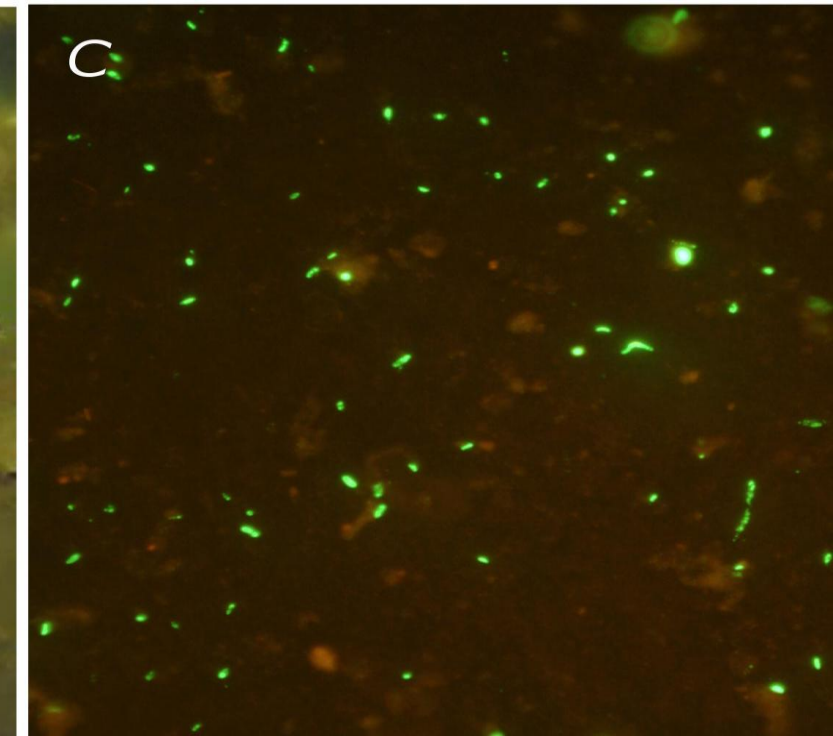
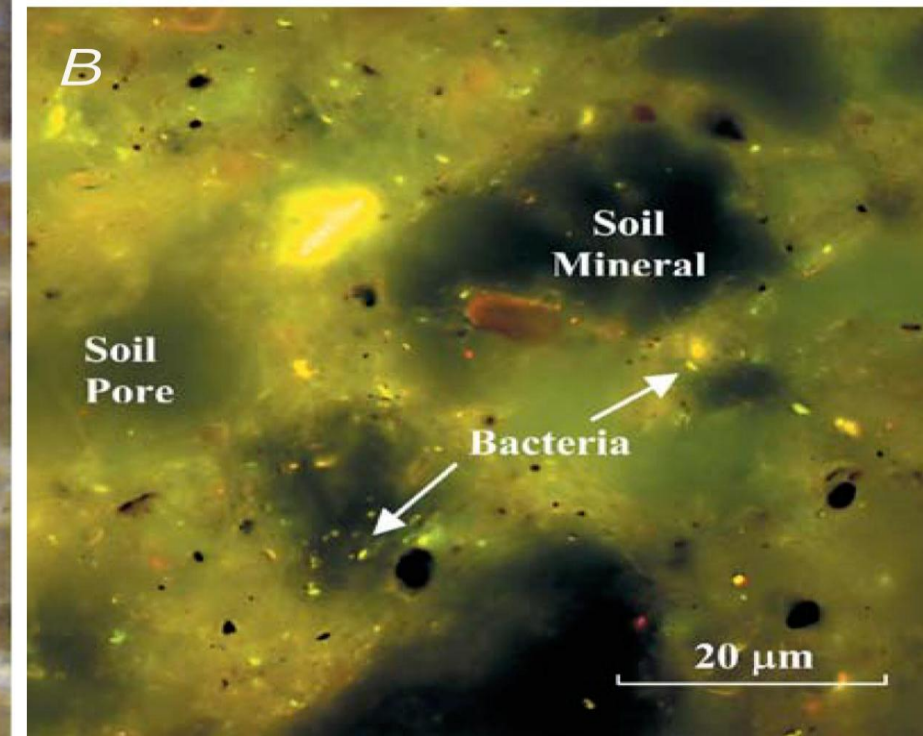
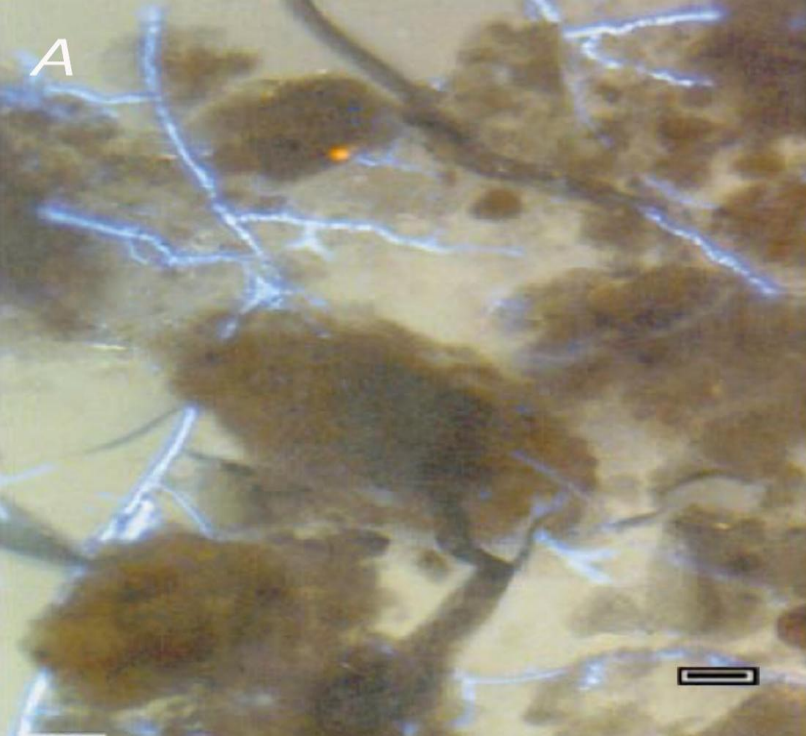




Dissolved Organic Matter as a Booster for Hydrocarbon Bioremediation: Insights from Positron Imaging and X-ray Spectroscopy

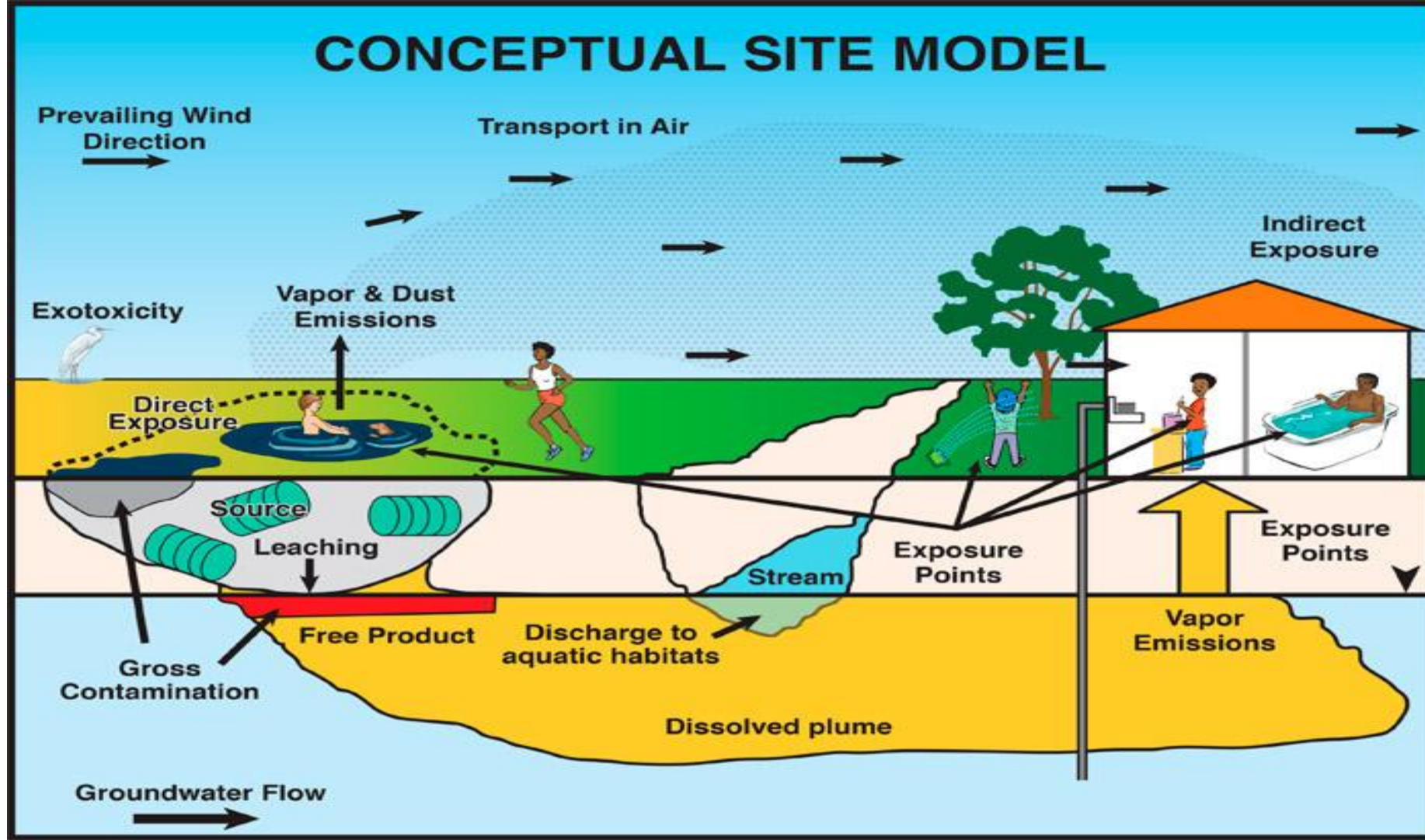
Tony Tian, Dr. Steven Siciliano

October 17, 2025

Contact tony.tian@usask.ca or connect with me on LinkedIn

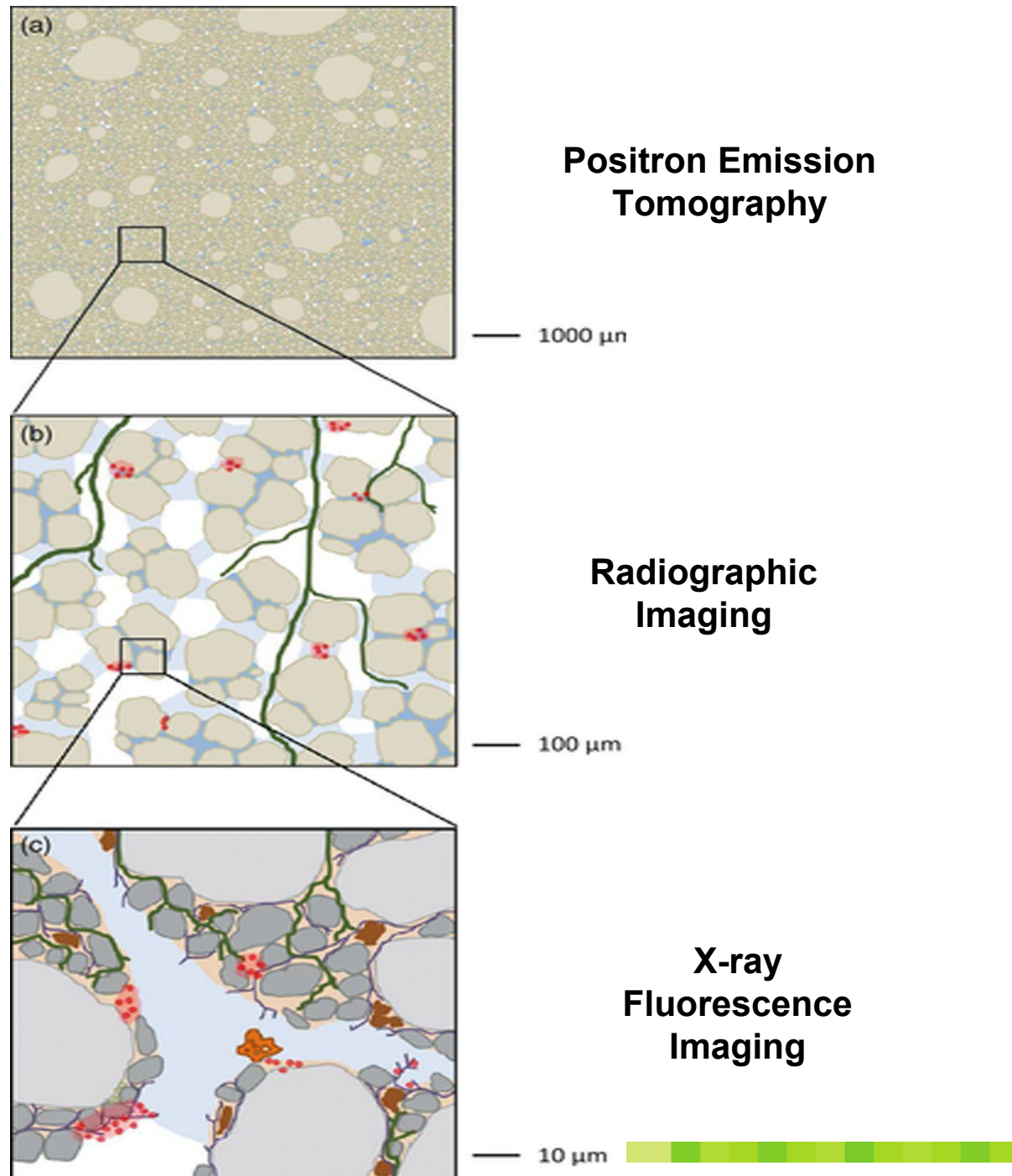
Cover image adapted from Baveye et al., 2018

The Problem: Persistent BTEX in Prairie Soils



Adapted from ITRC's *TPH Risk Evaluation at Petroleum-Contaminated Sites* (2018)

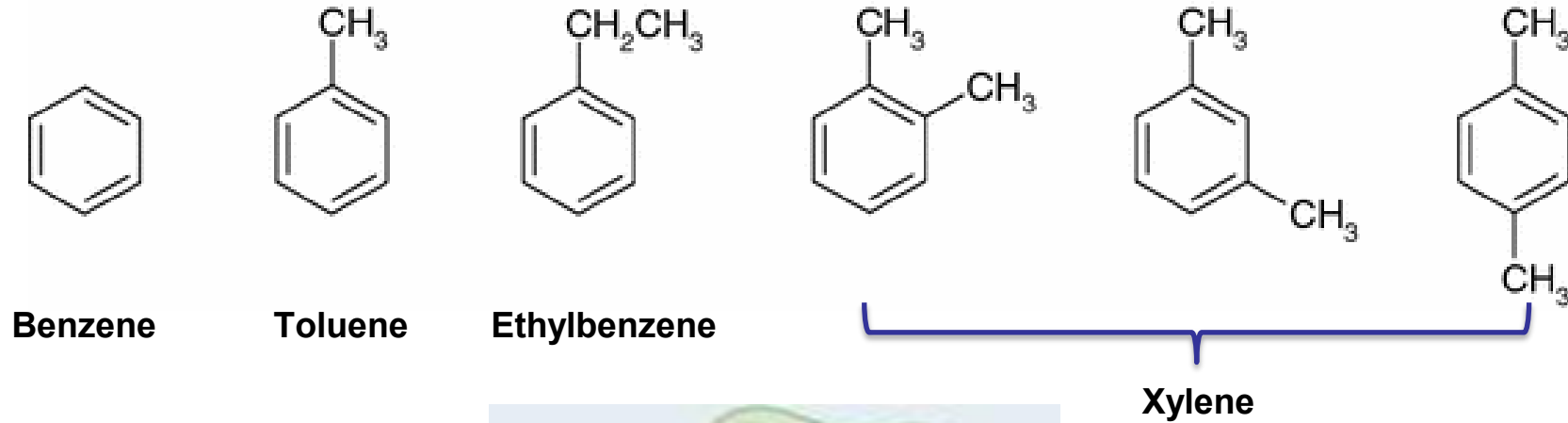
Spatial scales of various imaging techniques



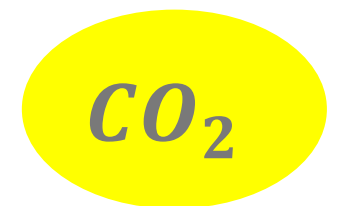
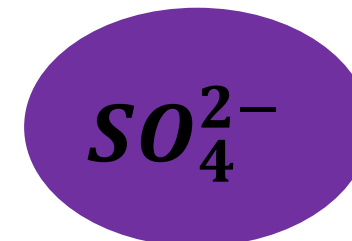
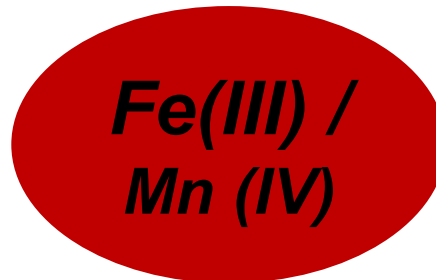
Overall Goal is to decipher how microbial activity in soil is linked to physicochemical properties in its **microenvironments that are relevant to bacteria, i.e. μm - mm**

Key Players in Anaerobic BTEX Biodegradation

Pollutants

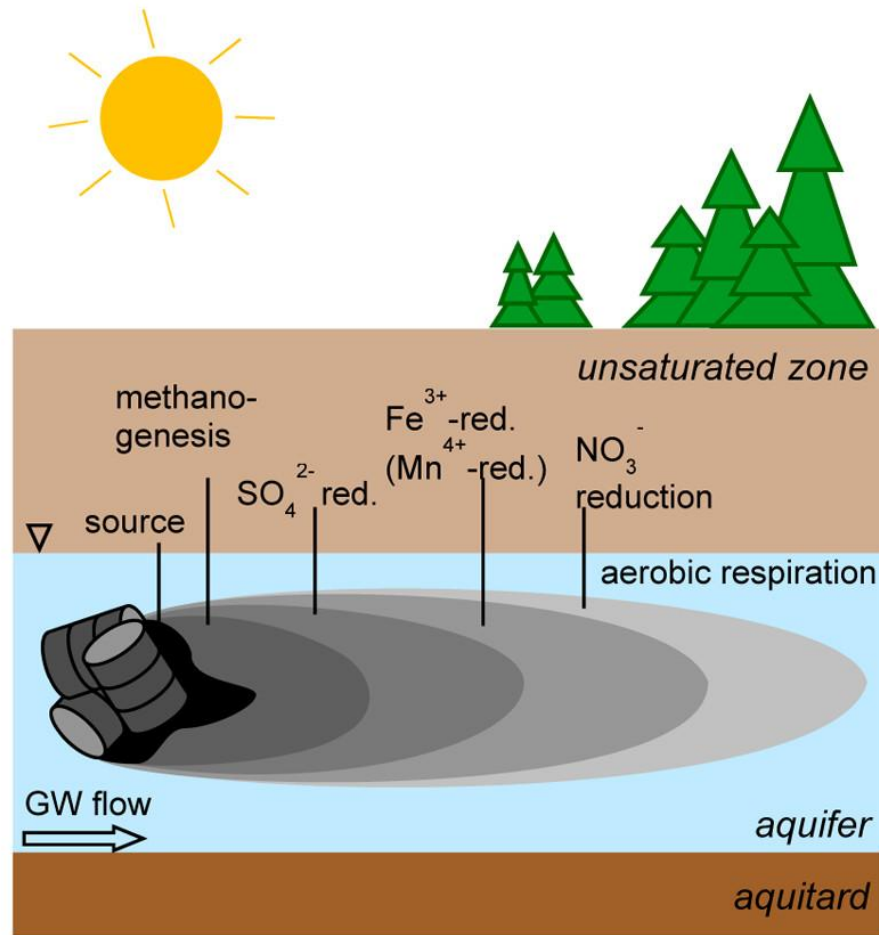


Electron acceptors (EAs)

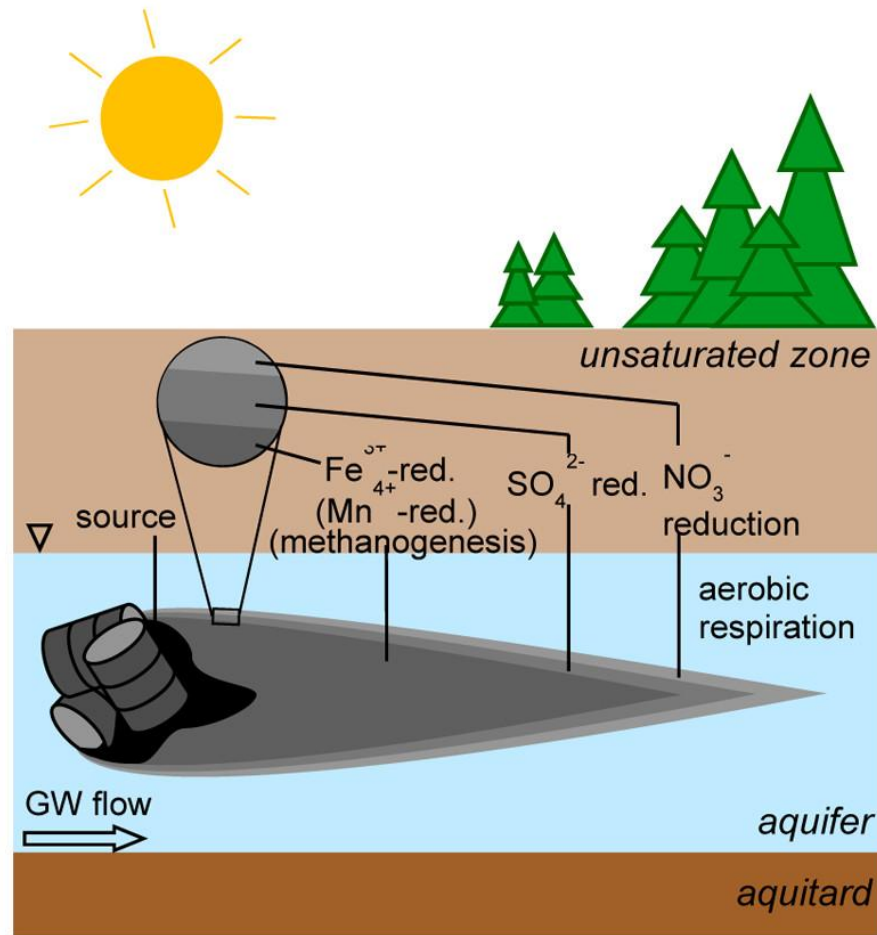


The Problem: Persistent BTEX in Prairie Soils

A. Redox zonation concept



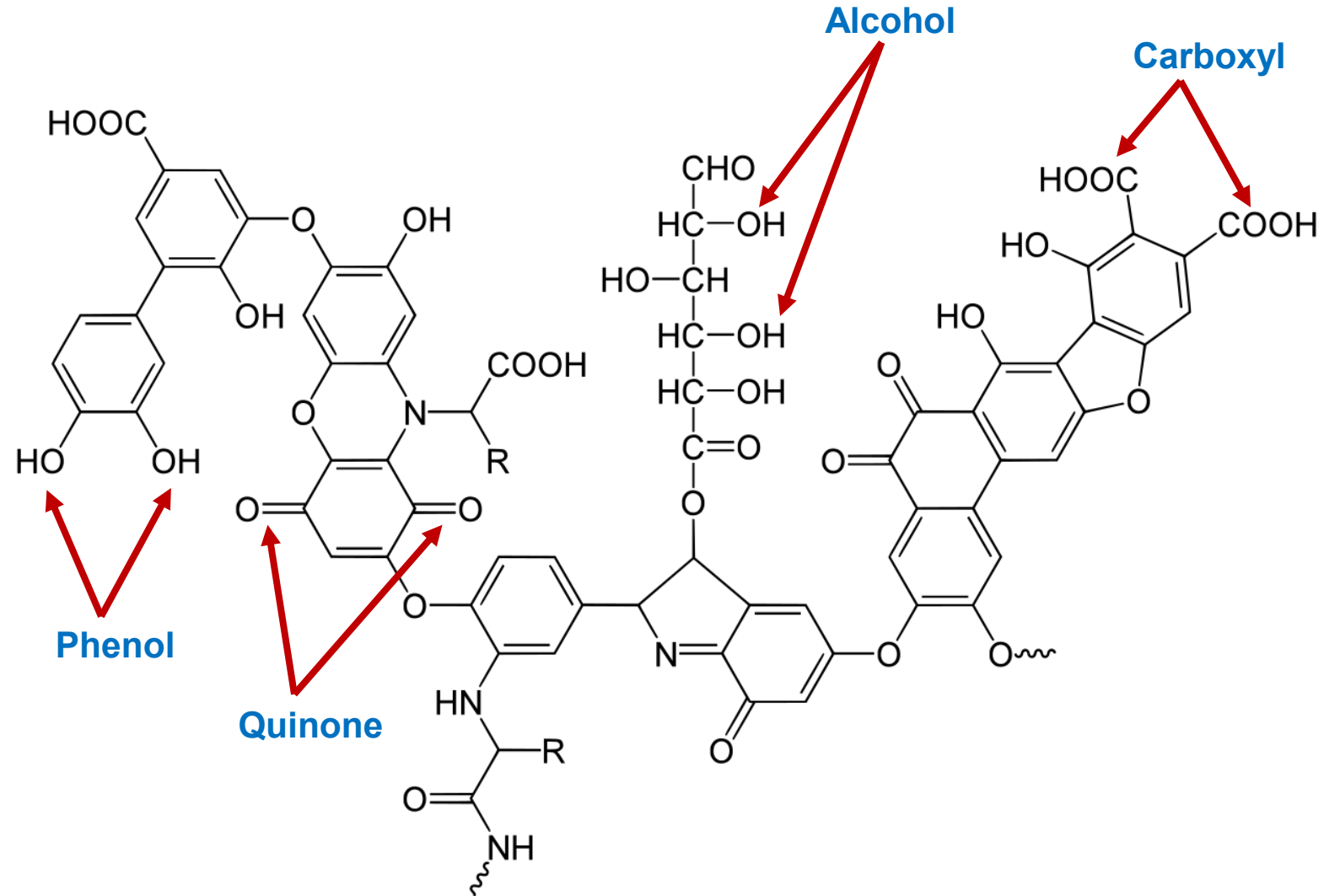
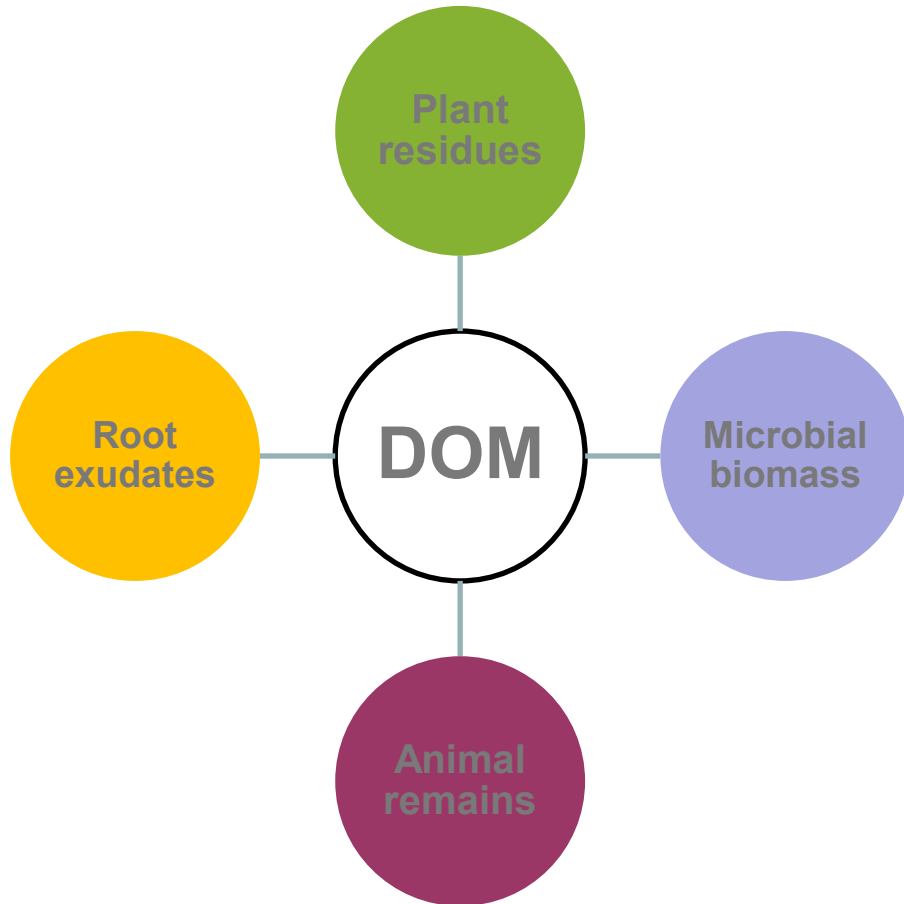
B. Plume fringe concept



- Traditional **redox zonation concept** only considers **thermodynamics**, whereas **plume fringe concept** takes **kinetics** into account too

- Soluble EAs are depleted in plume core, in which degradation relies on **insoluble EAs, e.g. Fe(III)**

What is Dissolved Organic Matter (DOM)



How Can DOM Help BTEX Biodegradation? Potentially Dual Roles

Model for Fe(III) Oxide Reduction
by *Geobacter* via Direct Cell-Fe(III)
Oxide Contact

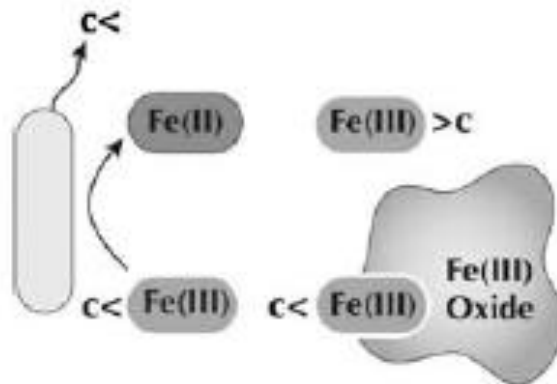
Fe(II)



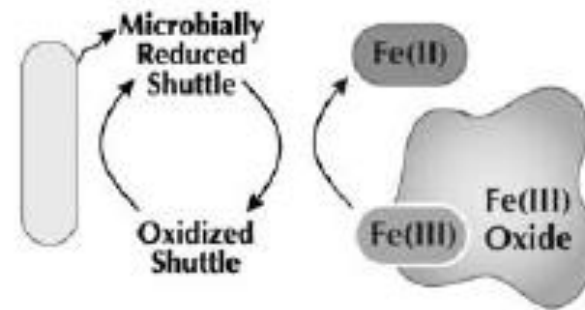
As a Fe(III) chelator

As an electron shuttle

Release of an Fe(III) Chelator



Release of an Electron Shuttle



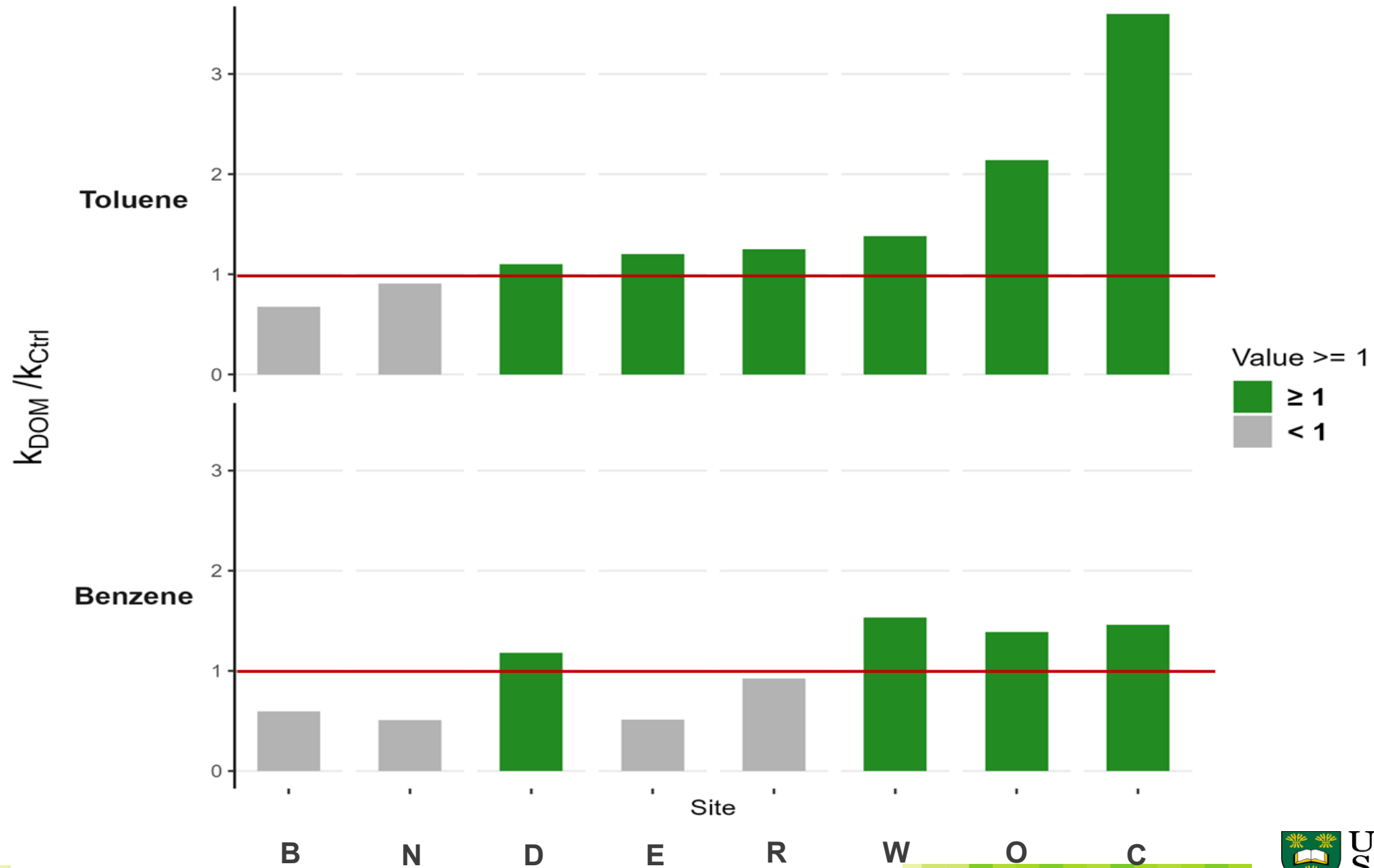
Model for Fe(III) Oxide Reduction
by *Shewanella* and *Geothrix* That
Alleviate the Need for Direct Cell-Fe(III) Oxide Contact

Adapted from Tabak et al., 2005

Field Soil Sampling & Lab Studies Setup

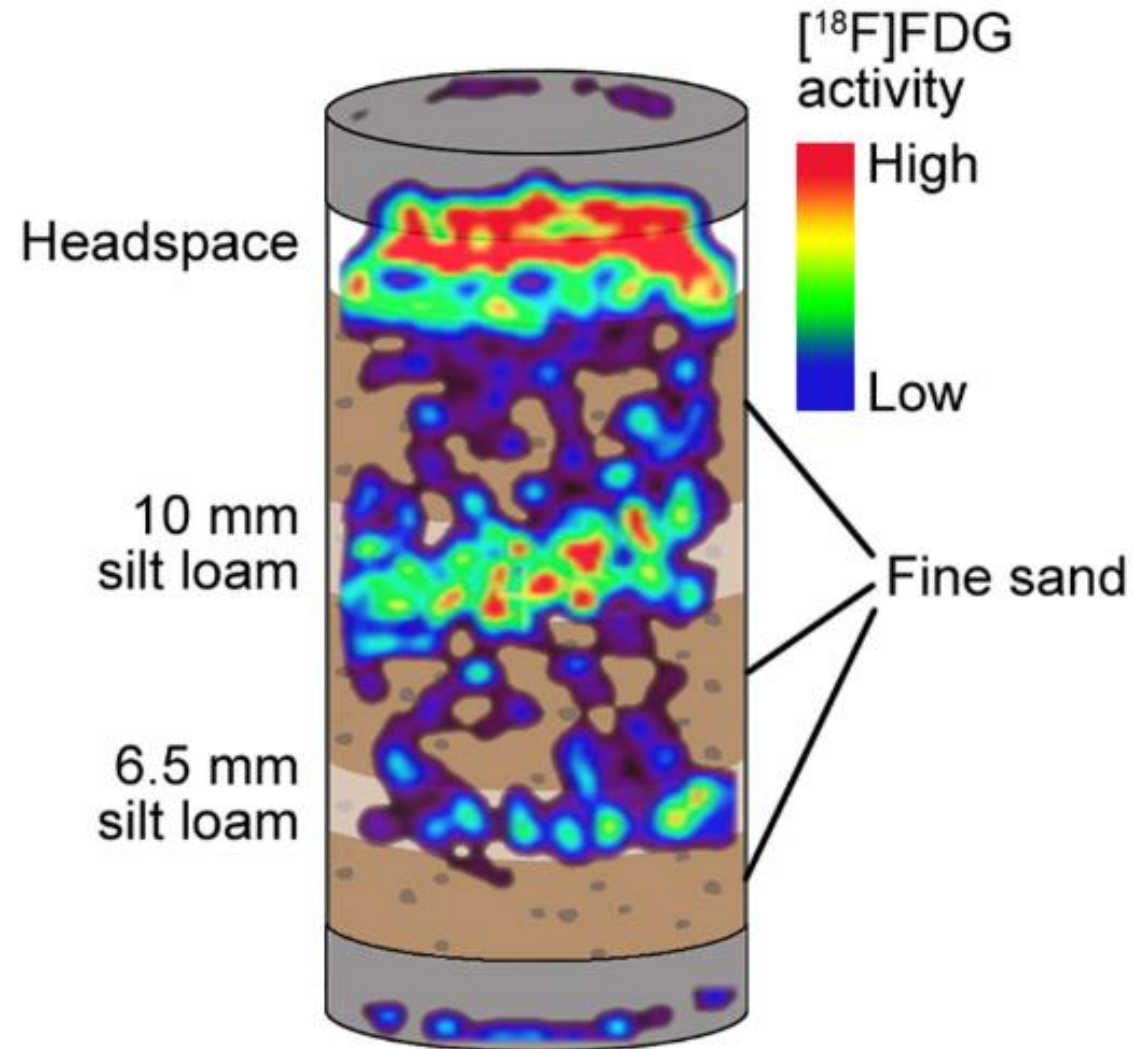


DOM Accelerates Toluene and Benzene Degradation



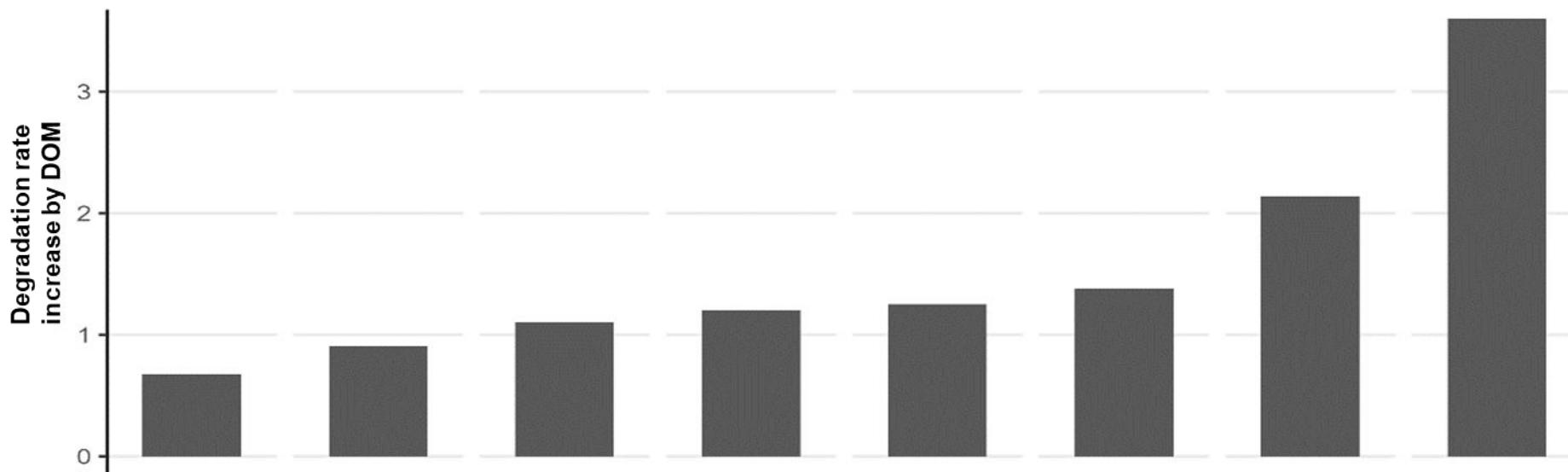
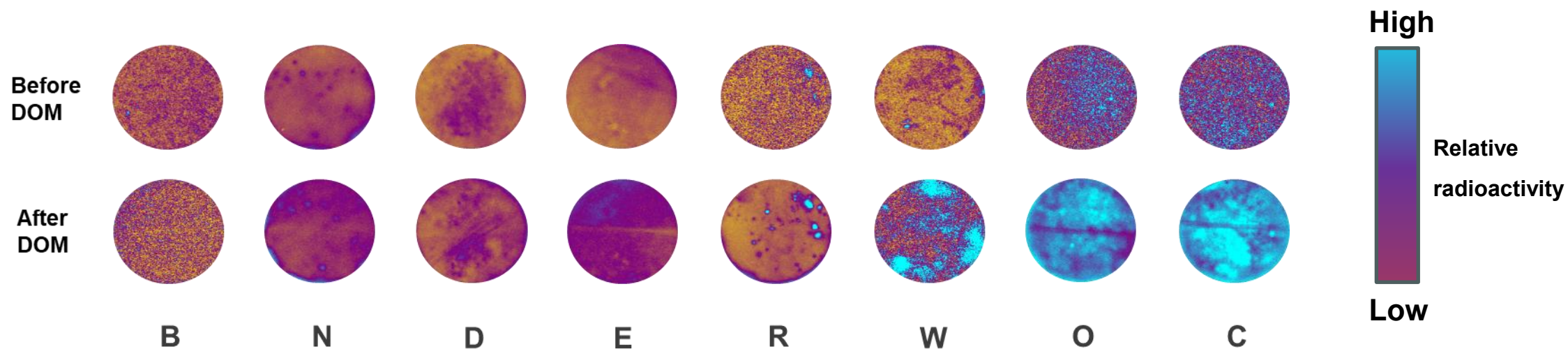
Allows Us to See Inside Out

A model soil column dosed with
[¹⁸F]FDG and imaged with Positron
Emission Tomography (PET)

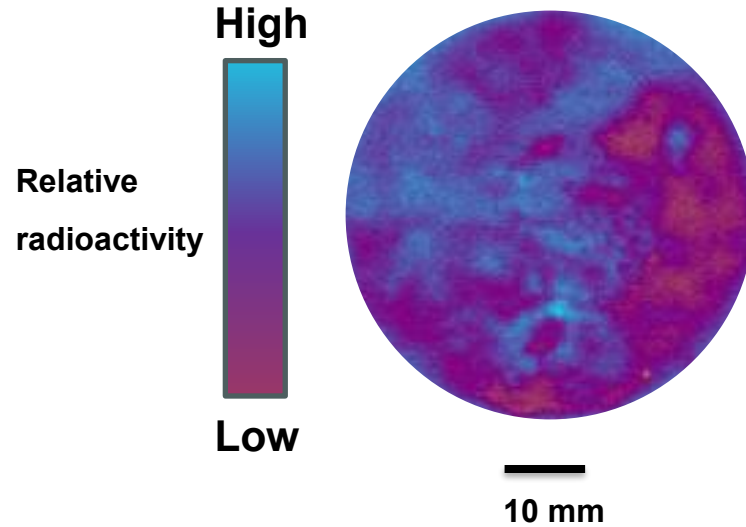


Adapted from Kinsella et al., 2012

Consistent Results between Radio-imaging and Degradation Kinetics



Radio-image of Soil

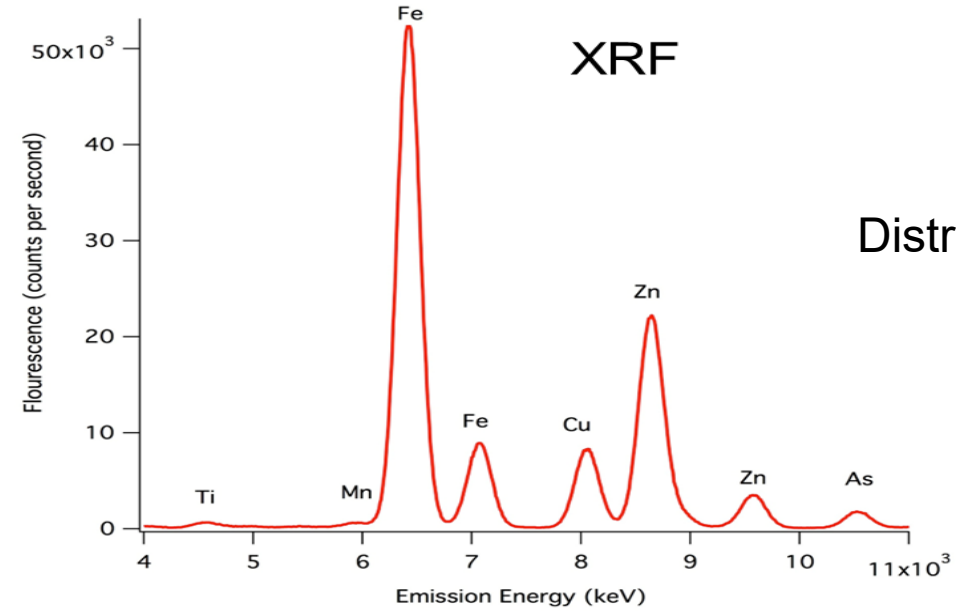


Why some spots
“hotter” than
others?

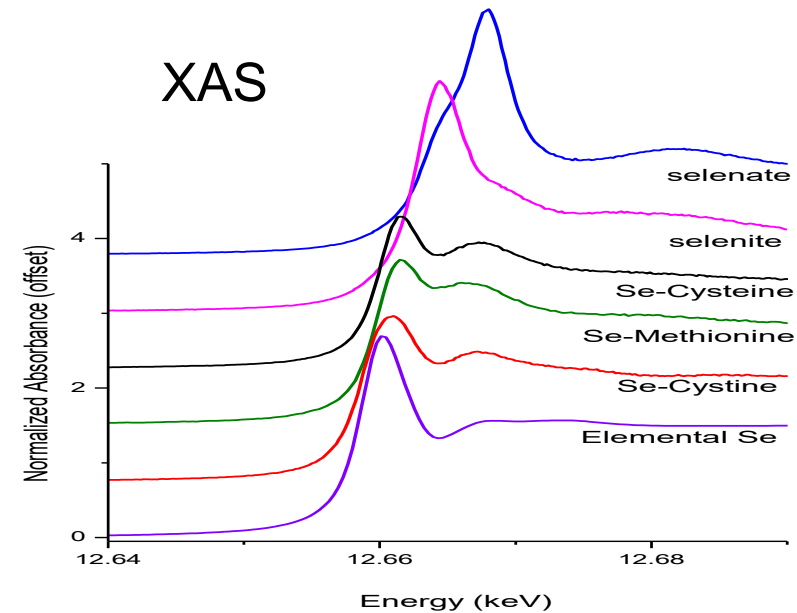
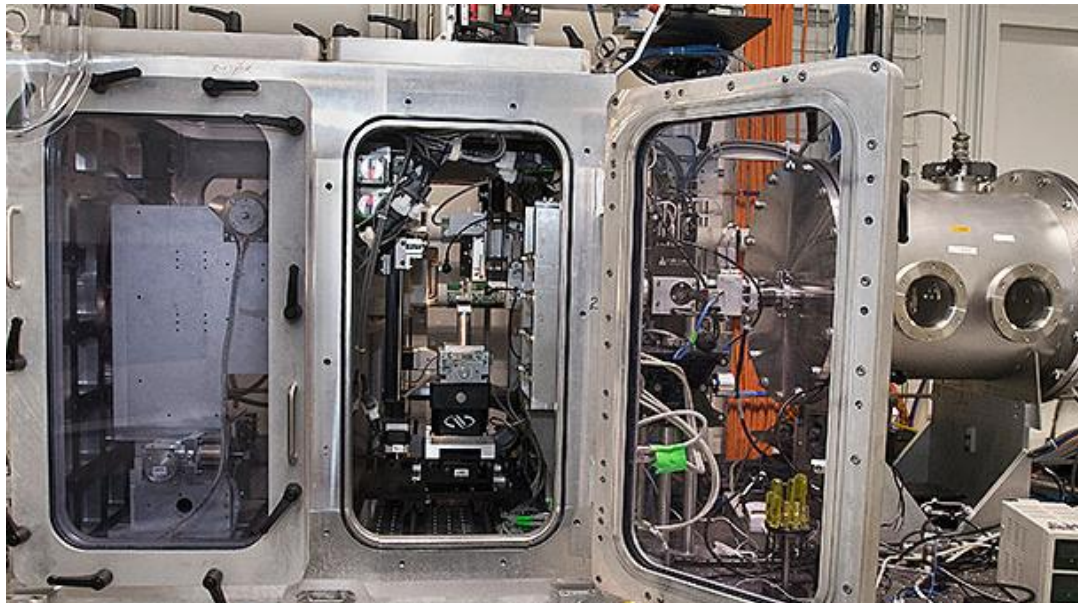
- More electron acceptors: Fe(III), nitrate, sulfate?
- More soil organic matter: C, N?
- More nutrients: N, P?

X-ray
spectroscopy!

Synchrotron-based X-ray Spectroscopy

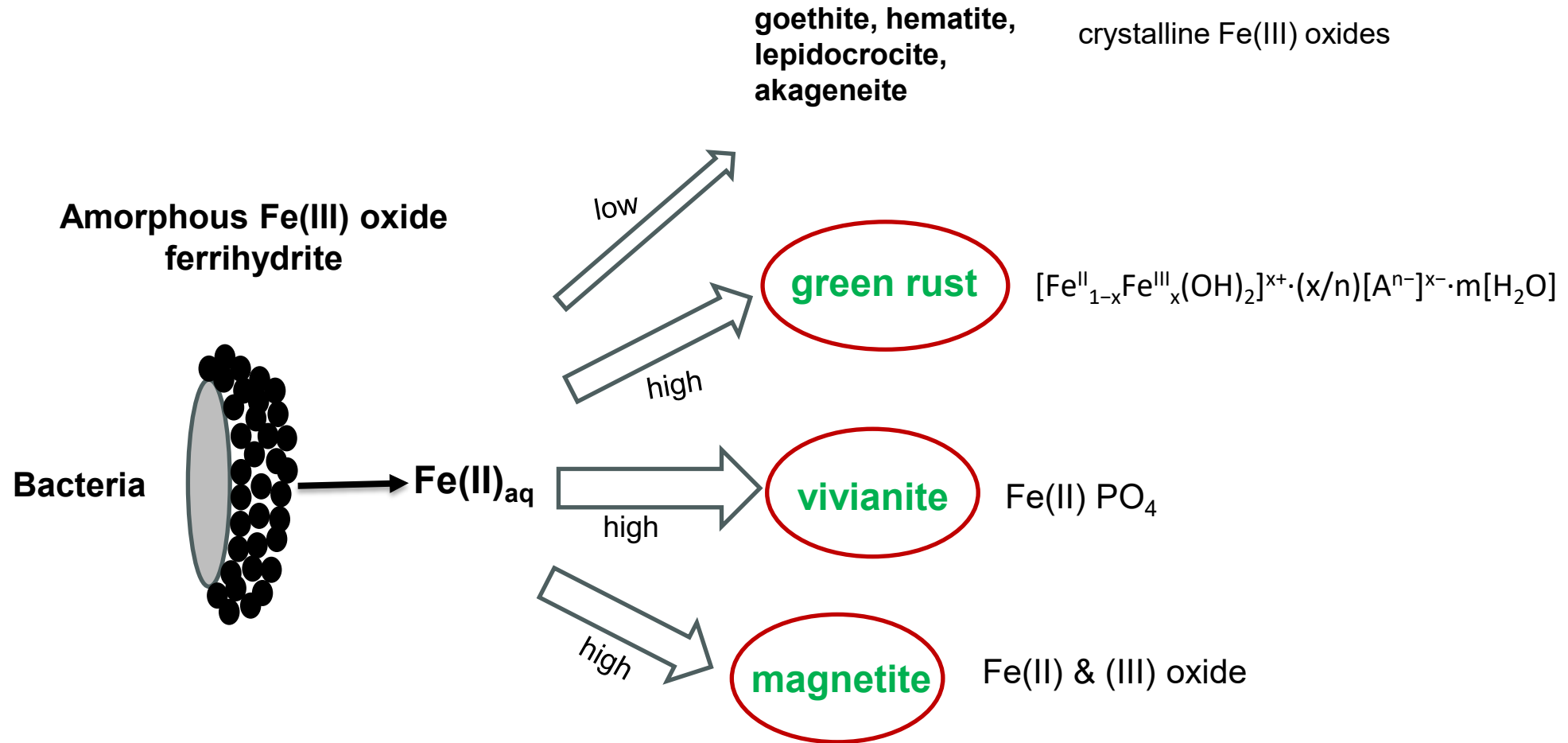


Distribution mapping



Elemental speciation

Dissimilatory Iron Reducing Bacteria (DIRB) Induced Iron Transformation

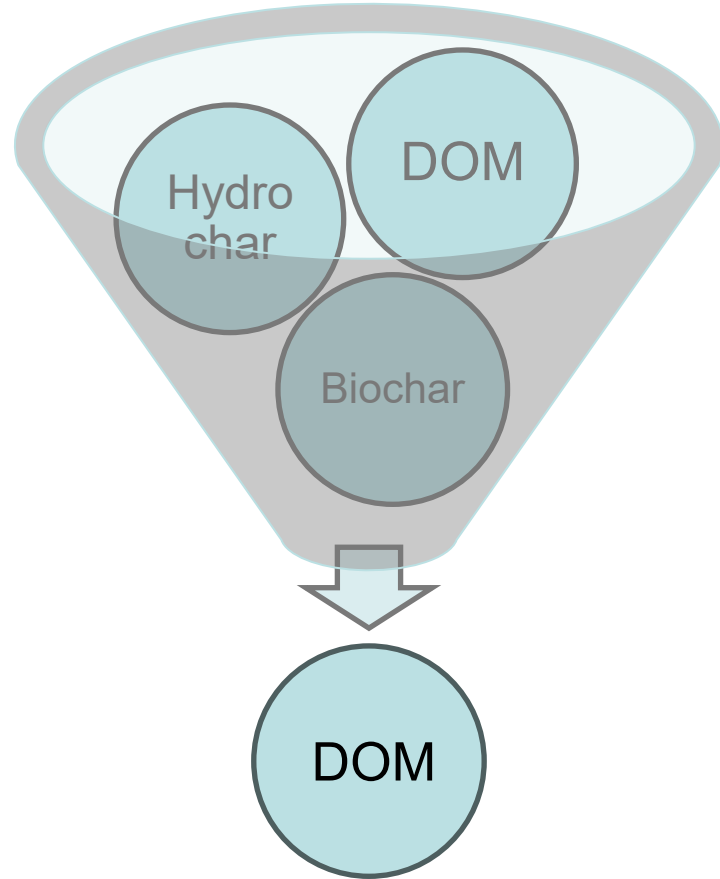


Adapted from Hansel et al., 2004. Originally based on Zachara et al., 2002.

Future Applications

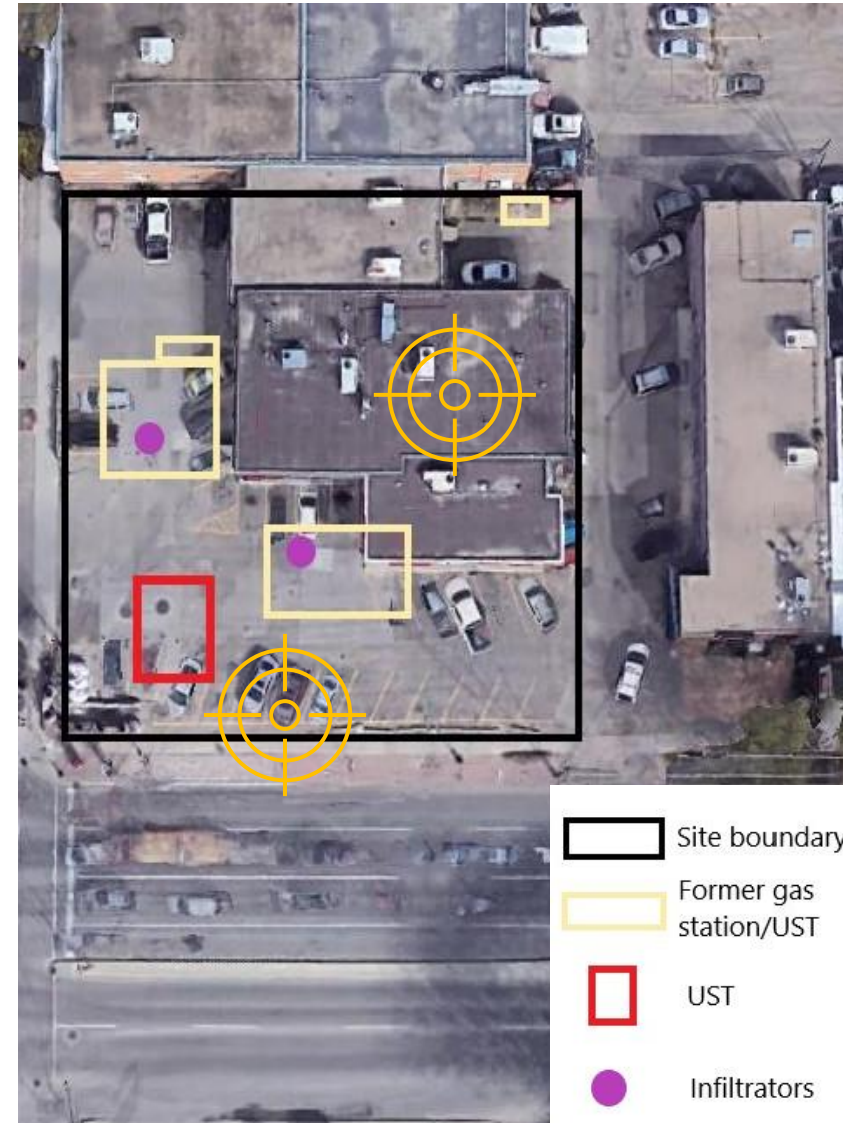
- ✓ Screen biostimulants before field trials

WHAT?



- ✓ Targeted delivery of amendments

WHERE?



Acknowledgement

Dr. Steve Siciliano

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Dr. Placid Orji

Dominique Rwizinkindi

Dr. George Gachumi

Dr. Beatrice Romero

Levi Lundell

Kyle Fransishyn



**Federated
Co-operatives
Limited**



**Canadian
Light
Source** **Centre canadien
de rayonnement
synchrotron**



THANKS

Questions & Comments



Contact tony.tian@usask.ca or connect with me on LinkedIn