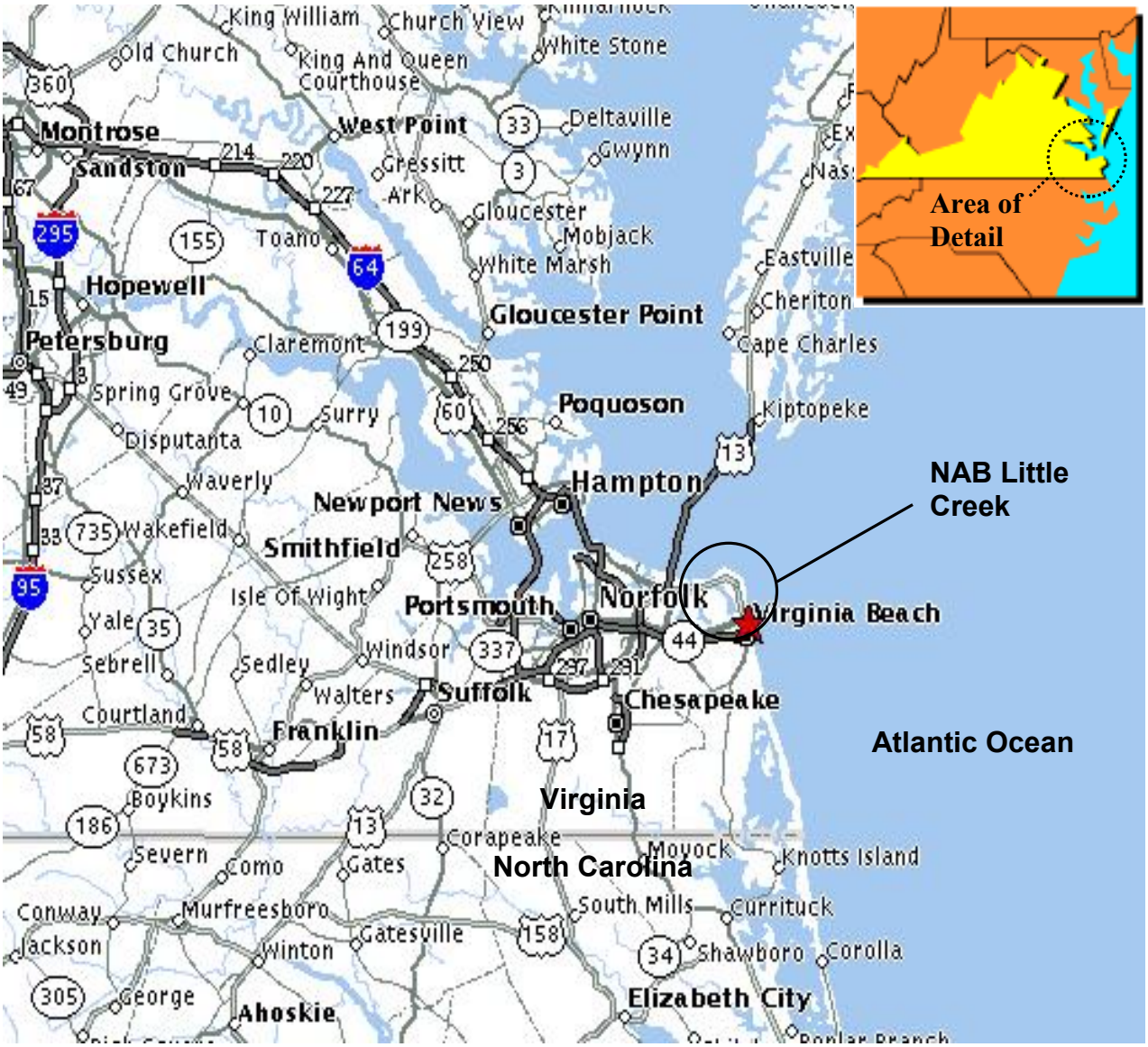


Figure 1. Site location plan for Naval Amphibious Base Little Creek, Virginia Beach, VA. Source: Mapquest.com.

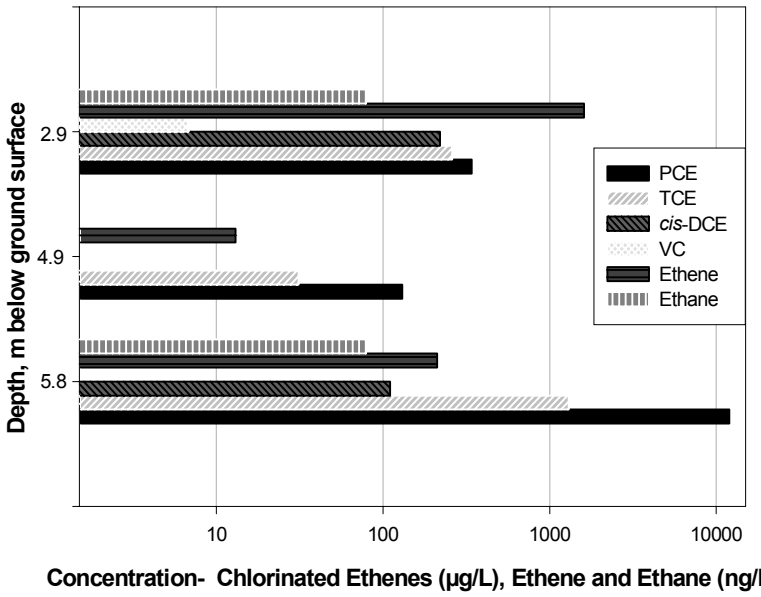


Figure 2. Reductive dechlorination products in well MLS-12 (source area) at Naval Amphibious Base Little Creek.

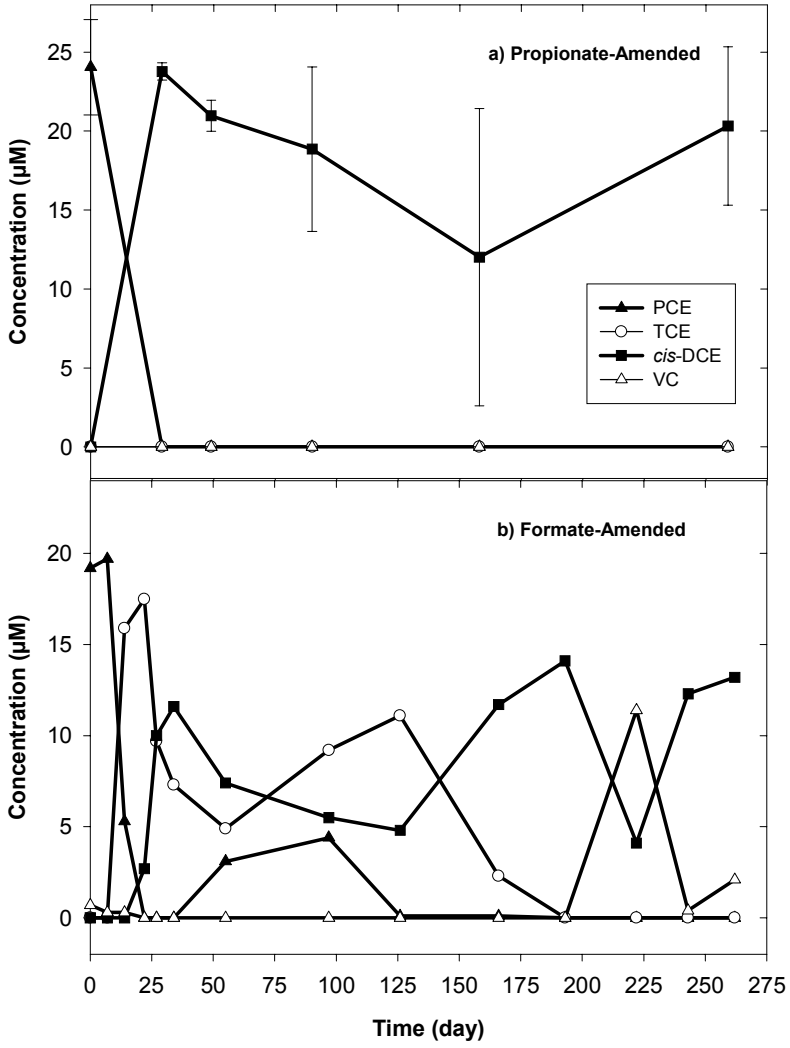


Figure 3. Reductive dechlorination in electron donor microcosms with (a) propionate-amendment and (b) formate-amendment. Data points represent average values of (a) triplicate and (b) duplicate samples. Error bars in (a) represent 1 standard deviation.

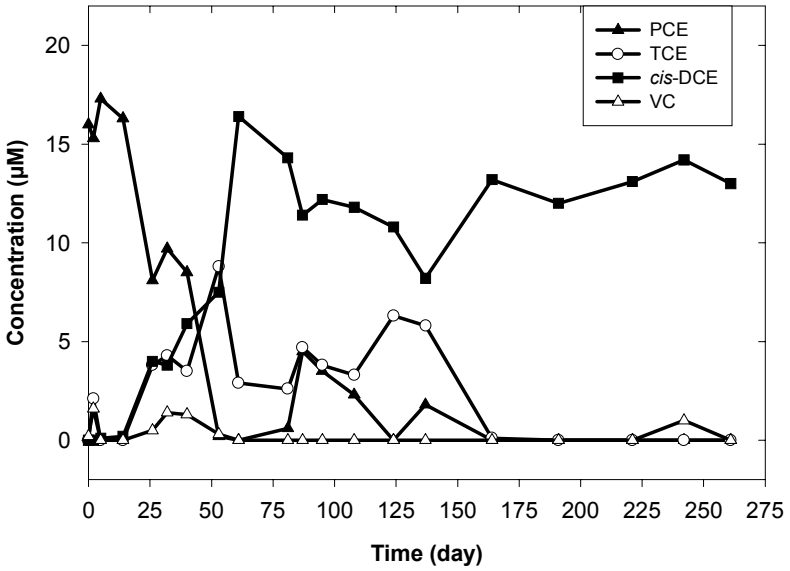


Figure 4. Reductive dechlorination in mineral medium-amended microcosms. Data points represent average values from duplicate analysis.

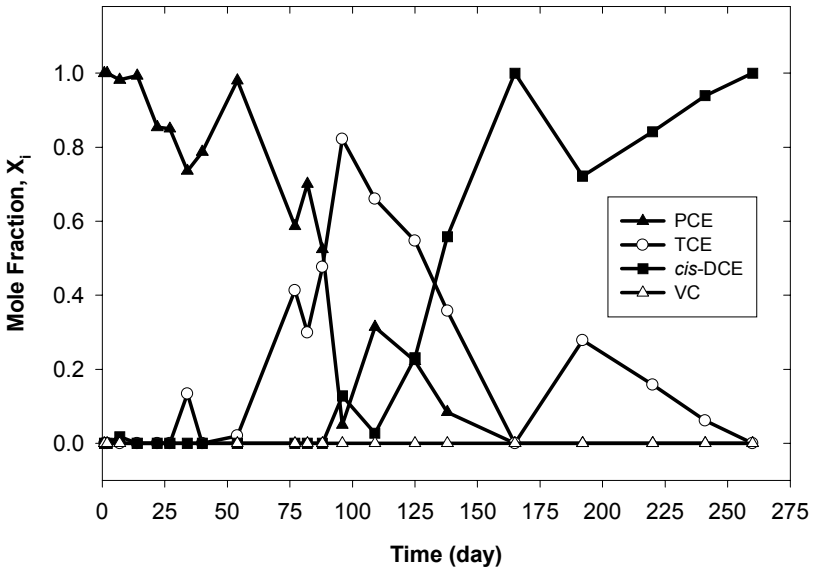


Figure 5. Reductive dechlorination in digester supernatant-amended microcosms. Data points represent average values of mole fraction, molar mass of individual compounds relative to the total molar mass, for each sampling period.

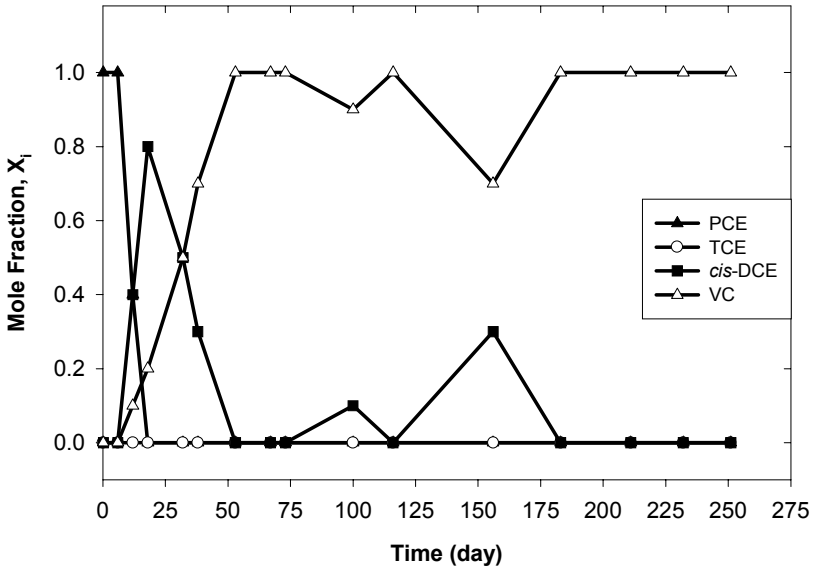


Figure 6. Reductive dechlorination in dechlorinating culture-amended microcosms. Data points represent average values of mole fraction, molar mass of individual compounds relative to the total molar mass, for each sampling period.

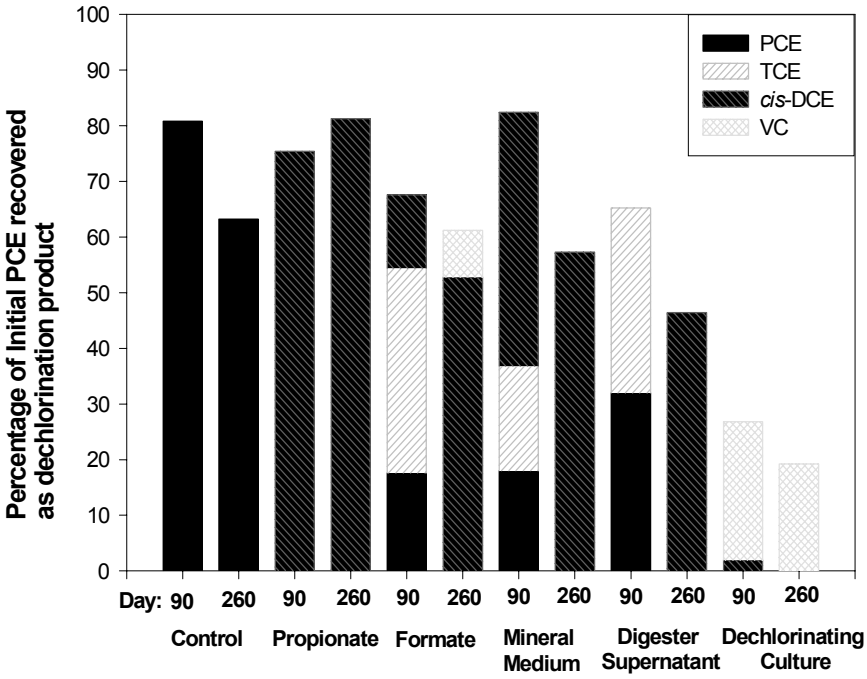


Figure 7. Dechlorination products measured on days 90 and 260. Based on average measurements relative to initial 25 µM PCE added.

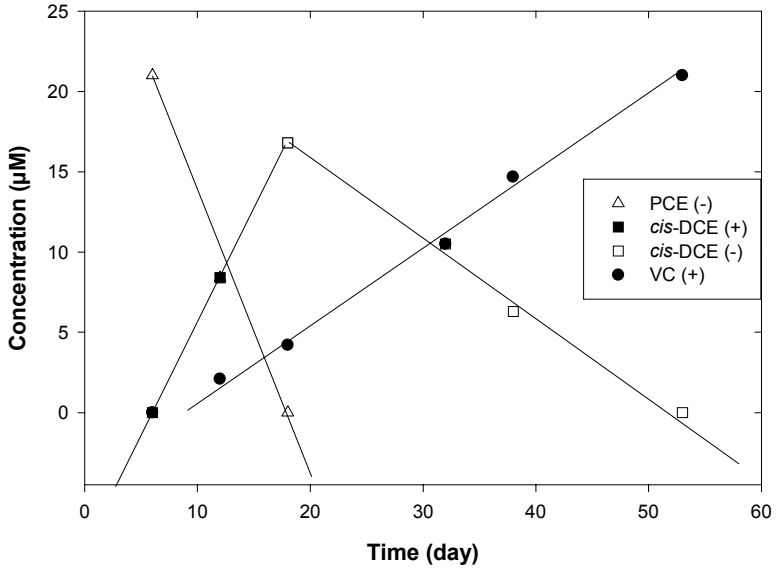


Figure 8. Zero-order biodegradation rates calculation for dechlorinating culture-amended microcosms. Concentrations corrected for chlorinated ethenes losses from microcosm venting.

Table 1. Natural attenuation indicator parameters from selected monitoring wells at NAB Little Creek[a].

Analyte	Well Location (distance along transect)				
	MLS-15 (Background)	**MLS-11 (0 m)**	**MLS-12 (43 m)**	**MLS-22 (70 m)**	**MLS-20 (96 m)**
PCE (µg/L)	ND	2,290	2,907	4,217	914
TCE (µg/L)	ND	7.57	362	830	179
cis-DCE (µg/L)	ND	ND	107	38.5	45.3
VC (µg/L)	ND	ND	10.6	ND	ND
Ethene (µg/L)	ND	0.016	3.45	1.66	0.077
Ethane (µg/L)	ND	0.013	0.055	0.652	0.027
Methane (µg/L)	32.5	10.32	44.4	37.1	843
Dissolved Hydrogen (nM)	NA	NA	2.88	NA	2.56
Carbon Dioxide (mg/L)	144.6	137.8	105.4	75.4	54.2
Chloride (mg/L)	21.4	27.6	36.5	29.3	29.6
Sulfate (mg/L)	40.2	42.7	74.9	41.8	14.7
Sulfide (mg/L)	0.14	0.11	0.11	0.10	0.14

[a] Depth averaged concentrations for individual multi-level sampler monitoring wells.
ND - Not detected above method detection limits.
NA - Not analyzed.

Table 2. Summary of enhanced bioremediation microcosm experiments.

Constituent	Experiment				
	Electron Donor-Propionate	**Electron Donor-Formate**	**Mineral Medium**	**Digester Supernatant**	**Dechlorinating Culture**
Aquifer sediment from MLS-12-Shallow	7 g	7 g	7 g	7 g	7 g
PCE	25 µM	25 µM	25 µM	25 µM	25 µM
Propionate	1 mM	--	--	--	--
Formate[a]	--	45 mM	45 mM	45 mM	45 mM
Yeast extract	50 mg/L	200 mg/L	200 mg/L	200 mg/L	200 mg/L
Trace metal and mineral salt medium	--	--	10.5 mL	--	4.5 mL
Groundwater, MLS-12	10.5 mL	10.5 mL	--	--	5.0 mL
Digester supernatant	--	--	--	10.5 mL	--
Dechlorinating culture	--	--	--	--	1 mL

[a] With exception to propionate-amended microcosms, 20 mM formate added to microcosms on days 90 and 180 for electron donor replenishment.

Table 3. Comparison of zero-order biodegradation rates (µM/day). MLS-12-Shallow.

	PCE	TCE		*cis*-DCE		VC	
Experiment	**Loss**	**Production**	**Loss**	**Production**	**Loss**	**Production**	**Loss**
Natural Conditions (Unamended)[a]	0.240	--	--	0.250	--	--	--
Electron Donor-Propionate	0.750	--	--	0.820	--	--	--
Electron Donor-Formate	1.30	1.14	0.064	0.064	--	--	--
Mineral Medium	0.339	0.197	0.053	0.232	--	--	--
Digester Supernatant[b]	0.177	0.264	0.235	0.256	--	--	--
Dechlorinating Culture[b]	1.75	--	--	1.40	0.486	0.458	--

[a] From Berry, et. al. 1999.
[b] Zero-order rates corrected for chlorinated ethene losses from microcosm venting.

APPENDIX A

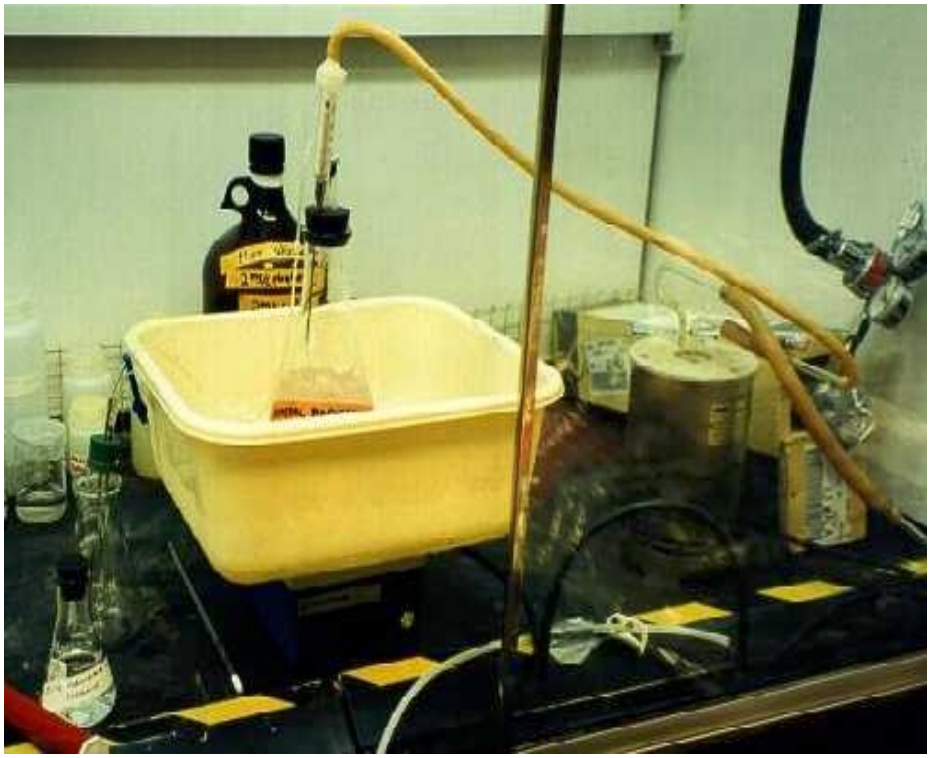
PROJECT PHOTOGRAPHS

Photograph 1. Borehole advanced in the immediate vicinity of well MLS-12 utilizing hollow-stem auger drilling equipment and split-barrel samplers.

Photograph 2. Aquifer sediments retrieved from 2.5 to 3.5 m below ground surface in sterile acetate liners. Driller is capping liners.

Photograph 3. Aquifer sediments placed in anaerobic glove bag and purged with nitrogen.

Photograph 4. Multi-level sampler well configuration. Colored tubing is used to distinguish sampling depths at the surface.



Photograph 5. Trace metal and mineral salt medium being sparged with nitrogen. Resazurin used as a redox indicator. Opaque appearance of medium indicates anaerobic conditions have been attained. Nitrogen is passed through Hungate device (on the right) containing hot copper filings to remove residual oxygen.

Photograph 6. Laboratory microcosms prepared in anaerobic glove bag.

Photograph 7. Laboratory microcosm experiments conducted in 15-mL amber vials containing 7 grams (wet) aquifer sediment, 25 µM PCE and 10.5 mL aqueous solution. Teflon-lined rubber butyl septum and aluminum crimp cap used to seal microcosm.

APPENDIX B

LABORATORY ANALYTICAL DATA

Table B-1. Analytical data for propionate-amended microcosm experiments. Based on triplicate analysis.

Time (day)	Mean-PCE (µM)	Std. Dev.-PCE (µM)	Mean-TCE (µM)	Std. Dev.-TCE (µM)	Mean-*cis*-DCE (µM)	Std. Dev.- *cis*-DCE (µM)	Mean-VC (µM)	Std. Dev.-VC (µM)	Mean-Total VOCs (µM)	Std. Dev.-VOCs (µM)
0	24.04	3.02	0.00	0.00	0.00	0.00	0.00	0.00	24.05	3.02
29	0.02	0.02	0.00	0.00	23.77	0.55	0.00	0.00	23.79	0.57
49	0.00	0.01	0.00	0.00	20.97	0.98	0.00	0.00	20.97	0.98
90	0.00	0.00	0.00	0.00	18.86	5.22	0.00	0.00	18.85	5.22
158	0.00	0.00	0.00	0.00	12.02	9.42	0.00	0.00	12.02	9.42
259	0.00	0.00	0.00	0.00	20.32	5.02	0.00	0.00	20.32	5.02

Table B-2. Analytical data for formate-amended microcosm experiments. Based on duplicate analysis.

Time (day)	Mean- PCE (μM)	Delta- PCE (μM)	Mean-TCE (μM)	Delta- TCE (μM)	Mean- *cis*-DCE (μM)	Delta- *cis*-DCE (μM)	Mean- VC (μM)	Delta- VC (μM)
0.0600	19.2000	0.2000	0.0000	0.0000	0.0000	0.0000	0.7000	0.3000
7.0000	19.7000	0.2000	0.0000	0.0000	0.0000	0.0000	0.3000	0.3000
14.0000	5.3000	4.7000	15.9000	0.0000	0.0000	0.0000	0.3000	0.2000
22.0000	0.0000	0.0000	17.5000	2.7000	2.4000	0.2000	0.0000	0.0000
27.0000	0.0000	0.0000	9.7000	1.7000	10.1000	2.9000	0.0000	0.0000
34.0000	0.0000	0.0000	7.3000	1.7000	12.9000	1.3000	0.0000	0.0000
55.0000	3.1000	3.1000	4.9000	0.6000	7.4000	0.6000	0.0000	0.0000
97.0000	4.4000	4.4000	9.2000	6.2000	5.5000	1.0000	0.0000	0.0000
126.0000	0.1000	0.1000	11.1000	4.3000	4.8000	2.0000	0.0000	0.0000
166.0000	0.1000	0.0000	2.3000	0.5000	11.7000	10.0000	0.0000	0.0000
193.0000	0.0000	0.0000	0.0000	0.0000	14.1000	2.5000	0.0000	0.0000
222.0000	0.0000	0.0000	0.0000	0.0000	4.1000	4.1000	11.4000	11.4000
243.0000	0.0000	0.0000	0.0000	0.0000	12.3000	1.1000	0.4000	0.4000
262.0000	0.0000	0.0000	0.0000	0.0000	13.2000	1.3000	2.1000	2.1000

Table B-3. Analytical data for mineral medium microcosm experiments. Based on duplicate analysis.

Time (day)	Mean- PCE (μM)	Delta- PCE (μM)	Mean-TCE (μM)	Delta- TCE (μM)	Mean- *cis*-DCE (μM)	Delta- *cis*-DCE (μM)	Mean- VC (μM)	Delta- VC (μM)
0.0400	16.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.1000
2.0000	15.3000	1.5000	2.1000	2.1000	0.0000	0.0000	1.6000	0.4000
5.0000	17.3000	1.6000	0.0000	0.0000	0.1000	0.1000	0.0000	0.0000
14.0000	16.3000	1.1000	0.0000	0.0000	0.2000	0.2000	0.0000	0.0000
26.0000	8.1000	6.7000	3.8000	3.8000	4.0000	4.0000	0.5000	0.3000
32.0000	9.7000	8.5000	4.3000	4.3000	3.8000	3.8000	1.4000	0.8000
40.0000	8.5000	8.4000	3.5000	3.5000	5.9000	4.6000	1.3000	0.4000
53.0000	0.2000	0.2000	8.8000	1.8000	7.5000	0.6000	0.3000	0.3000
61.0000	0.0000	0.0000	2.9000	2.9000	16.4000	3.5000	0.0000	0.0000
81.0000	0.6000	0.6000	2.6000	2.3000	14.3000	4.0000	0.0000	0.0000
87.0000	4.5000	4.4000	4.7000	0.4000	11.4000	9.3000	0.0000	0.0000
95.0000	3.5000	1.0000	3.8000	1.7000	12.2000	2.3000	0.0000	0.0000
108.0000	2.3000	2.3000	3.3000	3.3000	11.8000	7.1000	0.0000	0.0000
124.0000	0.0000	0.0000	6.3000	3.3000	10.8000	1.0000	0.0000	0.0000
137.0000	1.8000	1.8000	5.8000	3.8000	8.2000	3.9000	0.0000	0.0000
164.0000	0.0000	0.0000	0.1000	0.1000	13.2000	1.1000	0.0000	0.0000
191.0000	0.0000	0.0000	0.0000	0.0000	12.0000	1.5000	0.0000	0.0000
221.0000	0.0000	0.0000	0.0000	0.0000	13.1000	1.9000	0.0000	0.0000
242.0000	0.0000	0.0000	0.0000	0.0000	14.2000	2.1000	1.0000	1.0000
261.0000	0.0000	0.0000	0.0000	0.0000	13.0000	1.4000	0.0000	0.0000

Table B-4. Analytical data for anaerobic digester supernatant microcosm experiments. Based on duplicate analysis.

Time (day)	Mean- Mole fraction[a], PCE	Delta- Mole fraction, PCE	Mean- Mole fraction, TCE	Delta- Mole Fraction, TCE	Mean- Mole fraction, *cis*-DCE	Delta- Mole fraction, *cis*-DCE	Mean- Mole fraction, VC	Delta- Mole fraction, VC
0.8300	1.0000	0.0600	0.0000	0.0000	0.0000	0.0000	0.0000	0.060
2.0000	1.0000	0.0300	0.0000	0.0000	0.0000	0.0000	0.0000	0.030
7.0000	0.9820	0.0180	0.0000	0.0000	0.0180	0.0180	0.0000	0.0000
14.0000	0.9930	1.0000e-3	0.0000	0.0000	0.0000	0.0000	0.007	0.001
22.0000	0.8540	0.0180	0.0000	0.0000	0.0000	0.0000	0.146	0.018
27.0000	0.8500	0.0180	0.0000	0.0000	0.0000	0.0000	0.150	0.018
34.0000	0.7360	0.1060	0.1340	0.1340	0.0000	0.0000	0.130	0.028
40.0000	0.7870	0.0510	0.0000	0.0000	0.0000	0.0000	0.213	0.051
54.0000	0.9800	0.0200	0.0200	0.0200	0.0000	0.0000	0.0000	0.0000
77.0000	0.5870	0.0980	0.4130	0.0980	0.0000	0.0000	0.0000	0.0000
82.0000	0.7010	0.0860	0.2990	0.0860	0.0000	0.0000	0.0000	0.0000
88.0000	0.5240	0.4280	0.4760	0.4280	0.0000	0.0000	0.0000	0.0000
96.0000	0.0500	0.0500	0.8220	0.0390	0.1280	0.0890	0.0000	0.0000
109.0000	0.3140	0.3140	0.6600	0.3250	0.0270	0.0120	0.0000	0.0000
125.0000	0.2220	0.0410	0.5470	0.2470	0.2310	0.2060	0.0000	0.0000
138.0000	0.0840	0.0840	0.3580	0.3580	0.5580	0.4420	0.0000	0.0000
165.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
192.0000	0.0000	0.0000	0.2780	0.2780	0.7220	0.2780	0.0000	0.0000
220.0000	0.0000	0.0000	0.1580	0.1580	0.8420	0.1580	0.0000	0.0000
241.0000	0.0000	0.0000	0.0610	0.0610	0.9390	0.0610	0.0000	0.0000
260.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000

[a] Mole fraction represents molar mass relative to total molar mass of chlorinated ethenes for sampling period.

Table B-5. Analytical data for dechlorinating culture microcosms. Based on duplicate analysis.

Time (day)	Mean- Mole fraction[a], PCE	Delta- Mole fraction, PCE	Mean- Mole fraction, TCE	Delta- Mole Fraction, TCE	Mean- Mole fraction, *cis*-DCE	Delta- Mole fraction, *cis*-DCE	Mean- Mole fraction, VC	Delta- Mole fraction, VC
0.1700	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12.0000	0.4000	0.1000	0.0000	0.0000	0.4000	0.1000	0.1000	0.0000
18.0000	0.0000	0.0000	0.0000	0.0000	0.8000	0.1000	0.2000	0.1000
32.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.3000	0.5000	0.3000
38.0000	0.0000	0.0000	0.0000	0.0000	0.3000	0.3000	0.7000	0.3000
53.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
67.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
73.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
100.0000	0.0000	0.0000	0.0000	0.0000	0.1000	0.1000	0.9000	0.1000
116.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
156.0000	0.0000	0.0000	0.0000	0.0000	0.3000	0.1000	0.7000	0.1000
183.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
211.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
232.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
251.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000

[a] Mole fraction represents molar mass relative to total molar mass of chlorinated ethenes for sampling period.

Table B-6. Analytical data for control microcosm experiments. Based on duplicate analysis.

Time (day)	Mean- PCE (μM)	Delta- PCE (μM)	Mean-TCE (μM)	Delta- TCE (μM)	Mean- *cis*-DCE (μM)	Delta- *cis*-DCE (μM)	Mean- VC (μM)	Delta- VC (μM)
0.0000	26.3000	2.3000	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000
7.0000	23.6000	2.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13.0000	22.7000	1.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27.0000	20.1000	2.5000	0.0000	0.0000	0.0000	0.0000	0.1000	0.1000
39.0000	17.7000	1.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
77.0000	20.3000	2.3000	0.6000	0.6000	0.0000	0.0000	0.6000	0.6000
85.0000	20.2000	1.7000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
109.0000	17.8000	2.3000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
127.0000	18.2000	1.7000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
157.0000	19.9000	4.3000	0.5000	0.5000	0.0000	0.0000	0.0000	0.0000
174.0000	16.0000	1.6000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
192.0000	16.7000	1.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
222.0000	16.2000	2.3000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
250.0000	15.8000	1.4000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table B-7. Analytical data for methane headspace analyses. Average of duplicate analyses.

Formate		Mineral Medium		Digester Supernatant		Dechlorinating Culture	
Time (day)	Concentration (mol/L)	Time (day)	Concentration (mol/L)	Time (day)	Concentration (mol/L)	Time (day)	Concentration (mol/L)
0	0.000	0	0.000	0	0.000	0	0.000
7	0.000	14	0.000	14	0.180	6	0.009
14	0.000	21	0.000	22	0.315	6	0.008
22	0.000	26	0.000	27	1.369	6	0.945
27	0.000	32	0.007	34	0.839	12	11.170
34	0.000	40	0.001	40	0.381	18	12.409
41	0.000	46	0.046	53	0.354	25	6.246
48	0.000	52	0.001	76	0.557	**32**	5.016
55	0.000	59	0.009	**82**	0.803	38	1.267
64	0.000	67	0.005	88	0.744	45	0.465
72	0.000	73	0.020	96	2.005	54	5.023
78	0.000	79	0.115	138	0.680	62	0.467
83	0.000	85	0.068	165	2.245	68	0.595
89	0.003	95	1.232	192	1.652	73	0.782
97	0.006	124	0.237	220	3.932	100	1.469
126	0.001	164	1.637	241	1.136	116	0.879
139	0.010	221	1.823	260	6.332	156	2.373
166	0.013	242	0.094			183	1.060
193	0.245	261	0.923			211	3.983
222	1.748					232	1.220
243	0.002					251	4.858

BOLD indicates time when periodic microcosm venting began.

APPENDIX C

BIODEGRADATION RATE CALCULATIONS

Table C-1. Zero-order biodegradation rate calculations for propionate-amended microcosm experiments.

PCE Dechlorination	
Time (day)	Concentration (µM)
0	24.04
29	0.02

Rate: 0.750 µM/day

R^2: 1

cis-DCE Production	
Time (day)	Concentration (µM)
0	0
29	23.77

Rate: 0.820 µM/day

R^2: 1

Table C-2. Zero-order biodegradation rate calculations for formate-amended microcosm experiments.

PCE Dechlorination	
Time (day)	Concentration (μM)
7	19.7
14	5.3
22	0

Rate: 1.30 μM/day
R^2: 0.91

TCE Production	
Time (day)	Concentration (μM)
7	0
14	15.9
22	17.5

Rate: 1.14 μM/day
R^2: 0.79

TCE Dechlorination	
Time (day)	Concentration (μM)
22	17.5
27	9.7
34	7.3
55	4.9
97	9.2
166	2.3
193	0

Rate: 0.064 μM/day
R^2: 0.61

cis-DCE Production	
Time (day)	Concentration (μM)
14	0
22	2.4
55	7.4
97	5.5
126	4.8
166	11.7
193	14.1

Rate: 0.064 μM/day
R^2: 0.79

Table C-3. Zero-order biodegradation rate calculations for mineral medium-amended microcosm experiments.

PCE Dechlorination	
Time (day)	Concentration (µM)
14	16.3
26	8.1
32	9.7
40	8.5
53	0.2
61	0

Rate: 0.339 µM/day
R^2: 0.90

TCE Production	
Time (day)	Concentration (µM)
14	0
26	3.8
32	4.3
40	3.5
53	8.8

Rate: 0.197 µM/day
R^2: 0.85

TCE Dechlorination	
Time (day)	Concentration (µM)
53	8.8
87	4.7
95	3.8
108	3.3
124	6.3
137	5.8
164	0.1

Rate: 0.053 µM/day
R^2: 0.49

cis-DCE Production	
Time (day)	Concentration (µM)
2	0
5	0.1
14	0.2
26	4
32	3.8
40	5.9
53	7.5
61	16.4

Rate: 0.232 µM/day
R^2: 0.84

Table C-4. Zero-order biodegradation rate calculations for digester supernatant-amended microcosm experiments. Corrected for mass losses from microcosm venting (× 20 µM).

PCE Dechlorination	
Time (day)	Concentration (µM)
54	19.6
77	11.74
82	14.02
88	10.48
109	6.28
125	4.44
138	1.68
165	0

Rate: 0.177 µM/day
R^2: 0.94

TCE Production	
Time (day)	Concentration (µM)
40	0
54	0.4
77	8.26
82	5.98
88	9.52
96	16.44

Rate: 0.264 µM/day
R^2: 0.84

TCE Dechlorination	
Time (day)	Concentration (µM)
96	16.44
109	13.2
125	10.94
138	7.16
165	0

Rate: 0.235 µM/day
R^2: 0.99

cis-DCE Production	
Time (day)	Concentration (µM)
88	0
96	2.56
109	0.54
125	4.62
138	11.16
165	20

Rate: 0.256 µM/day
R^2: 0.90

Table C-5. Zero-order biodegradation rate calculations for dechlorinating culture-amended microcosm experiments. Corrected for mass losses from microcosm venting (× 21 µM).

PCE Dechlorination	
Time (day)	Concentration (µM)
6	21
12	8.4
18	0

Rate: 1.750 µM/day
R^2: 0.99

cis-DCE Production	
Time (day)	Concentration (µM)
6	0
12	8.4
18	16.8

Rate: 1.40 µM/day
R^2: 1

cis-DCE Dechlorination	
Time (day)	Concentration (µM)
18	16.8
32	10.5
38	6.3
53	0

Rate: 0.486 µM/day
R^2: 0.99

VC Production	
Time (day)	Concentration (µM)
6	0
12	2.1
18	4.2
32	10.5
38	14.7
53	21

Rate: 0.458 µM/day
R^2: 0.99

Figure C-1. Zero-order biodegradation in propionate-amended microcosm experiments.

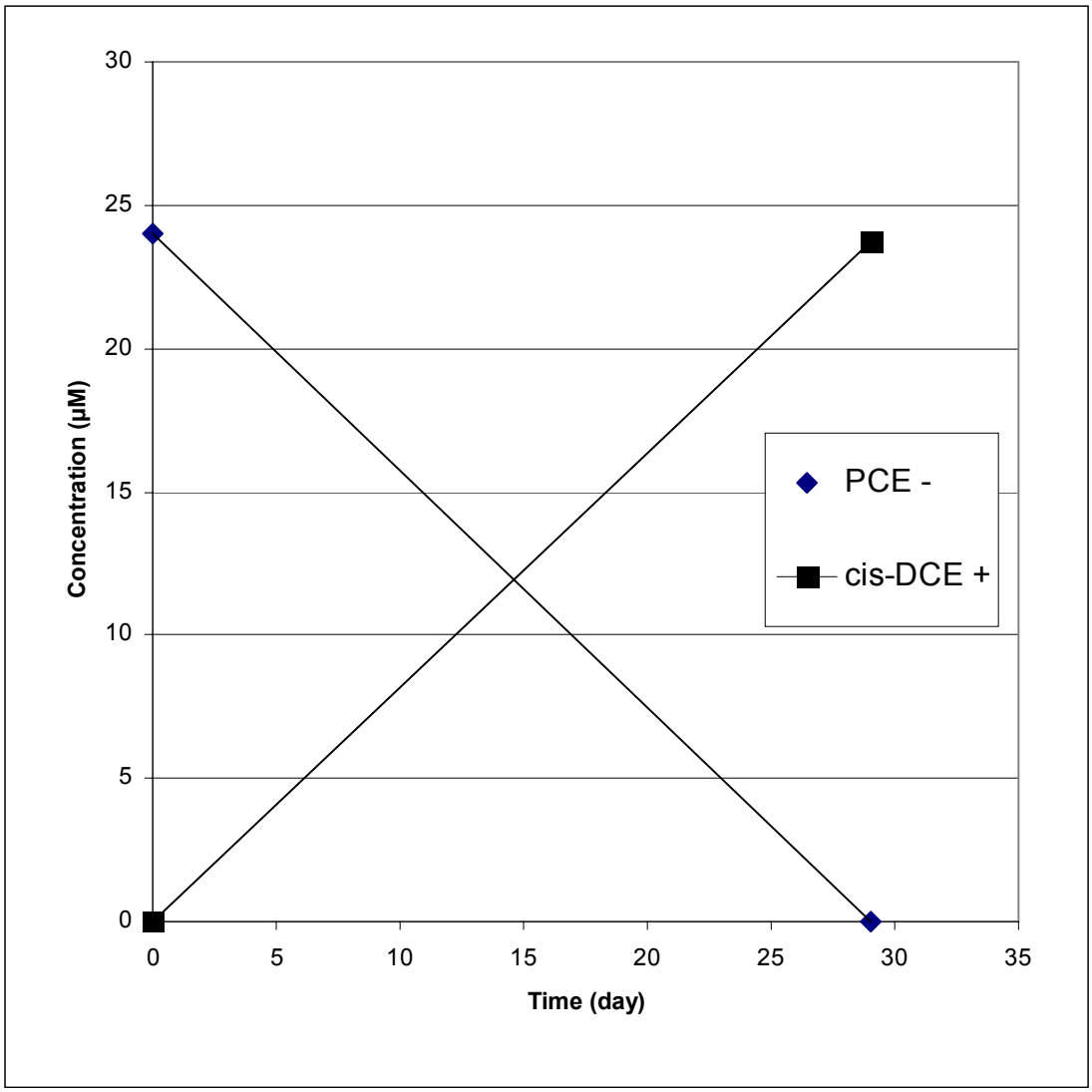


Figure C-2. Zero-order biodegradation in formate-amended microcosm experiments.

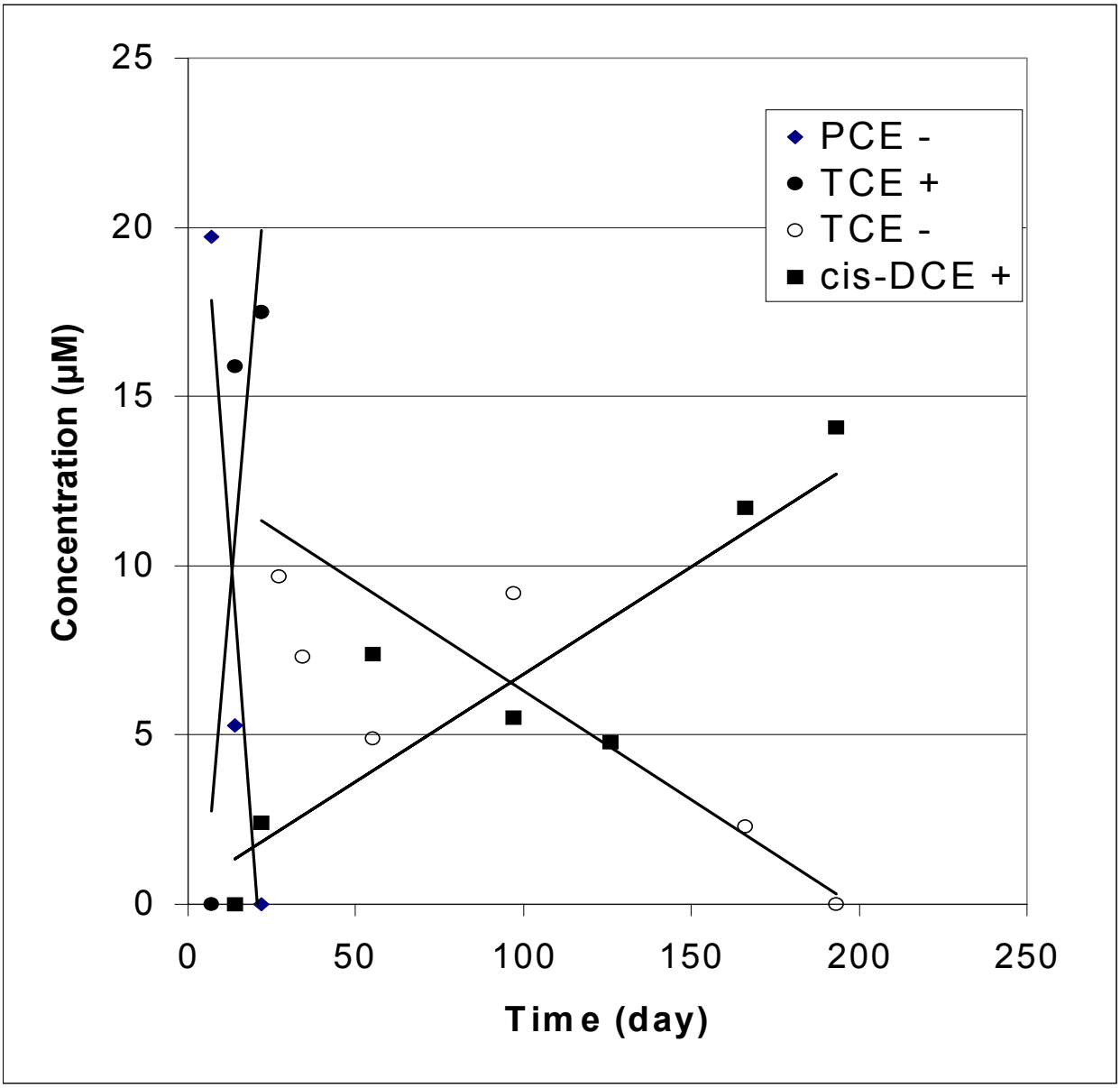


Figure C-3. Zero-order biodegradation in mineral medium-amended microcosm experiments.

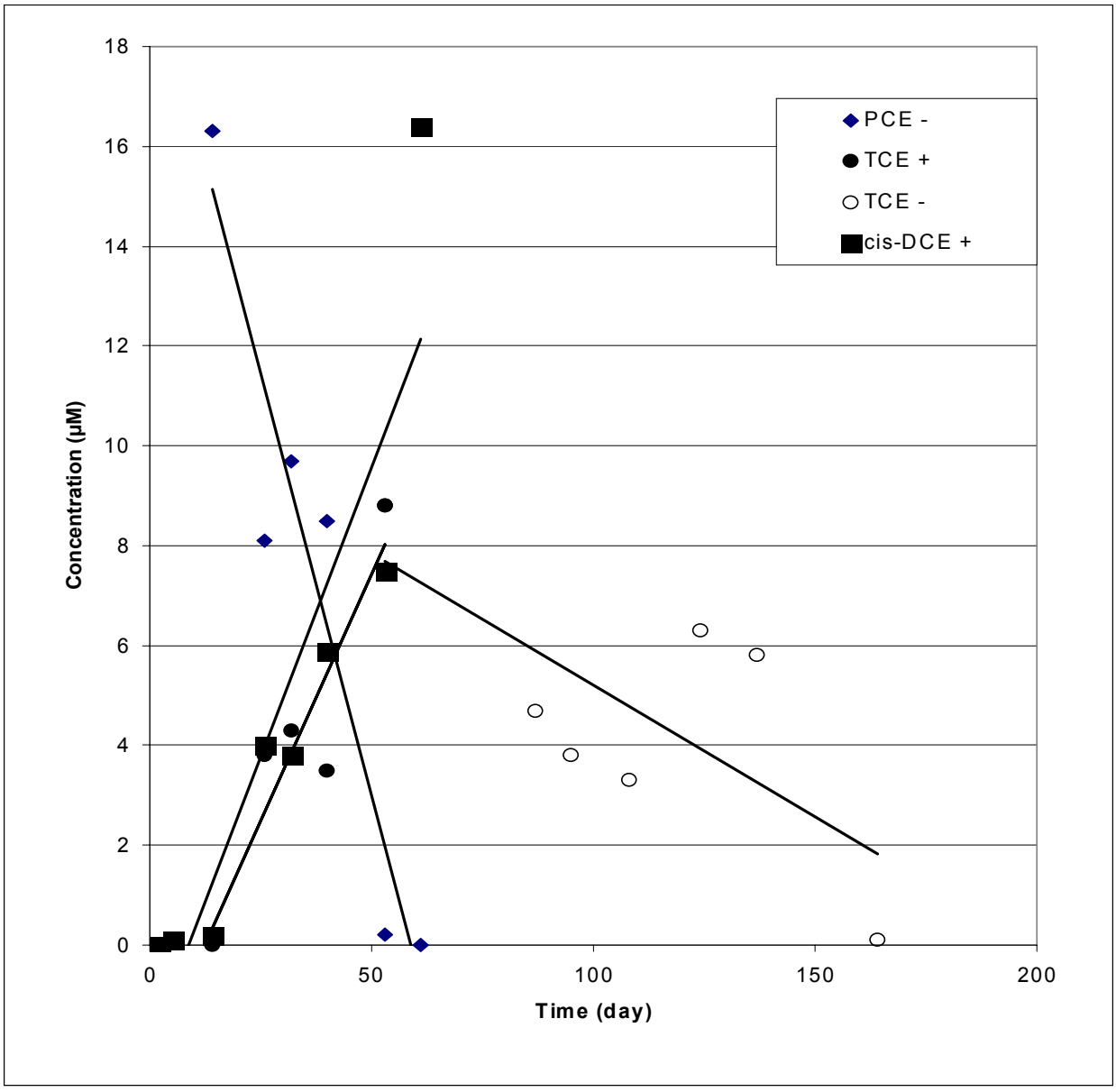


Figure C-4. Zero-order biodegradation in digester supernatant-amended microcosm experiments.

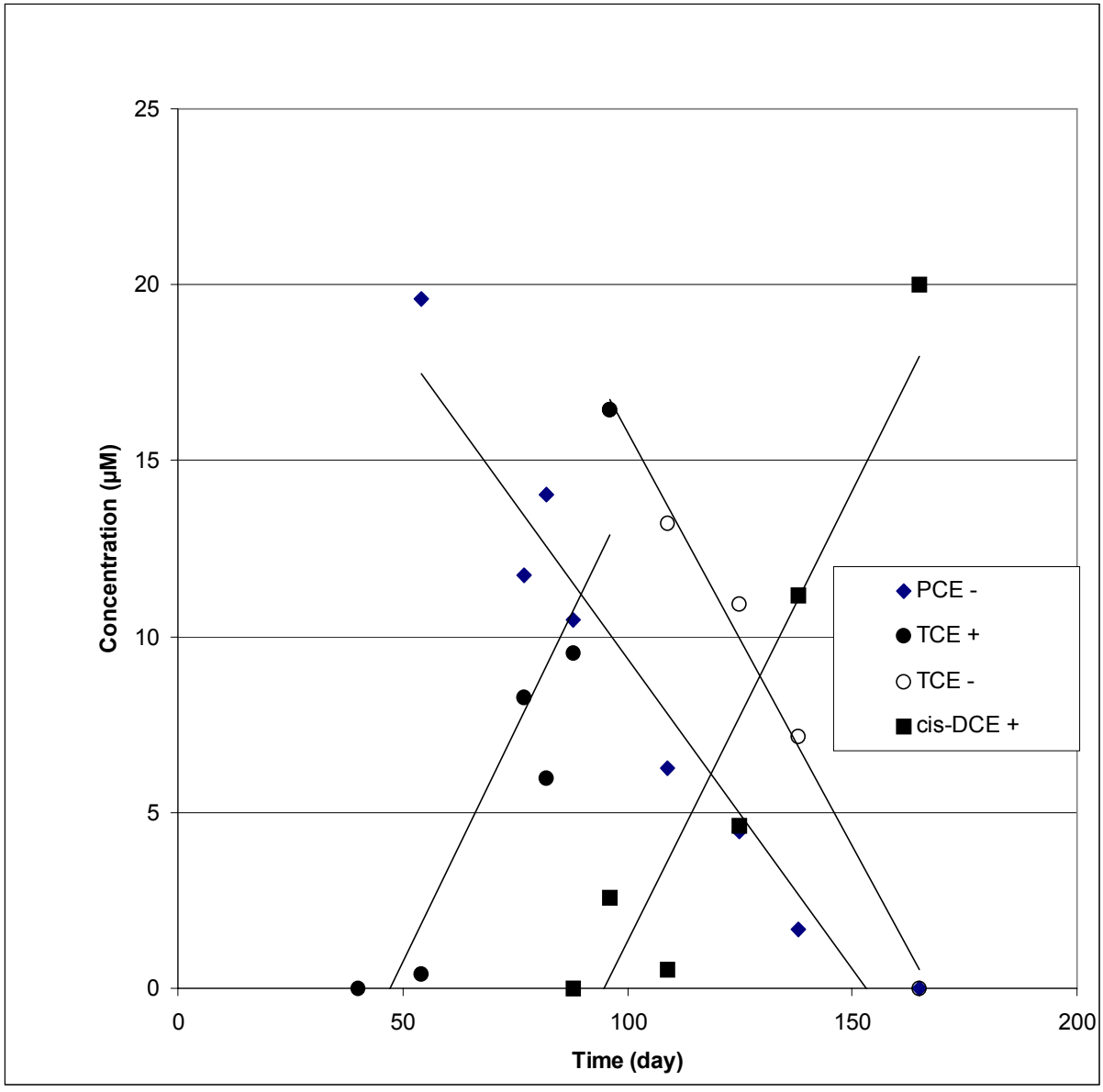
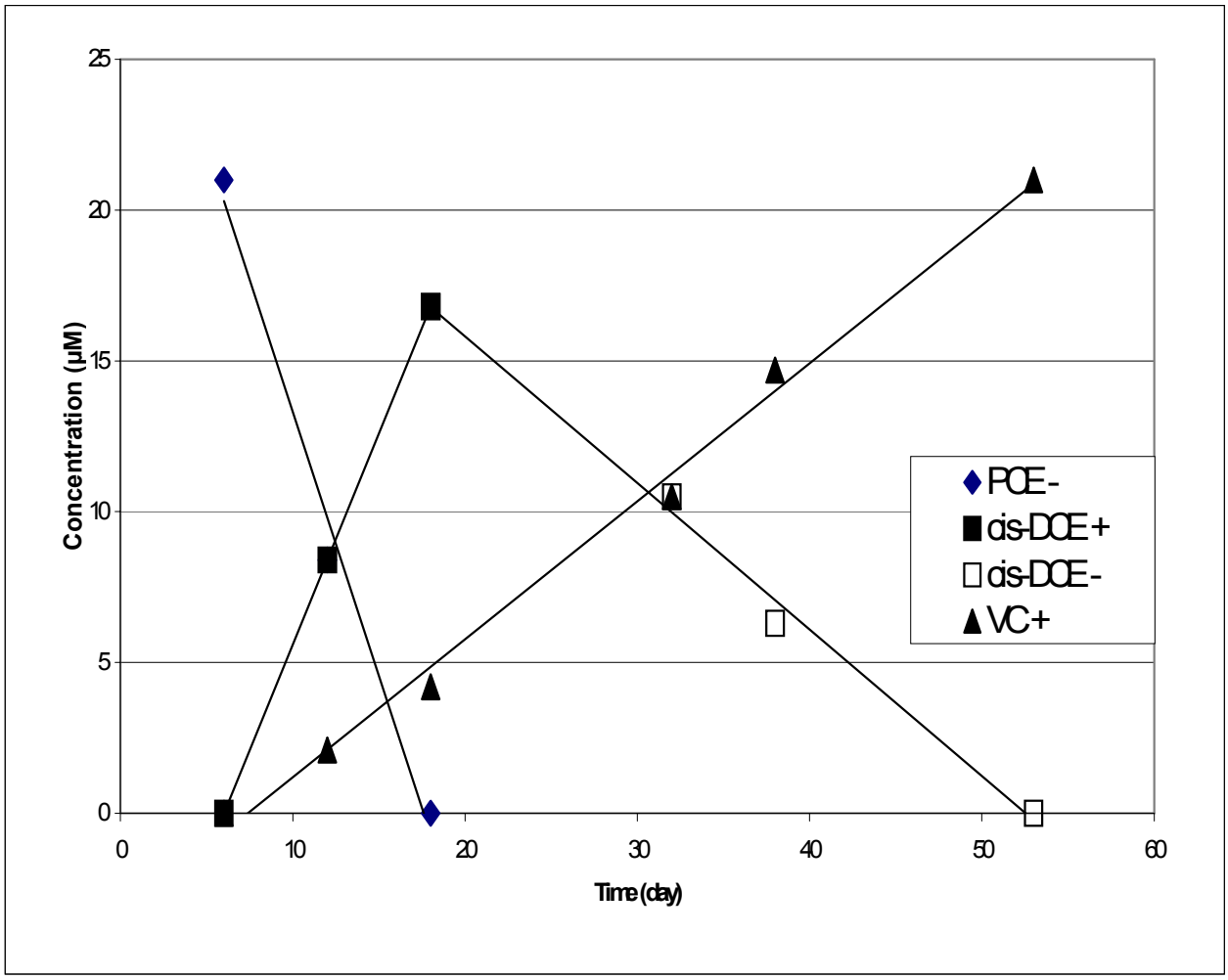


Figure C-5. Zero-order biodegradation in dechlorinating culture-amended microcosm experiments.



VITA

Felix Yuen-Yi Wang was born on March 12, 1975 in New York, New York. He earned his Bachelor's of Science degree in Public Affairs (major: Environmental Science) from Indiana University's (Bloomington, Indiana) School of Public and Environmental Affairs in May 1997. From June 1997 to August 1998, he was employed as a scientist with PMK Group Consulting and Environmental Engineers in Kenilworth, New Jersey. In August 1998, he entered Virginia Tech's (Blacksburg, Virginia) Department of Civil and Environmental Engineering to pursue a Master's of Science degree in Environmental Engineering. Following completion of the degree requirements, he will begin work with CH2M HILL in Parsippany, New Jersey as an engineer in their Water Business Group.