

AEROBIC DEGRADATION OF 1,4-DIOXANE IN A FIXED-FILM BIOREACTOR WITH TOLUENE, OTHER VOLATILES AND PHENOLICS AS CO-CONTAMINANTS

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BACKGROUND

Federal Superfund site in Northeastern U.S.

VOCs and 1,4-dioxane are key constituents of concern in bedrock groundwater

1,4-Dioxane up to 1,600 ug/L

Groundwater extraction from eight bedrock wells

Average flow rate approximately 7,500 gpd (5.2 gpm)

GROUNDWATER TREATMENT SYSTEM

MULTIPLE UNIT PROCESSES FOR AQUEOUS PHASE

- Fixed-film Aerobic Bioreactor
- Filtration
- Air Stripping
- Advanced Oxidation (HIPOx – Hydrogen Peroxide & Ozone)
- Granular Activated Carbon

FIXED-FILM AEROBIC BIOREACTOR

Pareto Chart of Influent Constituents (3-month mean, ug/L)

- Early in treatment train to remove biodegradable VOCs and SVOCs
- Injection of air and simple nutrients

Mean pH = 7.6 SU Mean DO = 7.1 mg/L

1,4-DIOXANE REDUCTION OBSERVED ACROSS BIOREACTOR

Boxplots of 1,4-Dioxane in Influent & Effluent (2016-2017)

Mean inf = 256 ug/L
Mean eff = 201 ug/L

Boxplot of 1,4-Dioxane Reduction (2014-2015 vs 2016-2017)

Mean reduction = 23.2%

Reduction increases over time

Statistically significant (P=0.000) Also statistically significant

HYPOTHESIS: Cometabolic degradation

POTENTIAL PROMOTERS AND POTENTIAL INHIBITORS

Boxplot of Potential Promoters: Toluene

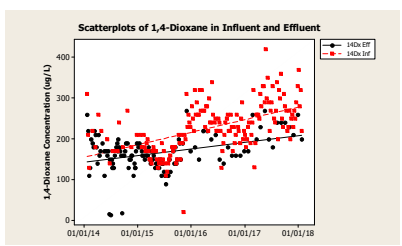
Boxplot of Potential Inhibitors: 1,1,1-Trichloroethane

POTENTIAL PROMOTORS:	POTENTIAL INHIBITORS:
Toluene (mean = 9,700 ug/L)	1,1-Dichloroethane (mean = 28 ug/L)
Phenolics (mean = 220 ug/L)	Trichloroethane (mean = 5,700 ug/L)
	cis-1,2-Dichloroethane (mean = 3,200 ug/L)
	1,1,1-Trichloroethane (mean = 100 ug/L)

MOLECULAR BIOLOGICAL TOOLS (MBTs)

Microbiological Target	Infl Water (cf/ml)	Infl Sed (cf/g)	Eff Water (cf/ml)	Eff Sed (cf/g)
SMMO - SMMO	2.10E+02	7.00E+02	5.50E+02	1.50E+02
ALDH - Aldehyde	<1.0E+04	<1.0E+04	<1.0E+04	<1.0E+04
PPO - Propane	1.00E+01	1.00E+01	1.00E+01	1.00E+01
SMMO - Soluble	1.00E+01	1.00E+01	1.00E+01	1.00E+01
PHE - Phenol	5.00E+01	6.00E+01	5.00E+01	1.00E+02
RMO - Ring	2.00E+01	1.00E+01	3.00E+01	1.00E+02
RMO - Toluene	4.33E+03	1.00E+04	8.50E+02	6.98E+02

1,4-Dioxane-Related MBTs for Bioreactor



CONCLUSION

Observed 1,4-dioxane reduction (mean = 23.2%) most likely due to biodegradation in the aerobic fixed-film bioreactor

- Reduction is statistically significant
- Reduction has also increased over time
- Volatility of 1,4-dioxane is low

Bioreactor is aerobic – biodegradation of 1,4-dioxane under aerobic conditions is supported by research literature

- Compounds that might inhibit biodegradation are present, but not at concentrations expected to be inhibitory
 - 1,1-Dichloroethane: Typically ND (<50 ug/L)
 - 1,1,1-Trichloroethane: Very low (130-290 ug/L)
 - cis-1,2-Dichloroethane: 2,100-5,600 ug/L
 - Trichloroethane: 1,400-8,500 ug/L
- Compounds that could promote co-metabolic degradation of 1,4-dioxane are present (toluene and phenolics)
- Enzymes associated with 1,4-dioxane biodegradation found at elevated concentrations in water and sediment samples from the bioreactor influent and effluent
- Results of compound-specific stable isotope analyses are pending (²H/¹H and ¹³C/¹²C)