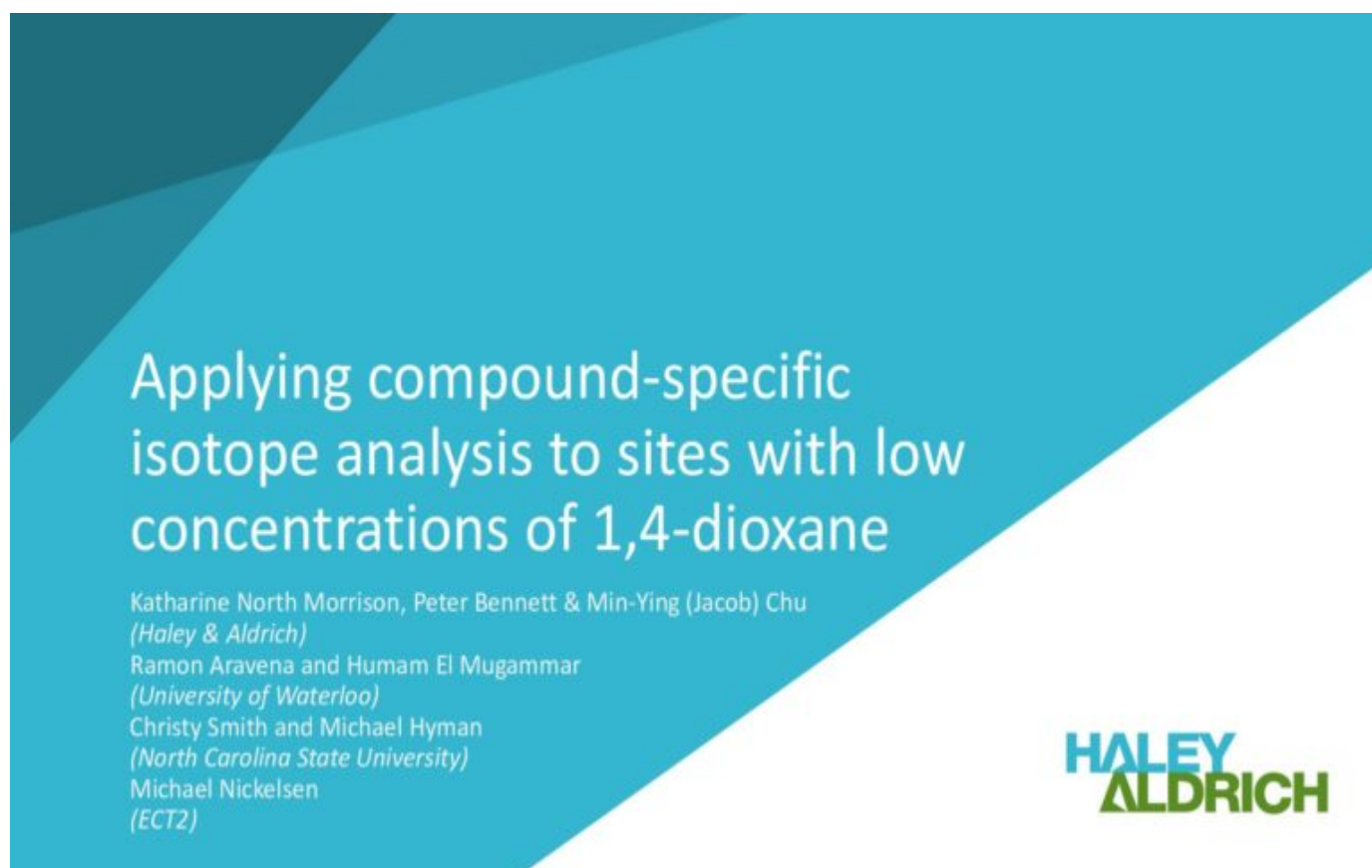


2019 Battelle Bioremediation Symposium technical presentations and posters

Haley & Aldrich experts presented their research at Battelle's 2019 Bioremediation Symposium (the Fifth International Symposium on Bioremediation and Sustainable Environmental Technologies), held this April in Baltimore, Maryland. Our involvement included several platform presentations and technical posters as well as a panelist, on topics ranging from 1,4-dioxane to CVOCs. Scroll down and click on any of the thumbnail images to view the presentations and posters.

Applying compound-specific isotope analysis to sites with low concentrations of 1,4-dioxane



Insights into variability of cometabolic degradation kinetics of 1,4-dioxane and co-contaminants under prolonged starvation conditions

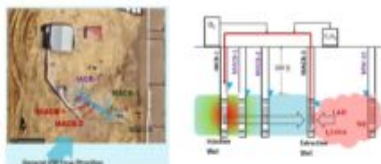
Insights into variability of cometabolic degradation kinetics of 1,4-dioxane and co-contaminants under prolonged starvation conditions

Min-Ying Jacob Chu
Haley & Aldrich, Inc.

HALEY
ALDRICH

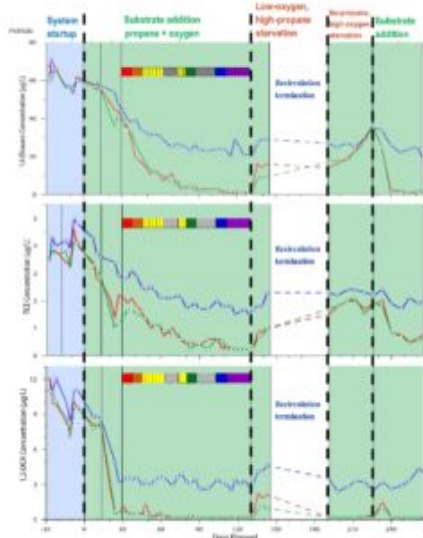
Background

Aerobic cometabolic biodegradation (ACB) has been shown to degrade a suite of chlorinated solvent compounds and emerging contaminants, such as 1,4-dioxane (1,4-D), 1,2,3-TCE, and NDMA. It is generally believed that cometabolic processes cannot be sustained long without primary substrate. When reserved energy obtained from primary substrate is used up, ACB is expected to stop. To understand the effects of lacking primary substrate on the longevity of stimulated ACB activity in situ, the trends of stimulated in situ microbial degradation activity on 1,4-D, TCE, and 1,2-DCA during a field pilot test were monitored under starvation conditions (i.e., no primary substrate addition).



Treatment efficiency of ACB for a dilute plume at the former McClellan AFB

Chemical	$C_{\text{in}} (\text{mg/L})$	$C_{\text{out}} (\text{mg/L})$	$C_{\text{in}} (\text{mg/L})$	Site-Specific Cleanup Goal	Single Pass Efficiency	Overall Efficiency
1,4-D	66	21	0.77	6.1	~96%	~99%
1,2-DCA	11.7	2.9	< 0.18	0.5	~97%	~99%
1,1-DCE	1.3	0.3	< 0.2	6	~67%	~82%
TCE	3.9	1.5	0.24	5	~84%	~93%



Degradation rate variability under starvation conditions

- 1,2-DCA degradation lasted approximately 3 months under the starvation conditions of low-oxygen or no-propane-addition conditions. When oxygen became available, 1,2-DCA was degraded quickly.
- Some TCE degradation was observed over the period of 3 months under both starvation conditions. More oxygen during the no-propane-starvation period did not increase degradation rate.
- 1,4-D degradation was affected by the low-oxygen conditions. The no-propane-starvation conditions eventually resulted in a complete loss of 1,4-D degradation activity (about 2-3 weeks).

Possible explanations of the observations

Low-oxygen, high-propane-concentration conditions:

- Many aerobic bacteria can metabolize under microaerobic conditions. At a low dissolved oxygen level, degradation of contaminants may still sustain by stimulated microbial population at a lower rate. The degradation activity for all contaminants was reduced by a similar extent, suggesting a common factor for observed lower activity.

No-propane, high-oxygen starvation conditions:

- Starvation may enhance expression of monooxygenases (R. jostii RHA1 and PrMO). Some ACB bacteria may use intracellular storage compounds to sustain contaminant degradation.
- 1,2-DCA is likely to be degraded by some common enzymes expressed under organic substrate conditions.
- Different types of enzymes and/or different groups of microorganisms are likely responsible for degradation variability. It is evidenced by the observation that enzymes/bacteria responsible for 1,4-D degradation are not as resilient as those for 1,2-DCA and TCE degradation.

Stable carbon and hydrogen isotope ratios for assessing fate and transport of 1,4-dioxane

Stable carbon and hydrogen isotope ratios for assessing fate and transport of 1,4-dioxane

Min-Ying Jacob Chu
Peter Bennett

5th International Symposium on Bioremediation & Sustainable Environmental Technologies
Baltimore, MD. April 15-18, 2019

HALEY
ALDRICH

Use of MBTs for decision-making following thermal remedy

HALEY
ALDRICH

Use of MBTs for decision-making following thermal remedy

Elizabeth Bishop



Rapidly reducing chlorinated solvents in multiple media (without upsetting the neighbors!)

Rapidly reducing chlorinated solvents in multiple media (without upsetting the neighbors!)



Peter Zawadzka, Elizabeth Bishop, Douglas Lindsay | pzawadzka@haleyaldrich.com | Haley & Aldrich

Site background

- Generations of industrial and commercial uses since the 1800s (see figure)
- High resolution site characterization revealed historic structures and process equipment
- Located in densely populated Boston neighborhood. Adjacent included high-occupancy residential, public transportation, and the local high school
- PCBs, mercury, and asbestos contamination in soil managed prior to CVOC remediation
- Residual petroleum NAPL co-mingled with CVOC source area



Project challenges

OVERALL CHALLENGE: Achieve Massachusetts groundwater cleanup standards on a site contaminated by high concentrations of CVOCs on developer's construction timeline.

Specific challenges:

- Health & safety: Ongoing construction activities in tandem with remediation activities, handling of remedial amendments and injection under pressure, in addition to inherent risks of soil vapor off-gassing to on-site workers, adjacent residents and public high school.
- Contamination: Initial concentrations of VOCs indicative of potential presence of free phase product (> 700,000 parts per billion of TCE)
- Complex urban brownfield: Broad expertise needed on multiple topics to achieve client goals and MassDEP requirements
- Integrated services: Collaboration with Haley & Aldrich geotechnical design team to create innovative solutions that avoided interfering with ongoing remedial considerations, vapor intrusion mitigation and redevelopment timeline

Remedial selection

- Various remedial alternatives were evaluated to treat Site CVOCs including in-situ chemical oxidation, dig and haul, and in-situ enhanced reductive dechlorination (ERD). ERD approach ultimately selected. Due to elevated concentrations present, in-situ soil mixing event was proposed for shallow soil and groundwater and injections proposed for deeper groundwater.
- Building construction designs were modified to include a sub-slab vapor barrier and mitigation system that could be run in either passive or active modes.

Safety considerations

- Real-time dust monitoring for potential exposure to soil contaminants such as metals, PCBs, and asbestos
- Mitigated vapor risks to on-site personnel and site neighbors during remedial tasks such as soil mixing
- Active construction site during remediation, building activities occurring simultaneously with remediation

Remedial implementation (CVOCs)

For treatment of TCE and degradation products present in soil as well as shallow and deep groundwater, two remedial steps completed:

Step 1:

- Soil mixing with approximately 50,000 pounds of zero-valent iron (ZVI) and electron donor in shallow groundwater zone



Step 2:

- In-situ injection of ZVI and electron donor in deeper groundwater zone



Step 3:

- Follow-up in-situ injection of ZVI and electron donor in shallow and deep zone to further enhance remediation

Step 4:

- Construction of on-site building included sub-slab vapor mitigation system and continuously accessible groundwater injection and monitoring points.



Remedial outcome

- Created strongly reducing conditions with elevated ethene and ethane present, showing complete degradation of TCE, and strongly reduced iron present, mostly in ferrous state
- Concentrations of dichloroethene (DCE) of between 10" to 10" gone down per liter, with elevated reductants, and dechlorinated (DHO) between 10" to 10" gone down per liter, without biodegradation
- Plume contraction in both shallow and deep plumes leading to low plume fringe concentrations and limited off-site impacts
- Elevated degradation product and end product formation, with ethene present in parts per million concentration ranges up to 9 mg/L in source area wells
- Source area groundwater concentrations of TCE decreased between 44% and 100% in deep groundwater and between 62% and 100% in shallow groundwater



Highlights

- Project completed on schedule, within the remedial budget, with protection of potential receptors, and no health or safety incidents
- Worked in a heavily collaborative team of remediation, regulatory (MassDEP, TSCA), and geotechnical experts and architectural, foundation and construction contractors. Building specifically designed to not inhibit remedial activities or preclude site conditions through use of grouted micropiles, early-stage design of sub-slab mitigation system, and monitoring and injection well design that remained accessible during and after construction
- Rapid removal of source area mass has made former brownfield viable for beneficial reuse, currently an active commercial property
- Lessons learned: Need for well characterization and look at site—holistically—taking into account health and safety considerations, receptors, contamination concentrations, geotechnical needs for reconstruction, and client's goals and timelines

