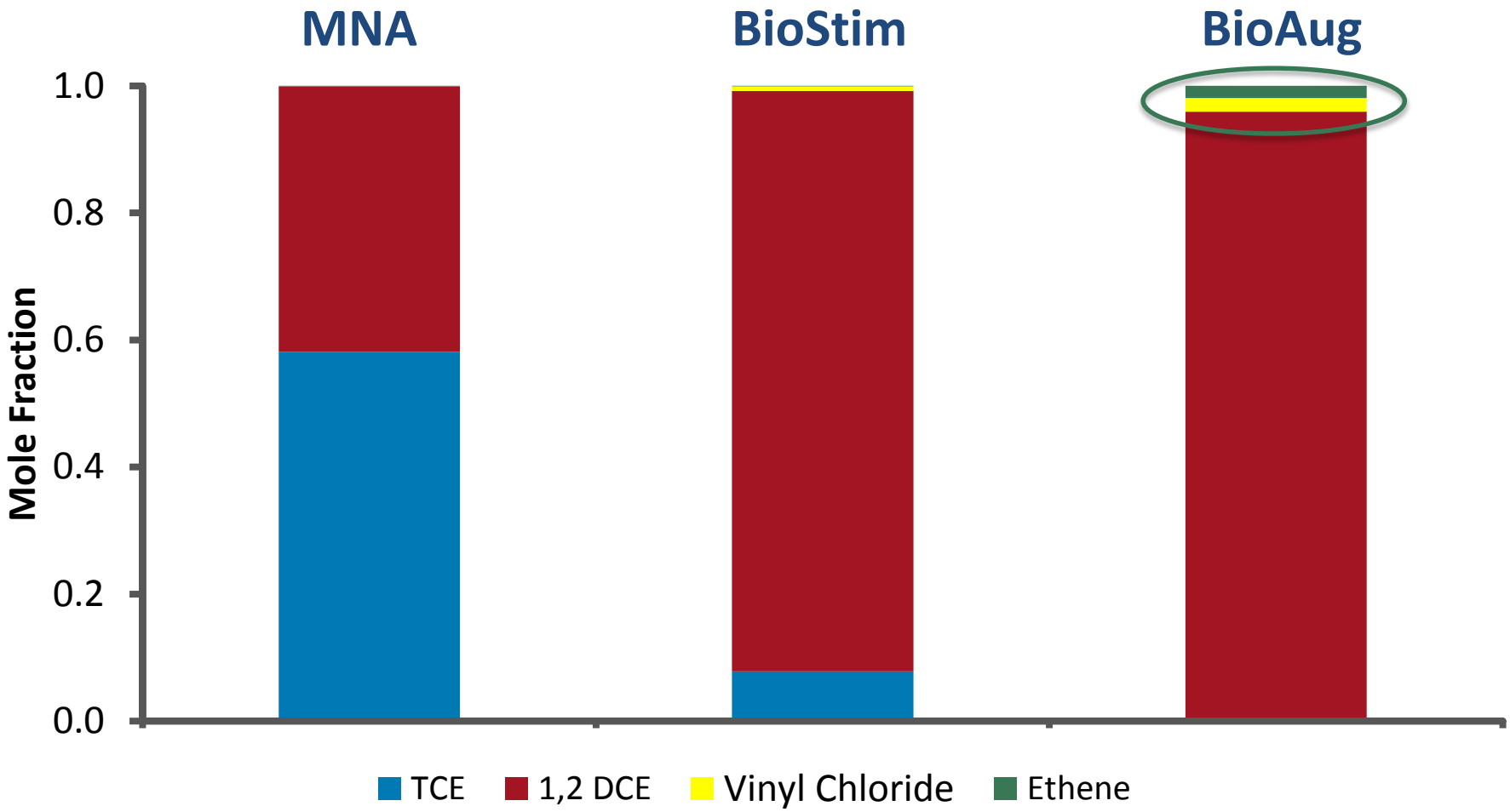
# BioStim vs. BioAug – Impact on COCs



# Bio-traps and Chlorinated Hydrocarbon Impacted Sites

- Standard bio-traps can measure degradation potential by quantifying *Dehalococcoides* and functional genes characteristic of reductive dechlorination (pre- or post-injection)
- Bio-traps coupled with *in situ* microcosms can compare effectiveness of amendments designed to stimulate bioremediation

For a copy of this presentation email kerry-sublette@utulsa.edu

For more information go to *microbe.com*

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