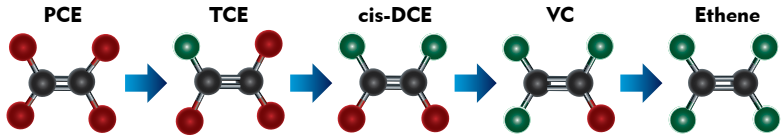
CENSUS® – Reductive Dechlorination

CENSUS® MOLECULAR BIOLOGICAL TOOL

Detect and quantify Dehalococcoides and other bacteria capable of reductive dechlorination

Under anaerobic conditions, certain bacteria can use chlorinated ethenes (PCE, TCE, DCE, and VC) as electron acceptors in a process called reductive dechlorination. The net result is the sequential dechlorination of PCE and TCE through daughter products DCE and VC to non-toxic ethene, which volatilizes or can be further metabolized.



Successful reductive dechlorination can be hindered by a few site-specific factors that cannot be evaluated with chemical and geochemical tests including:

- a lack of a key dechlorinating bacteria including *Dehalococcoides*, the only known bacteria that completely dechlorinates PCE and TCE to non-toxic ethene
- reasons for incomplete dechlorination and the accumulation of daughter products (DCE stall)

CENSUS® provides the most direct avenue to investigate the potentials and limitations to implementing corrective action plan decisions and to target a variety of organisms involved in the reductive dechlorination pathway.

Target	Code	Contaminants	Environmental Relevance / Data Interpretation
Dehalococcoides	qDHC	PCE, TCE, DCE, VC	Only known group of bacteria capable of complete dechlorination of PCE and/or TCE to ethene Absence of *Dehalococcoides* suggests dechlorination of DCE and VC is improbable and accumulation of daughter products is likely The presence of *Dehalococcoides* even in low copy numbers indicates the potential for complete reductive dechlorination Higher copy numbers and the presence of daughter products suggest that dechlorination may be occurring
Dehalococcoides Functional Genes	qTCE qVC	TCE, VC	Functional genes encoding reductive dehalogenases for TCE and VC Presence of TCE reductase indicates the ability to reduce TCE to DCE and VC Presence of VC reductase indicates the potential for reductive dechlorination of VC to ethene Absence of VC reductase suggests that VC may accumulate
Dehalobacter	qDHB	DCA, TCA, PCE, TCE	Capable of dechlorination of PCE and TCE to cis-DCE Converts TCA, a common co-contaminant at PCE/TCA-impacted sites to chloroethane
Desulfuromonas	qDSM	PCE, TCE	Capable of dechlorination of PCE and TCE to cis-DCE using acetate as an electron donor
Desulfitobacterium	qDSB	PCE, TCE	Capable of dechlorination of PCE and TCE to cis-DCE
Total bacteria	qEBAC		Index of total bacterial biomass Domain level
Methanogens	qMGN		Methanogens utilize hydrogen and carbon dioxide to produce methane Compete with dechlorinating bacteria for available hydrogen
Sulfate Reducing Bacteria	qAPS		Targets functional gene involved in sulfate reduction SRB can compete with dechlorinating bacteria for available hydrogen

When combined with chemical and geochemical groundwater monitoring programs, CENSUS® results provide a valuable tool to determine:

- the feasibility of bioremediation of PCE/TCE under MNA conditions
- the ability of bioremediation approaches to meet overall treatment goals
- the effectiveness of enhanced bioremediation (e.g. sodium lactate or vegetable oil injection) to promote reductive dechlorination

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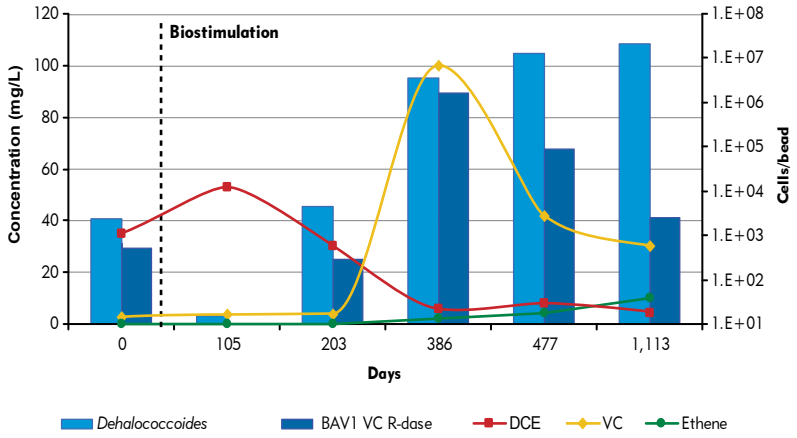
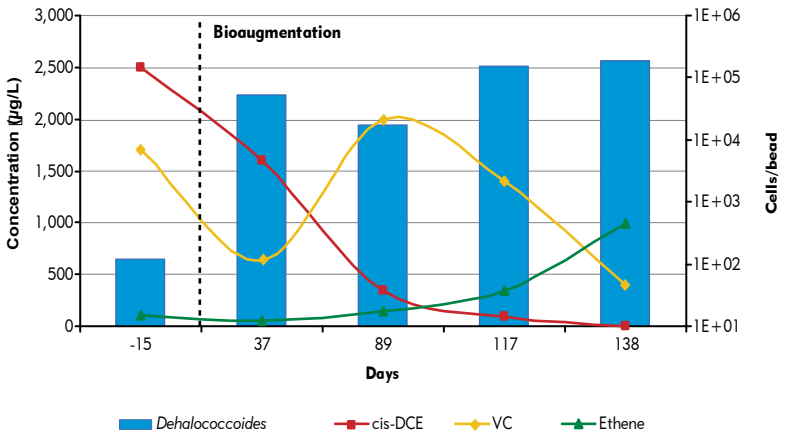
Biostimulation



- The relatively low *Dehalococcoides* (DHC) population (10^3 cells/bead) and the accumulation of the daughter product DCE indicated that monitored natural attenuation (MNA) would not meet remediation goals in an acceptable timeframe.
- Following HRC® injection to promote reductive dechlorination, the DHC population increased to 10^6–10^7 cells/bead with a corresponding decrease in DCE.
- Vinyl chloride (VC) concentrations temporarily increased due to the reductive dechlorination of DCE.
- As indicated by the high number of DHC and VC reductase genes however, microorganisms capable of reductive dechlorination of VC were present.
- VC concentrations decreased after the initial spike with a corresponding increase in ethene.

Bioaugmentation



- Initially, the *Dehalococcoides* (DHC) population was low (10^2 cells/bead) and daughter products had accumulated suggesting MNA would not provide complete reductive dechlorination of PCE.
- Following bioaugmentation, the DHC population increased by 3 orders of magnitude with a corresponding decrease in DCE.
- Vinyl chloride (VC) concentrations temporarily increased due to the reductive dechlorination of DCE.
- The continued detection of DHC, however, indicated the potential for complete reductive dechlorination.
- VC concentrations decreased with a corresponding increase in ethene production.

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