SIRCA

Sustainable In-Situ Remediation Co-operative Alliance

Electrical conductivity as an indicator of biostimulatory solution dispersal and PHC biodegradation potential

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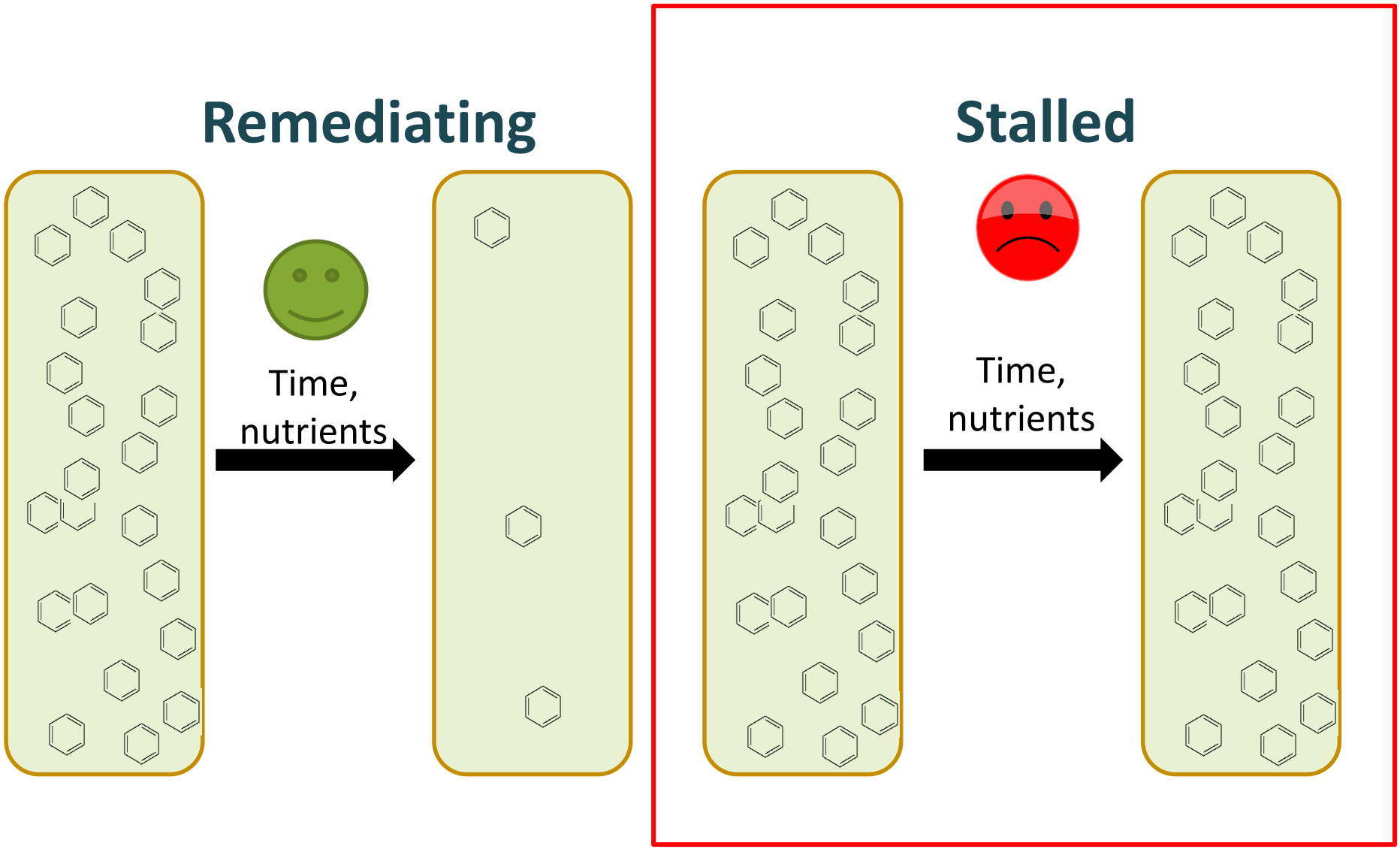
Presenting Members

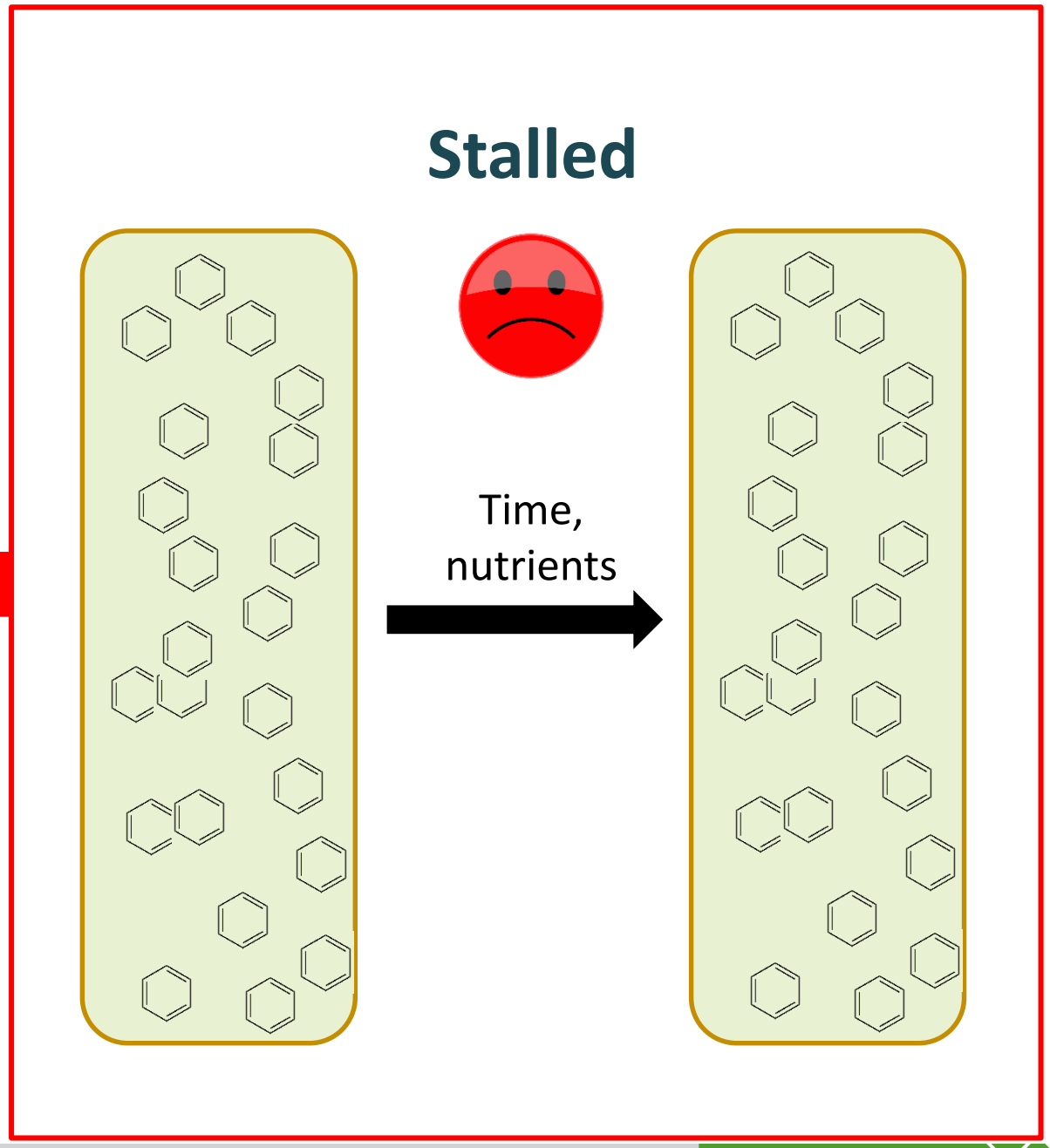
University of Saskatchewan

CO-OP


Remediating
Time,
nutrients
Stalled
Time,
nutrients

Site often dismissed

No further investigation



Are there any indicators of unconstrained PHC degradation?

Are there any indicators that PHC degradation may be or will become stalled?

First, we need to understand the PHC conditions on site

Soil database

Started in 2015 (S4) and 2016 (S1 – S3) as the pre-amendment period

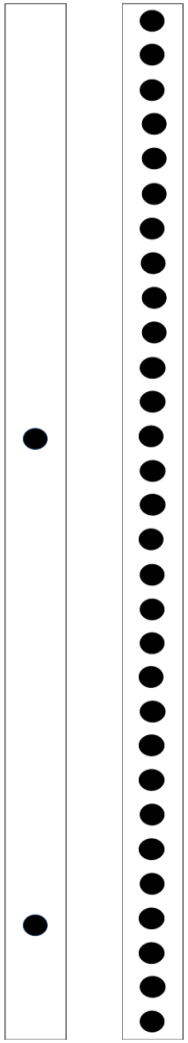
Site	Number of soil samples
Site 1	251
Site 2	278
Site 3	198
Site 4	203
Total	930

Sampling data from at least 4 years **(Locations without 4 years of data excluded)**

Incremental sampling methodology sampling for F1/BTEX

Incremental sampling methodology

ISM sampled core (left) and discrete sampled core (right)



Discrete sampling is unable to accurately represent site conditions

The purpose of ISM is to obtain a single sample for analysis that represents the mean analyte concentration

30 to 100 increments are combined, processed and subsampled according to specific protocols.

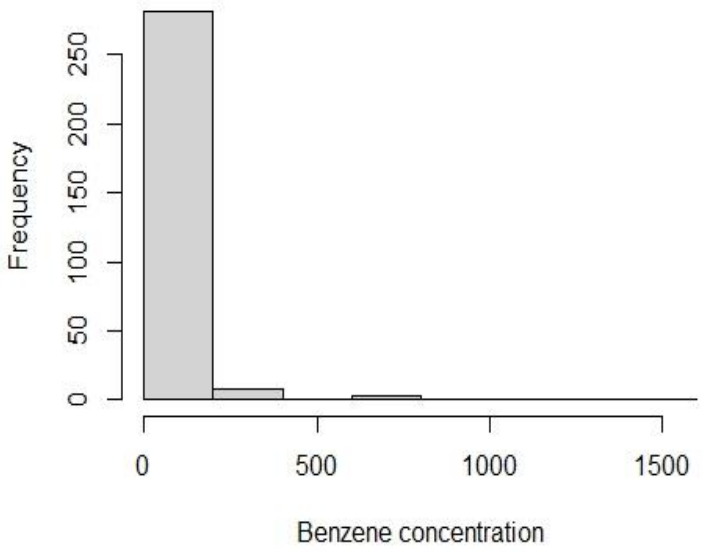
Reduces the fundamental error associated with the heterogeneous nature of the soil by increasing the mass of soil used for analysis.

Photo source: Hyde et al. 2019. Soil and Sediment Contamination: An International Journal.

Environmental data

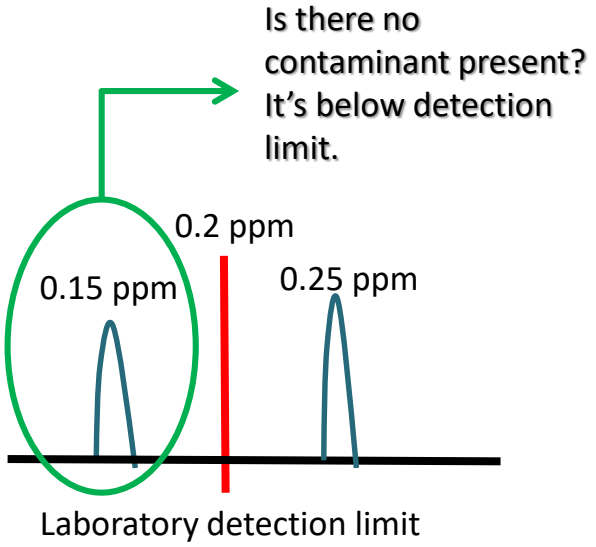
- Number of data points varies
  - *e.g.* Number of aliquots at one borehole by year
    - 2016: 8
    - 2017: 4
    - 2018: 5
    - 2019: 14

Benzene concentrations at Site 2 over 4 years



- Heavily left-censored and skewed
- High variance
- Data not normal or lognormal

- Non-detects



Use Hurdle model to determine mean of benzene

Hurdling Over Non-Detects

Environmental Science & Technology

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Assessing Space, Time, and Remediation Contribution to Soil Pollutant Variation near the Detection Limit Using Hurdle Models to Account for a Large Proportion of Nondetectable Results

Lidong Huang,[†,‡] Kris Bradshaw,[§] Jay Grosskleg,[§] and Steven D. Siciliano*[,‡]

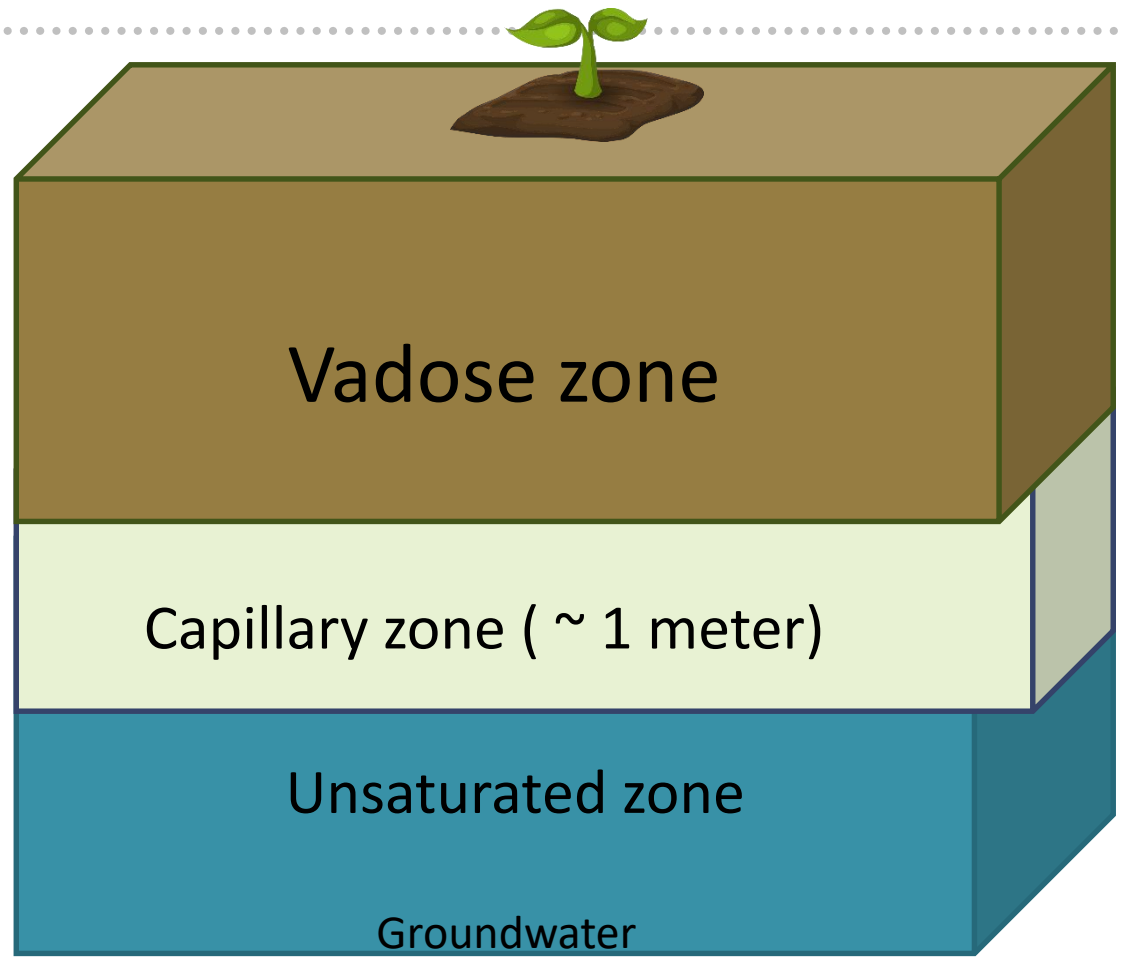
ABSTRACT: Many emerg
pose risks to humans and e
(DL) of existing analytical s
and management options a
that are sparse, highly sk
analysis methods are unable
from covariates, such as s
management. As a case st
variance of censored soil be
three year period by gam
likelihood. Further, a combi
left-censored concentration
affecting benzene variation.
the success and spatial depe
in reducing benzene concentrations at very low concentrations. Benzene concentrations decreased due to the addition of biostimulatory solution and spatial effects, but the detection of soil benzene after biostimulation was highly spatially dependent. By combining computed values for censored observations estimated by the hurdle-gamma model and uncensored observations, we can get the pseudocomplete data sets. The combined model is ideally suited to evaluate existing and emerging pollutants, that pose risks to humans and ecosystems but are typically at or near analytical detection limits.

Split the data, into two groups:

- Non-detects which are modelled using a Binomial (presence/absence).
- Detects which are modelled using a Gamma distribution (continuous and flexible).

Determine from means and confidence intervals (95%) whether a site is **remediating/remediated or stalled**

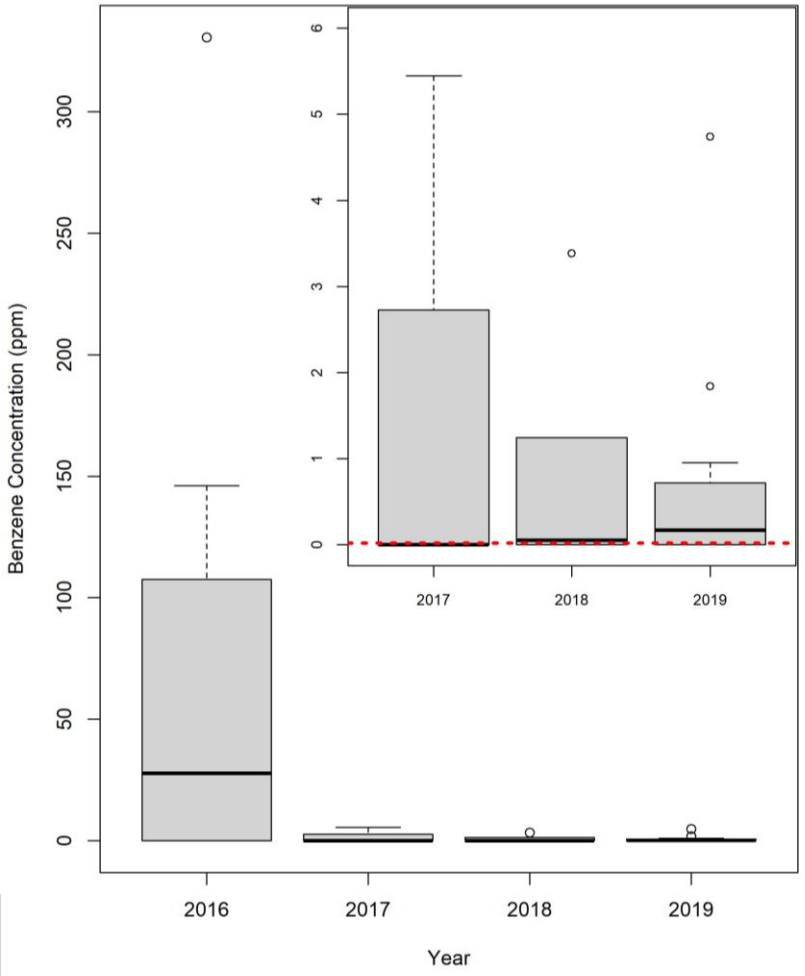
Degradation by soil zones



Example: Stalled vs. remediated

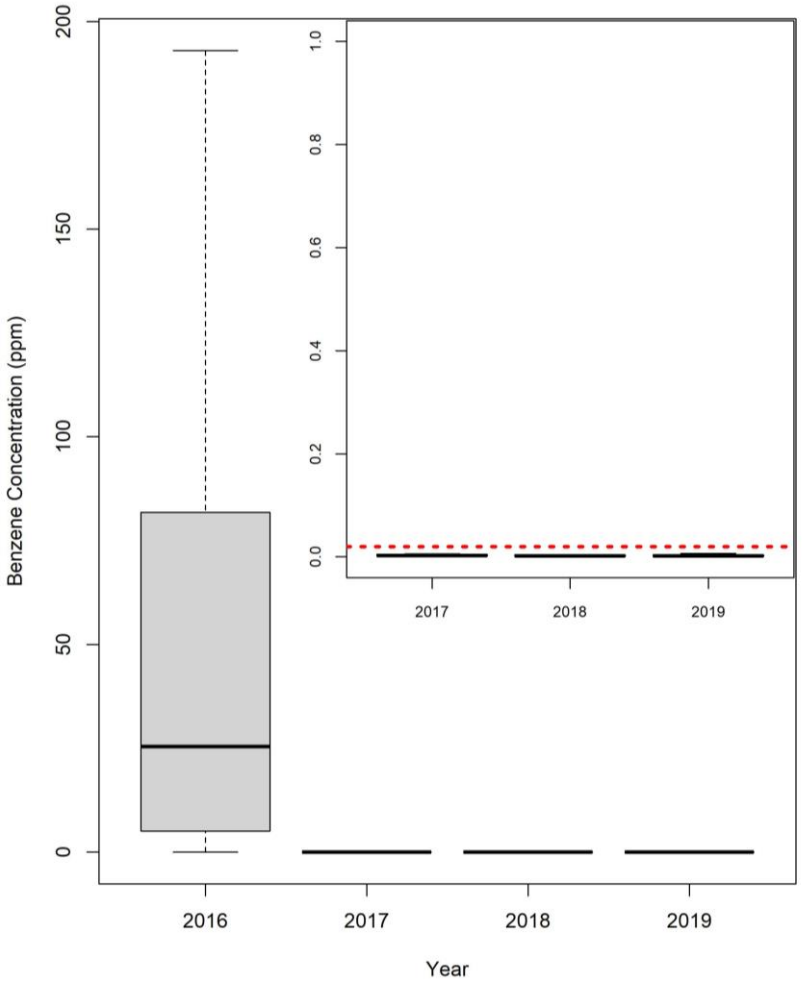
Stalled

Site 2, Location 5



Remediated

Site 2, Location 2



Site	Total	Number of Locations				
		Clean		Stalled		Remediating
		Always Clean	Remediated	Remediating, now stalled	Stalled past and present	Remediating
1	26	9	4	7	6	0
2	18	3	7	7	0	1
3	27	15	7	2	3	0
4	21	0	0	5	16	0

Effects of biostimulation

There has been degradation at most sites over time, but it is highly variable.

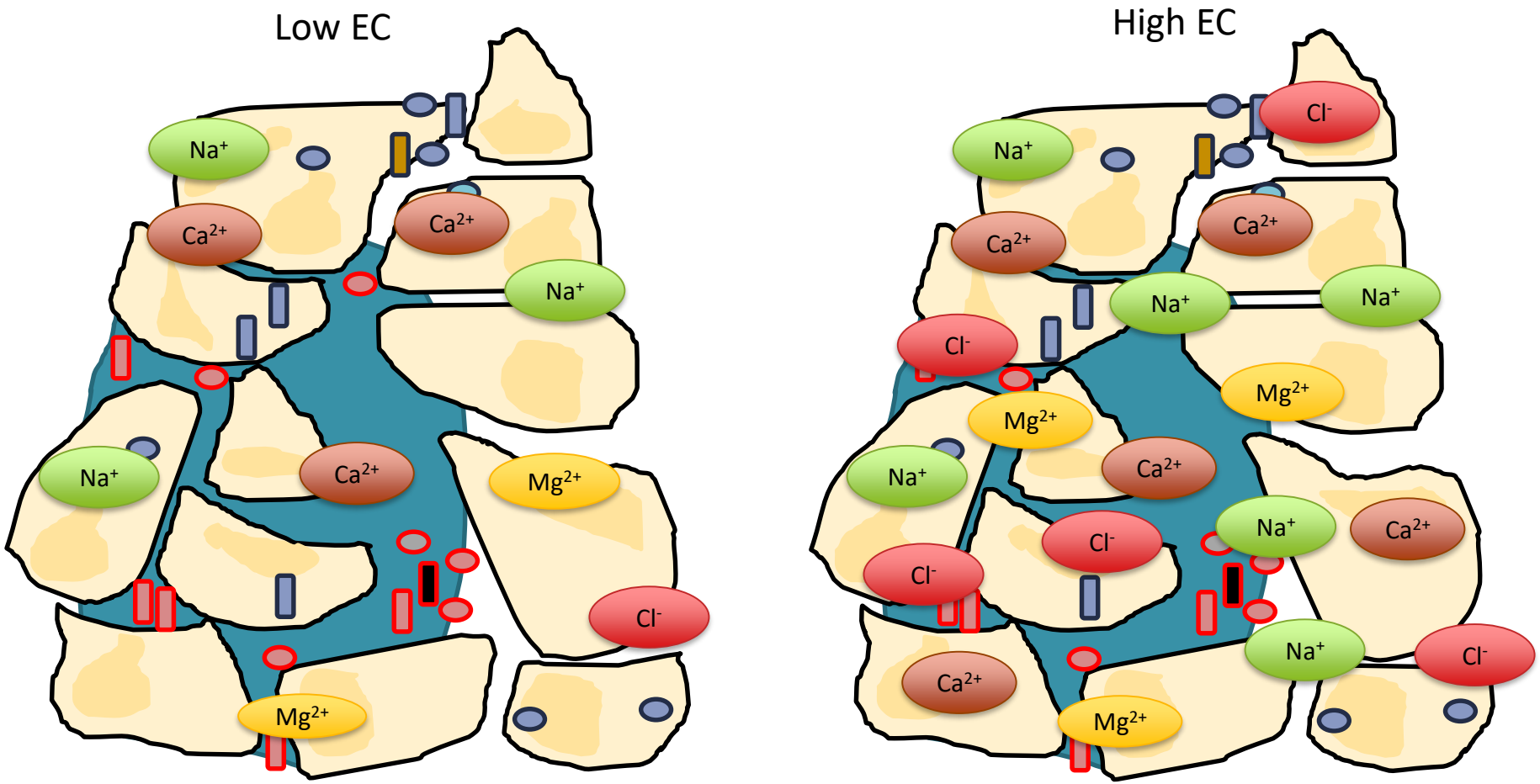
Cause of this variability is yet unknown

Remediation by bio-stimulation uses nitrogen, phosphorus and other fertilizers salts

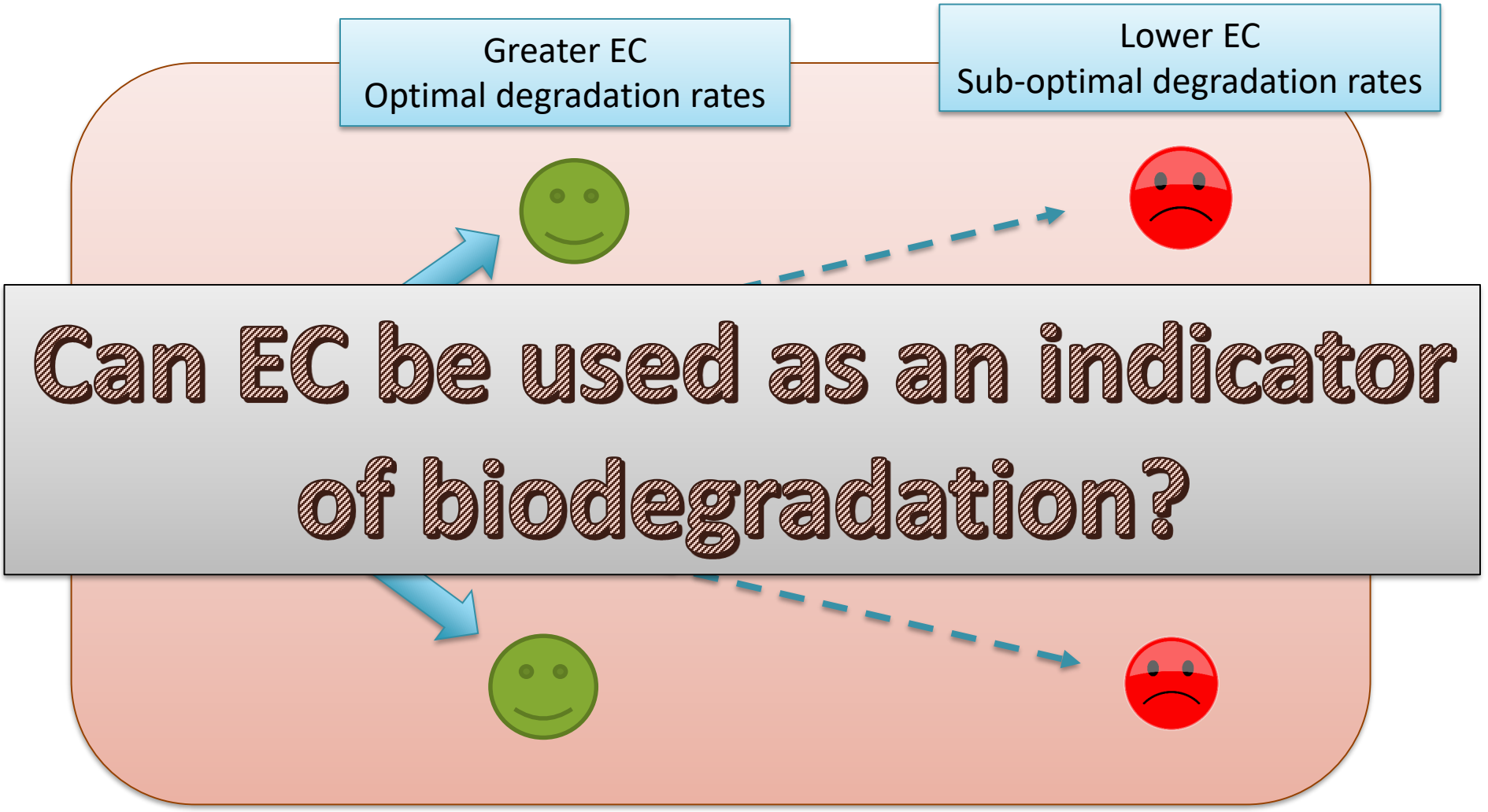
A simple and effective potential avenue to measure the inflow of nutrients to an area and potential microbial activity is with electrical conductivity (EC).

Electrical conductivity

Electrical conductivity (EC) is a measure of salt quantity in soil



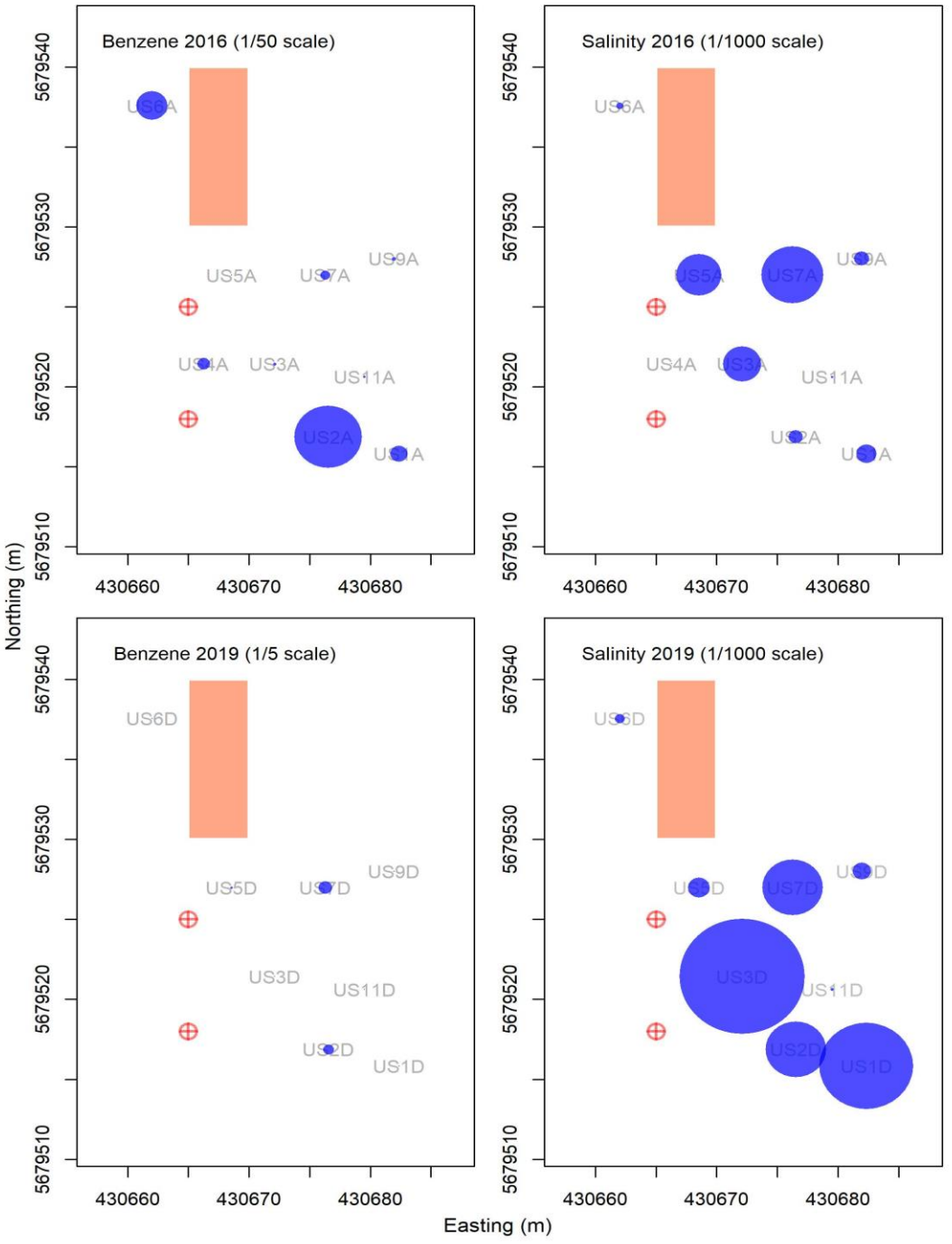
Biostimulatory solution distribution



Site 2 EC and benzene

2016 Average
Benzene: 109.2 ppm

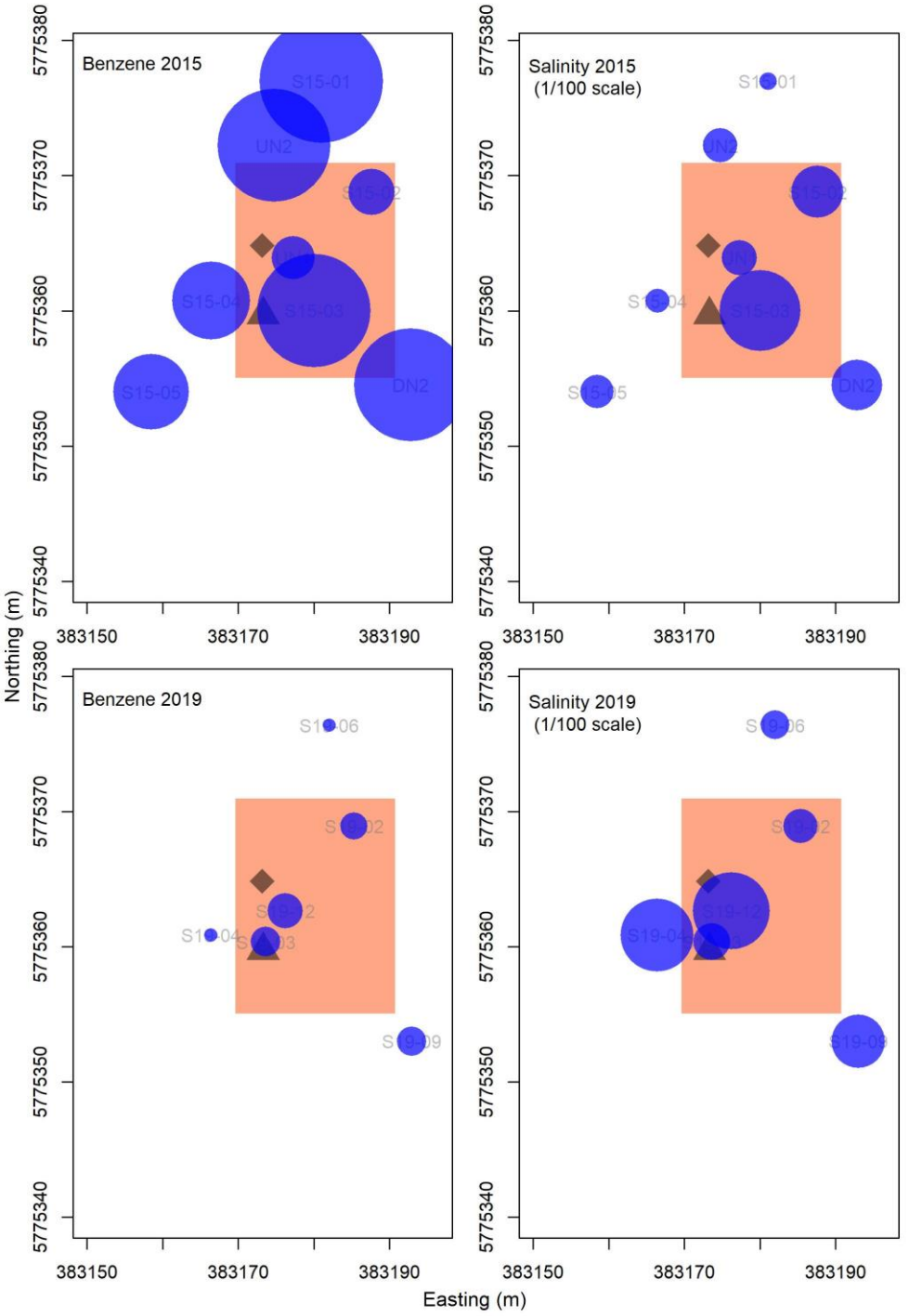
2019 Average
Benzene: 2.1 ppm



2016 Average
Benzene: 7.05 ppm

Site 4 EC and benzene

2019 Average
Benzene: 3.07 ppm



Current work & Future work

The jury is still out on the importance of measuring EC as an indicator for biodegradation…

Would the combination of any of these with EC indicate degradation?

HOWEVER: Having a large database lends itself to a lot of future investigations:

Ground soil for:

Magnetic susceptility
Phosphorus
Total Nitrogen
Total Iron

Fresh soil for:

- Microbial community changes by year
- Metabolites
- Microcosm experiments

In progress during limited laboratory services

Questions? Contact: ads147@usask.ca

Before

After

SIRCA