Comparison of Catalytic Behaviors between Two 1,4-Dioxane Degrading Monooxygenases

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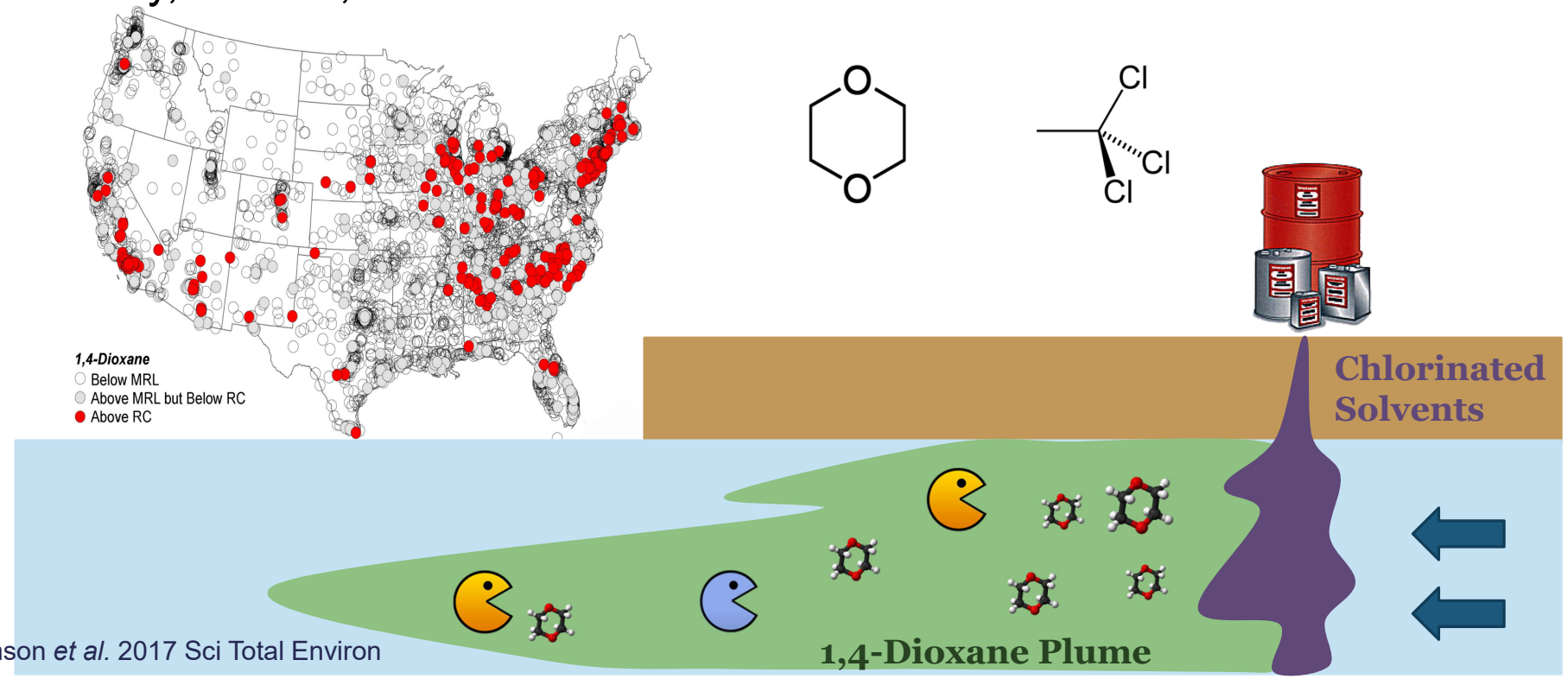
Monitored natural attenuation is an cost-efficient method for low level dioxane removal

MNA is the combination of natural biological, chemical and physical processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of the contaminants



Adamson *et al.* 2017 Sci Total Environ

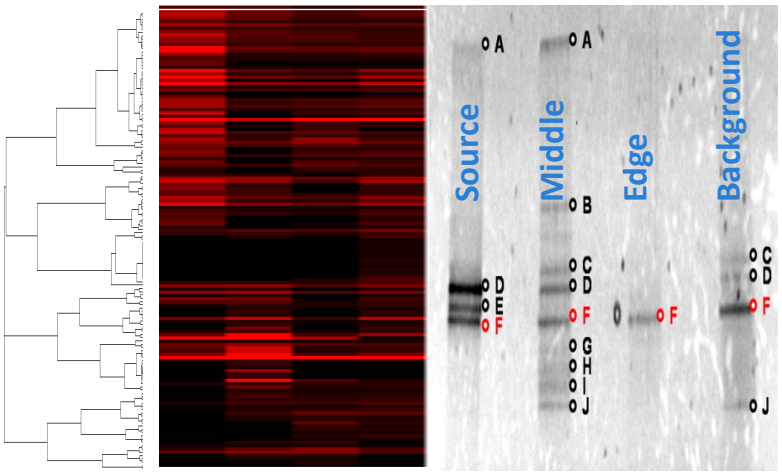
THM-mediated dioxane biodegradation has been widely exploited for MNA

Pseudonocardia CB1190

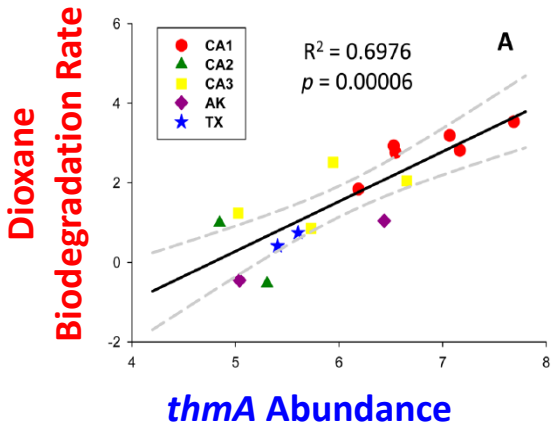
THF Monooxygenase (THM)

thmADBC

Microarray

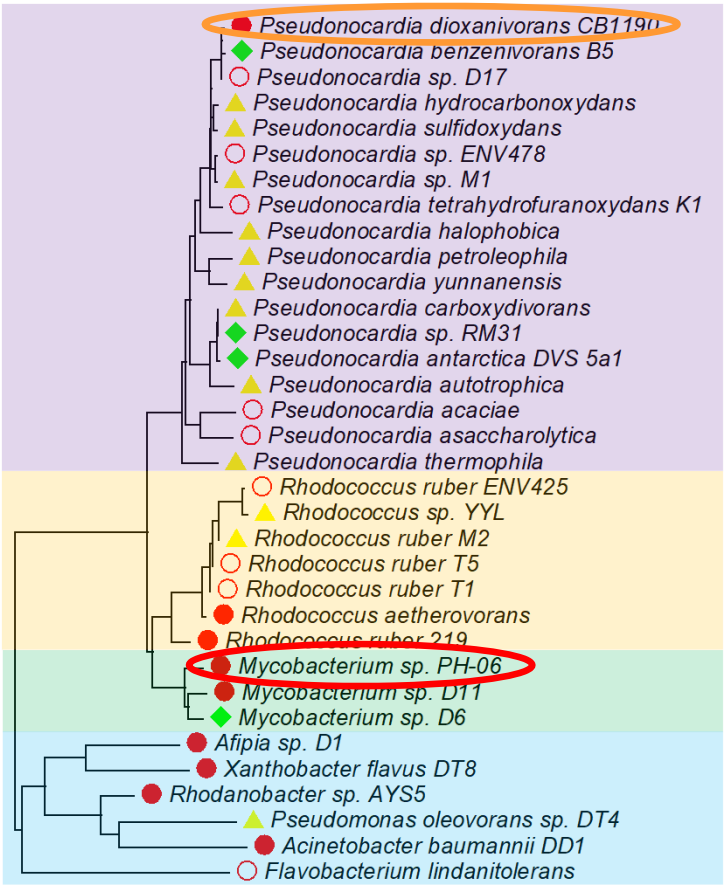


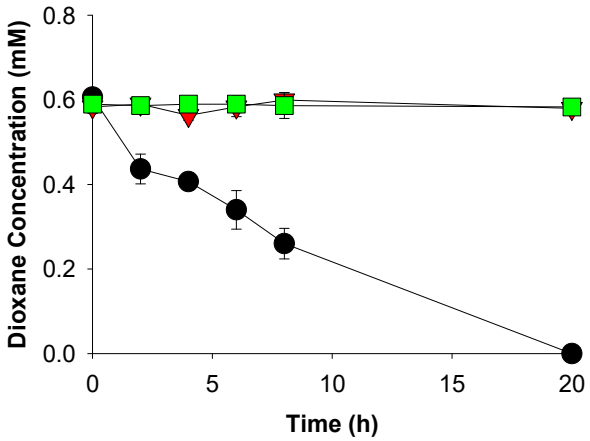
Biomarker



Parales *et al.*, AEM, 1994; Sales *et al.*, AEM, 2013;Li *et al.* ES&T 2013;Li *et al.*, ES&T Letters, 2014.

PRM is a new enzyme that can initiate the dioxane metabolism





Propane Monooxygenase (PRM)

prmABCD

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Letter
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pubs.acs.org/journal/estlcu

A Novel Propane Monooxygenase Initiating Degradation of 1,4-Dioxane by *Mycobacterium dioxanotrophicus* PH-06

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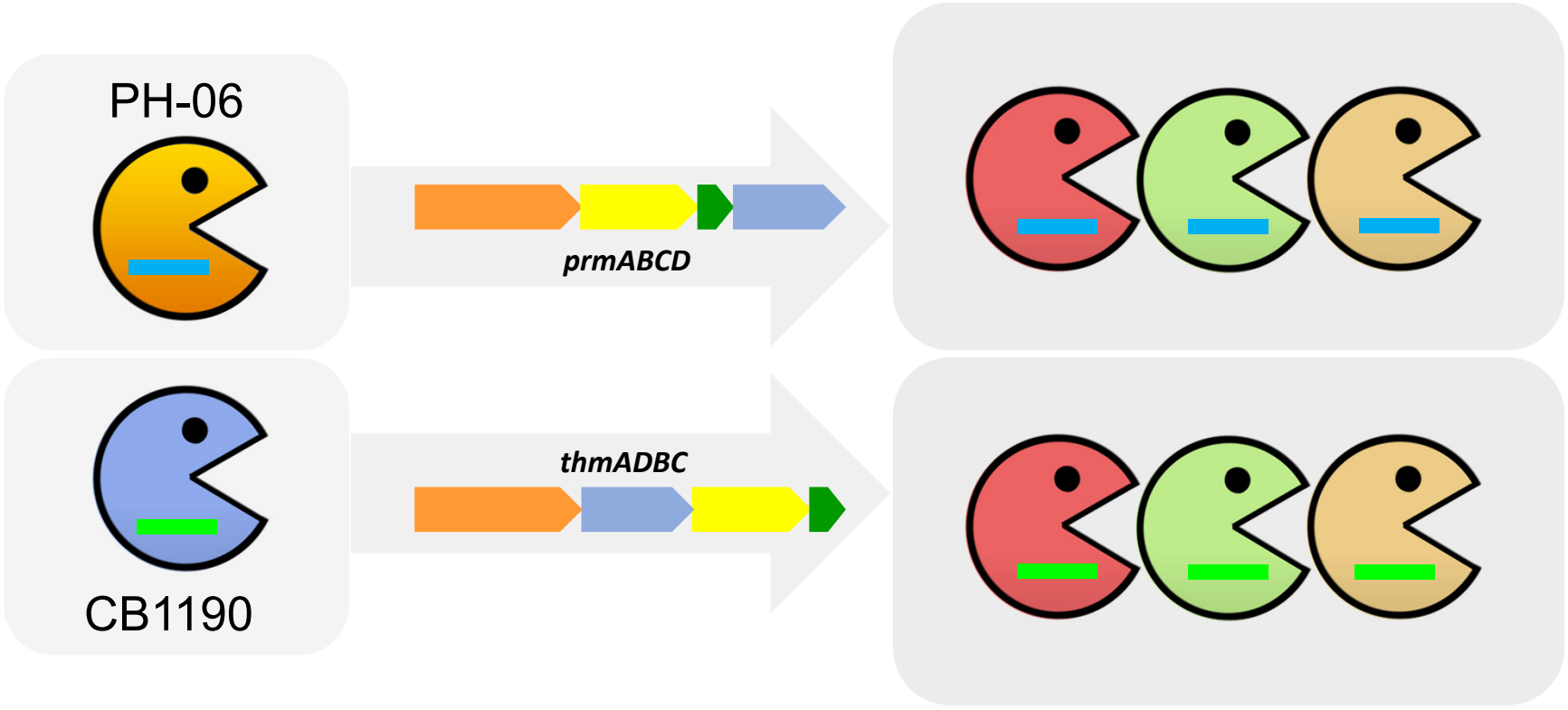
Kim *et al.*, Biodegradation., 2009; Li *et al.*, AM&B, 2018; Deng *et al.*, ES&T Letters, 2017.

Dioxane degradation genes can be disseminated among indigenous bacteria in dioxane-impacted aquifer

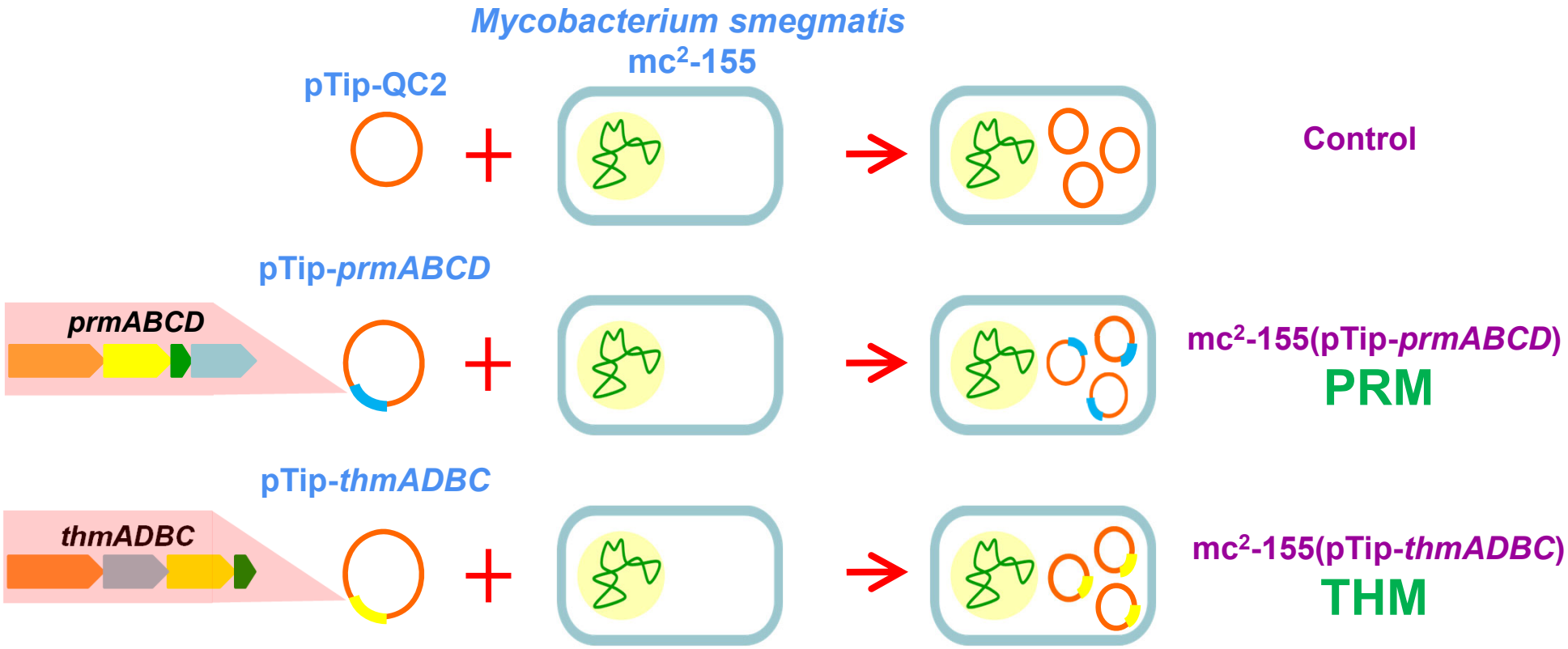


Objective

To compare the catalytic behaviors between two archetypic 1,4-dioxane degrading enzymes (THM and PRM) and exploit their potentials in monitored natural attention at field-relevant conditions.

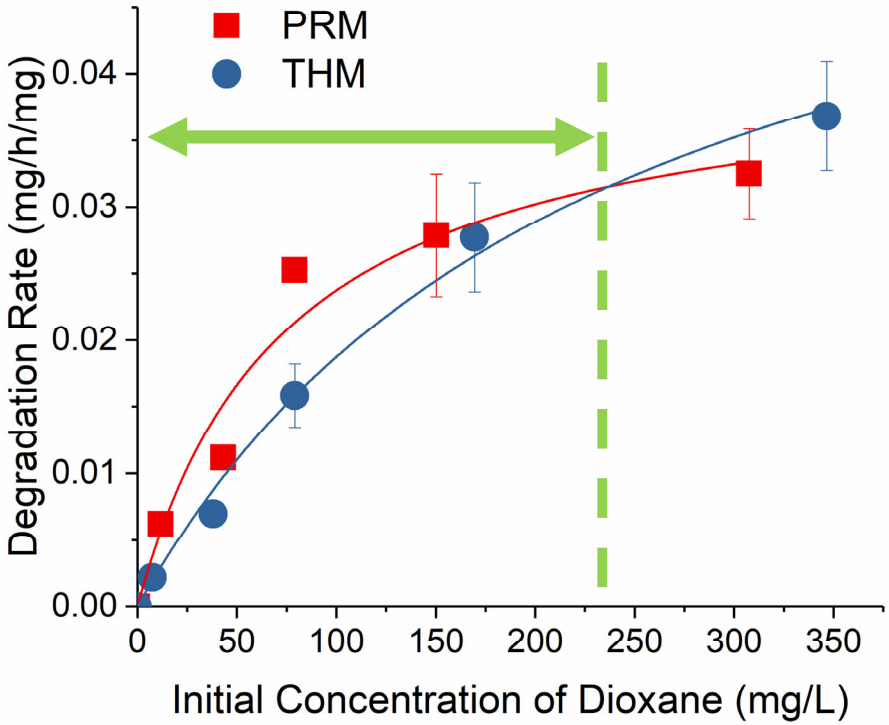
- ❖ Which enzyme exhibits a higher affinity to dioxane?
- ❖ Which enzyme is less vulnerable to co-occurring CVOCs?
- ❖ Which enzyme creates more profound isotopic fractionation for a sensitive detection by CSIA?

Flow chart: comparison of PRM with THM



Deng *et al*., ES&T Letters, 2017

PRM has higher affinity to dioxane than THM



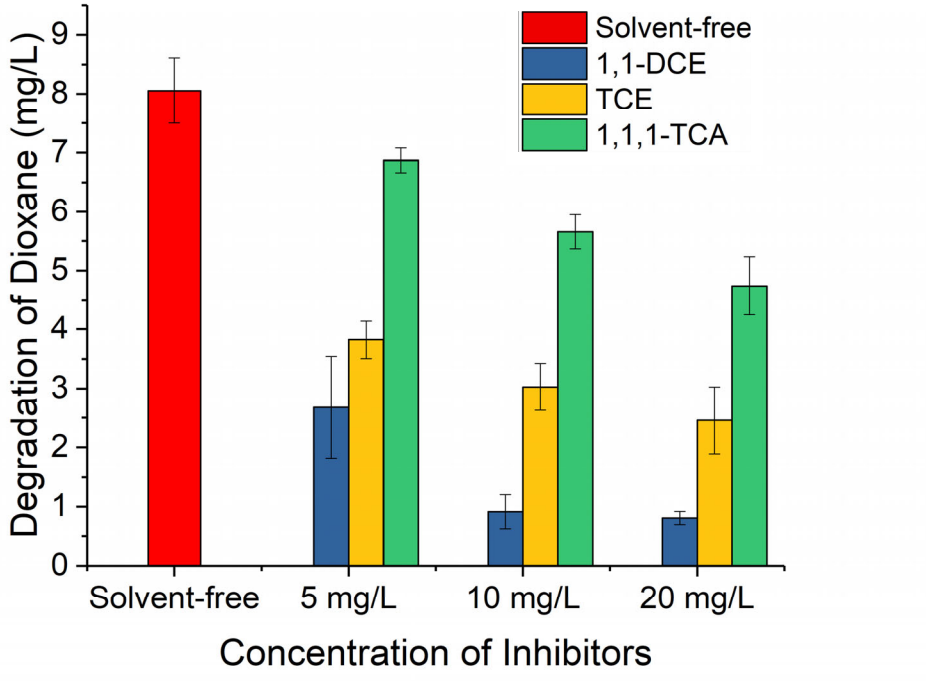
Li *et al.* in preparation

↓ K_m → Affinity ↑

	PRM		THM
Rate	0-230mg/L	>	0-230mg/L
K_m	74.73 ± 27.35	<	236.02 ± 42.00
R^2	0.952		0.994

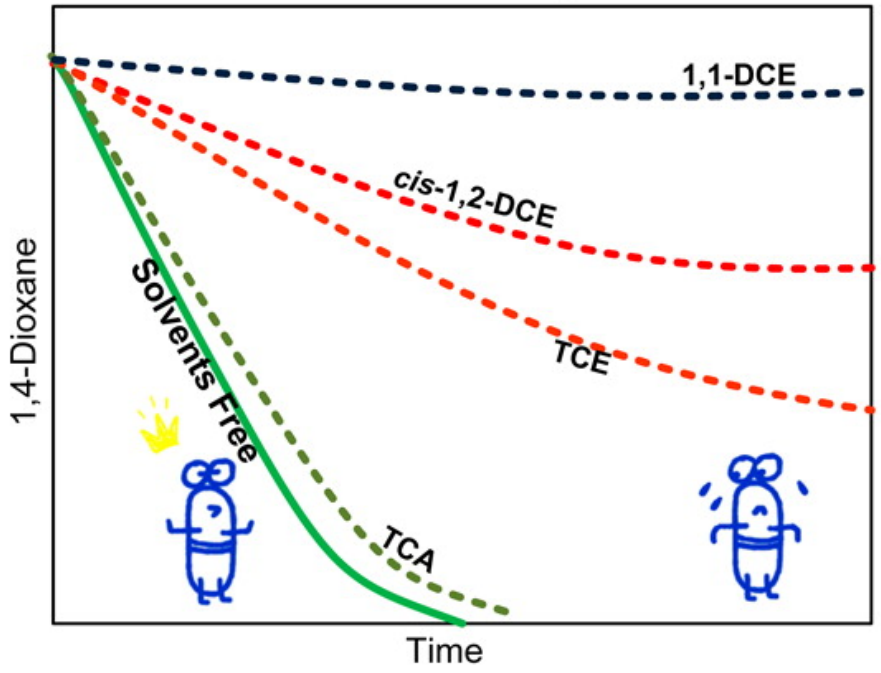
Inhibitory effects: 1,1-DCE > TCE > 1,1,1-TCA

PH-06



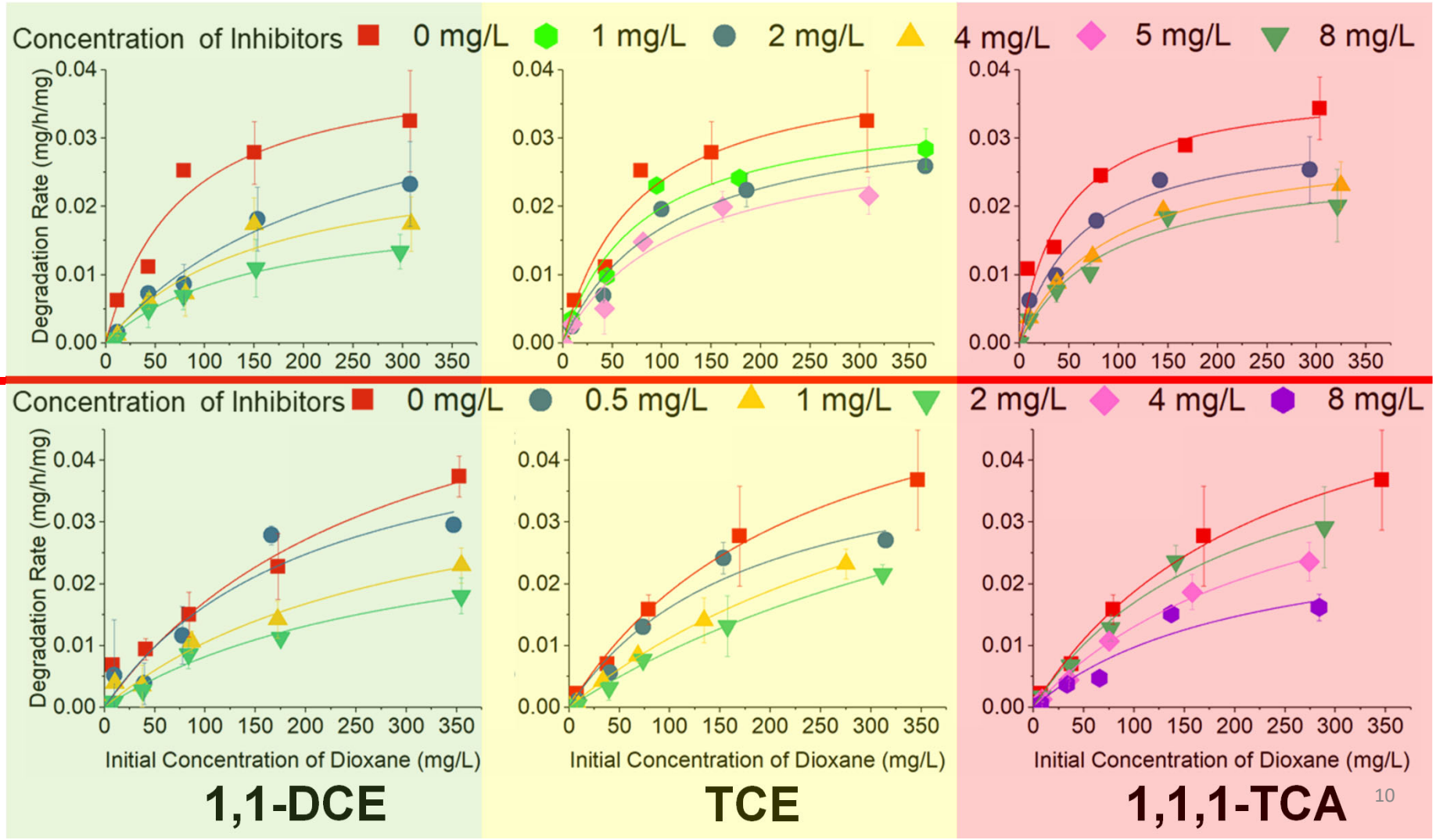
Li *et al.* in preparation

CB1190



Zhang *et al.* ES&T 2016

Inhibition kinetics



Chlorinated solvents resistance: PRM > THM

Inhibitor	Enzyme	Competitive		Noncompetitive		Uncompetitive	
		K_{IC} (mg/L)	R^2	K_{IN} (mg/L)	R^2	K_{IU} (mg/L)	R^2
1,1-DCE	PRM	5.27	0.745	6.75	0.937*	-19.20	0.216
	THM	1.41	0.901	2.14	0.987*	-10.00	0.172
TCE	PRM	5.23	0.919*	18.43	0.857	-13.00	0.800
	THM	1.13	0.921*	-22.48	0.053	-3.06	0.599
1,1,1-TCA	PRM	5.17	0.888	20.66	0.940*	-15.15	0.747
	THM	8.23	0.951	6.89	0.957*	110.00	0.054

* The model with highest R^2 as the best model are selected.

DCE/TCA V_{max} ↓ Capacity ↓

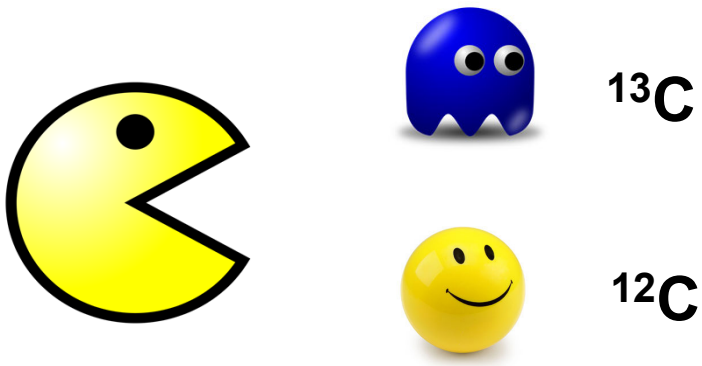
TCE K_m ↑ Affinity ↓

K_I(PRM)>K_I(THM) Resistance: PRM>THM

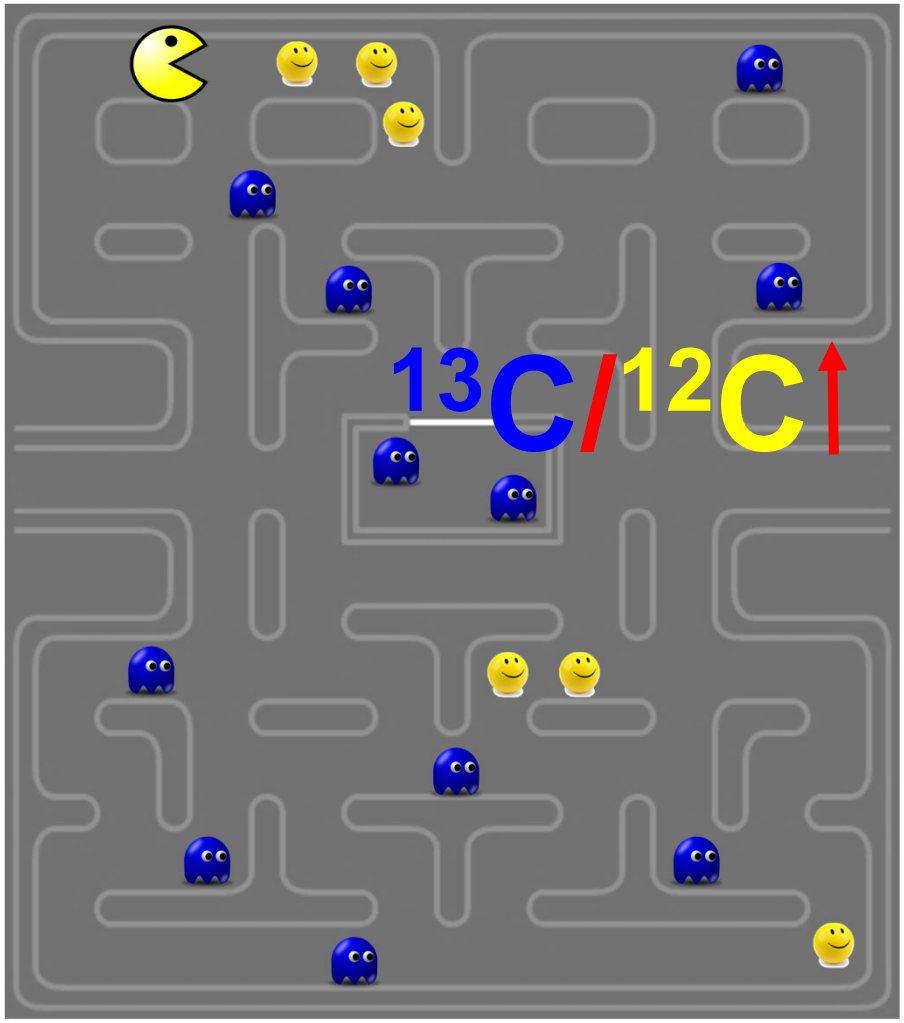
$$v_0 = \frac{V_{max}[S]}{K_m + [S]}$$

Li *et al.* in preparation

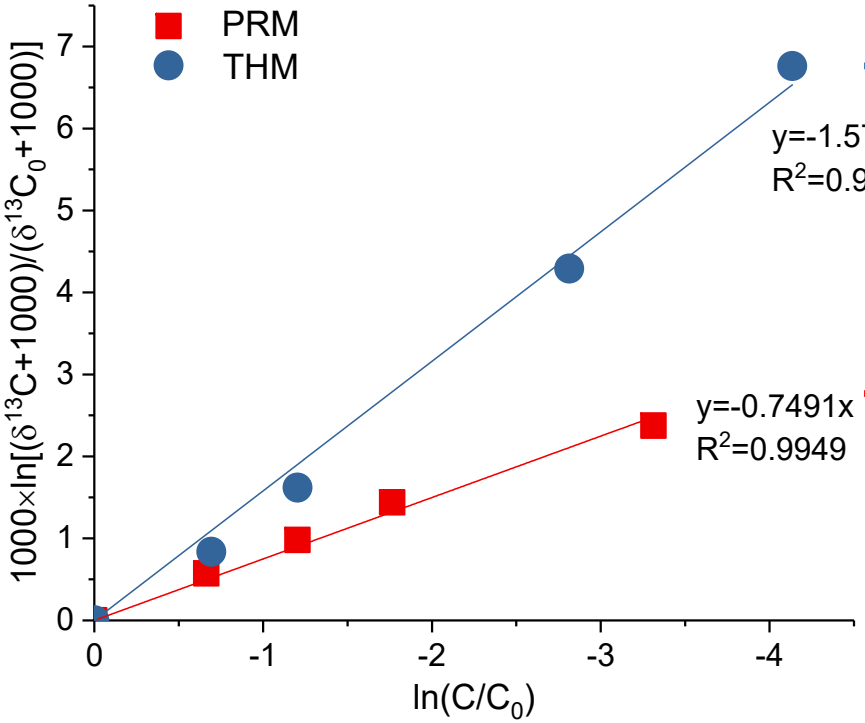
Compounds-specific isotope analysis (CSIA)



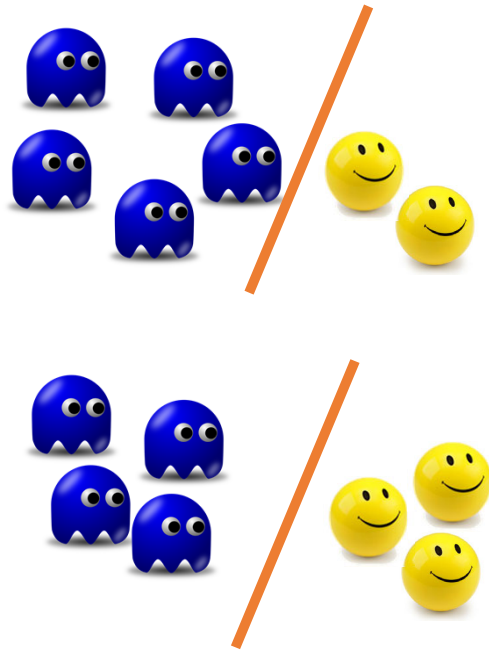
CSIA can distinguish enzyme-mediated attenuation of target pollutants.



^{13}C Enrichment efficiency: THM > PRM



CSIA is more sensitive to THM-derived dioxane biodegradation.



THM

PRM

Enzyme	ε (‰)
PRM	-0.75
THM	-1.58

Li *et al.* in preparation

PRM

THM

ROUND 1

ROUND 2

ROUND 3

ROUND 4

- Microbes harboring PRM may be more prevalent than THM in the field given their enhanced affinity and resistance to co-occurring inhibitors.
- PRM-mediated MNA has been long underestimated due to the lack of biomarkers and limited isotopic fractionation.

Ongoing research

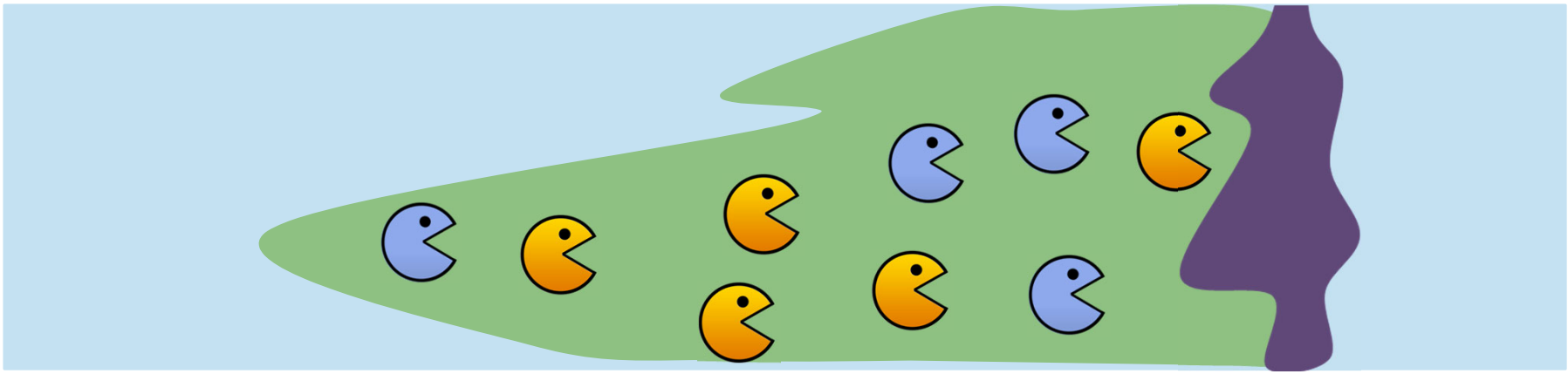
THM

PRM

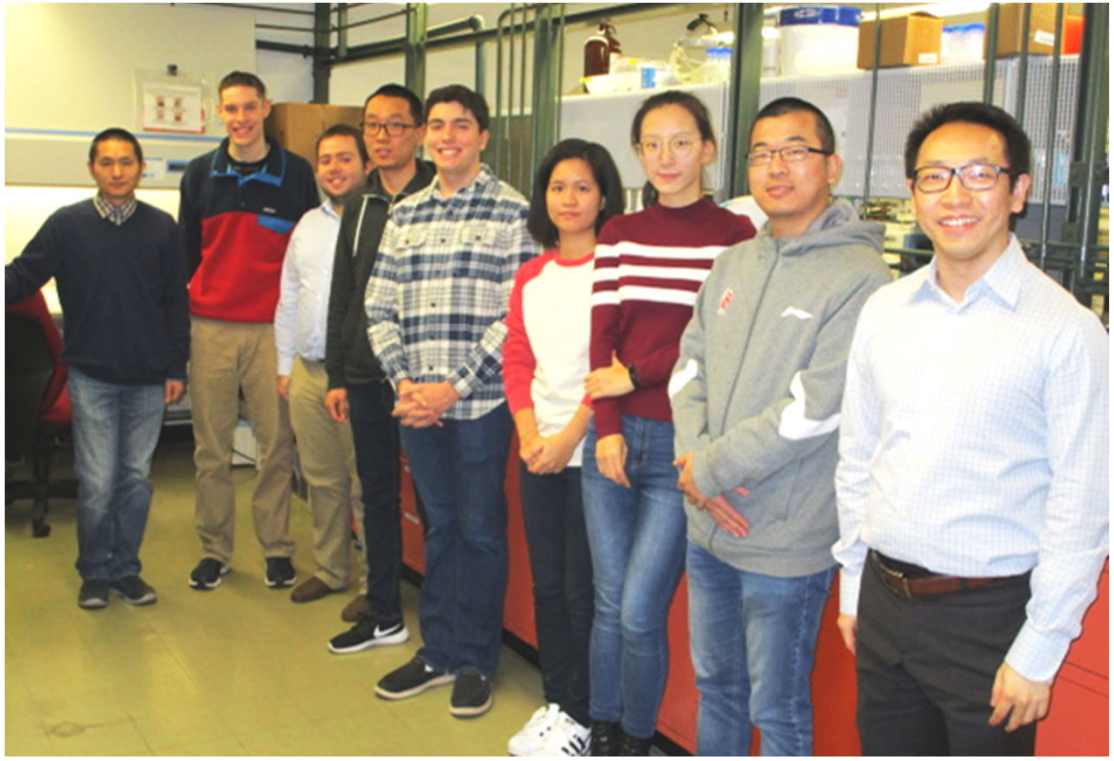
Biomarker

CSIA

A comprehensive assessment of MNA



Acknowledgements



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Welcome to our platforms/posters

Title	Presenter	Location and Time
Concurrent Biodegradation of 1,4-Dioxane and 1,1-Dichloroethylene by a Gram-Negative Propanotroph *Azoarcus* sp. DD4.	Mengyan Li NJIT	Holiday Ballroom 5 Wednesday 1:50 pm.
Effective Removal of Contaminants of Emerging Concern by Biologically-Active Filters.	Mengyan Li NJIT	Holiday Ballroom 3 Thursday 1:00 pm.
Comparison of Catalytic Behaviors between Two 1,4-DioxaneDegrading Monooxygenases.	Fei Li NJIT	Holiday Ballroom 5 Wednesday 10:30 am.
1,4-Dioxane Bioaugmentation during and after Anaerobic Degradation.	Lingke Zeng LANGAN	Holiday Ballroom 5 Wednesday 2:50 pm.
1,4-Dioxane Contamination Survey at River Estuaries and Wastewater Treatment Plants in Northern NJ.	Fei Li NJIT	Exhibit Hall No.70 Monday/Tuesday
Substrate-Mediated Biotransformation and Biodefluorination of 6:2 FTOH by *Mycobacterium* and *Rhodococcus* Species.	Chen Wu NJIT	Exhibit Hall No.8 Monday/Tuesday

Thanks for your attention!