

Real-time Field Monitored Soil Gas Data as Inexpensive Line of Evidence for In Situ Bioremediation

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Presented by:

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Overview

- Multiple lines of evidence approach
- COC Laboratory Analysis
- Biogeochemical data
- MBT's
- Cost
- Field collected soil gas
- Case Studies
- Next Steps



COC Laboratory Analysis

- COC chemical data critical to track progress
- Identifies most daughter products
- Some laboratory methods more accurate than others
 - Perchlorate
 - 1,4-dioxane



Multiple Lines of Evidence Approach

- Chemical data not sufficient to assess bioremediation alone
- Chemical data expensive and at some sites collected at most, quarterly
- Need supporting biogeochemical data



Biogeochemical Data

- Field collected DO, ORP, pH not always reliable
 - Human error
 - Equipment error
- Dissolved iron, manganese
- EMD's
 - MBT's



Examples of EMD's

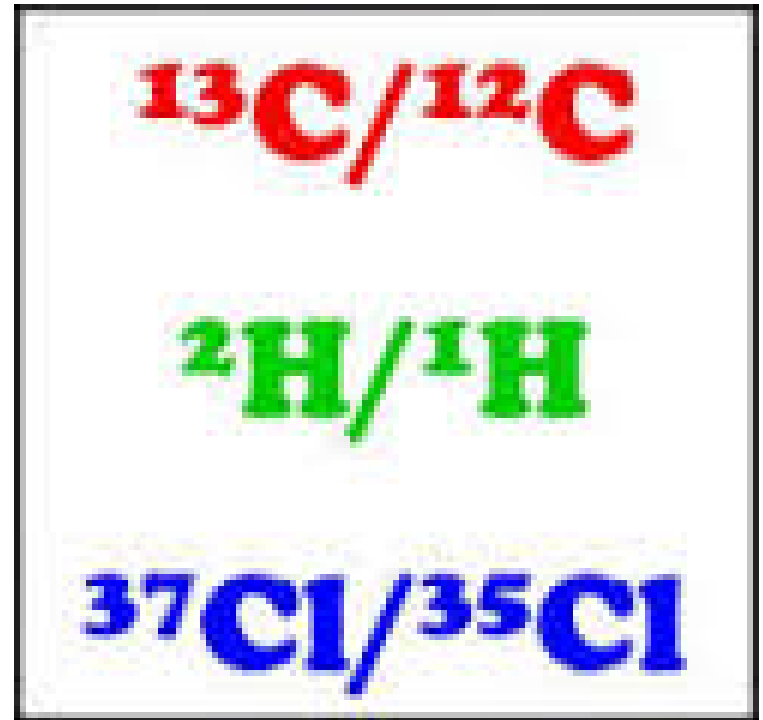
- Compound Specific Isotope Analysis (CSIA),
- Stable Isotope Probing (SIP),
- Background Fluorescence Analysis (BFA)
- quantitative PCR (qPCR),
- microbial fingerprinting methods,
- microarrays/quantarrays,
- enzyme activity probes (EAPs), and
- fluorescence in situ hybridization (FISH)



Compound Specific Isotope Analysis

CSIA - Identifies the relative abundance of specific stable isotopes (e.g. $^{13}\text{C}/^{12}\text{C}$, $^2\text{H}/^1\text{H}$) of the major component elements of contaminants. Degradation processes can cause measurable shifts in isotopic ratios.

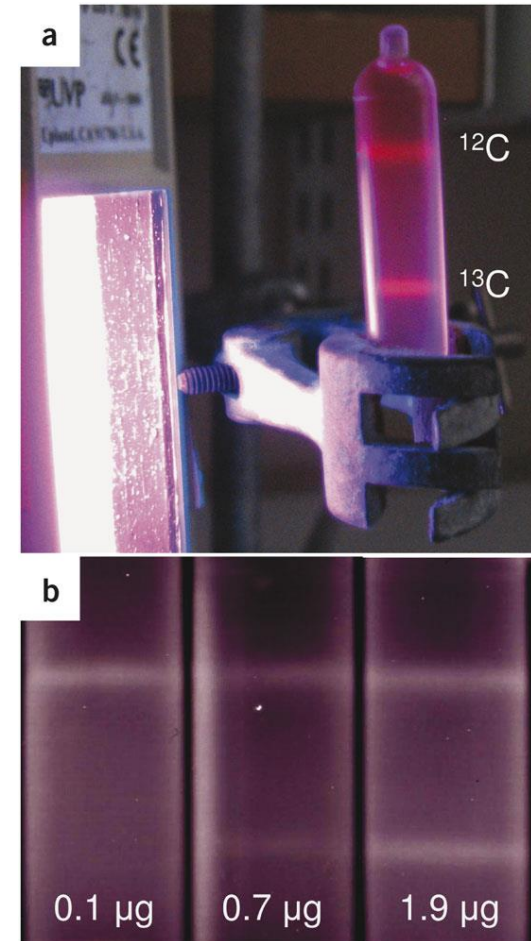
- Determine if contaminant degradation is occurring
- Investigate degradation mechanisms
- **Potentially** identify contaminant sources



Stable Isotope Probing

SIP - Detects the presence of an added synthesized form of the contaminant containing a stable isotope (e.g. ^{13}C). If biodegradation is occurring, the isotope will be detected in biomolecules (PLFA, DNA) and metabolites.

- Determine whether biodegradation of a specific contaminant is occurring
- Identify the microbes responsible for activity



Molecular Biological Tools

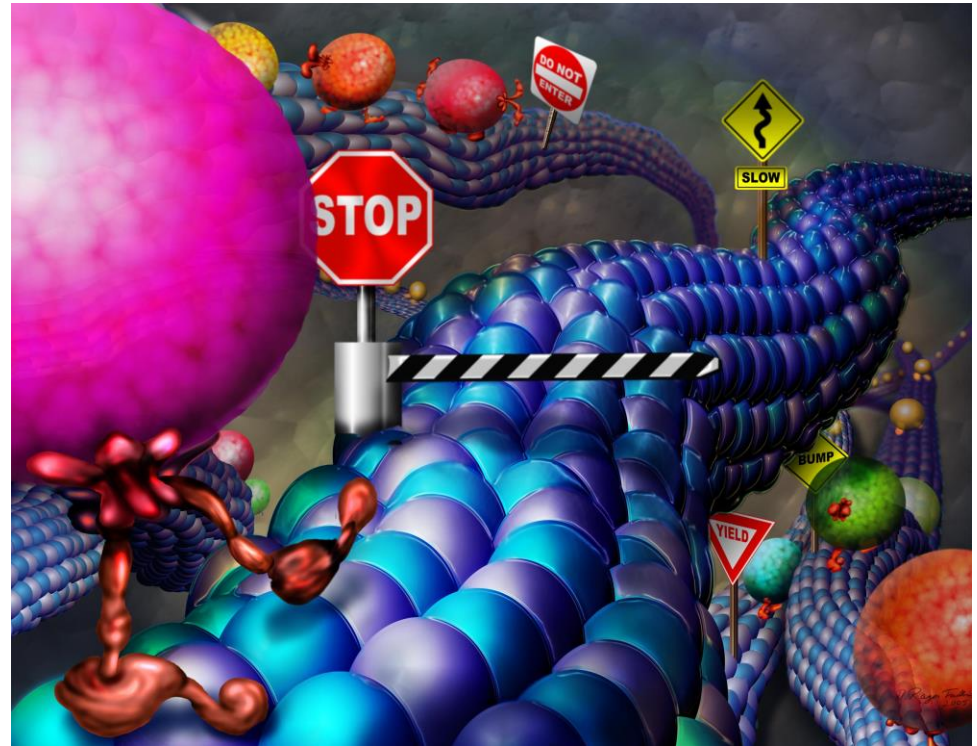
A subset of EMDs that target biomarkers/biomolecules to provide information about indigenous microorganisms and processes relevant to the assessment and/or remediation of contaminants.



Molecular Biological Tools

MBTs can include:

- quantitative Polymerase Chain Reaction (qPCR),
- microbial fingerprinting,
- microarrays,
- enzyme activity probes (EAPs), and
- fluorescence in situ hybridization (FISH)

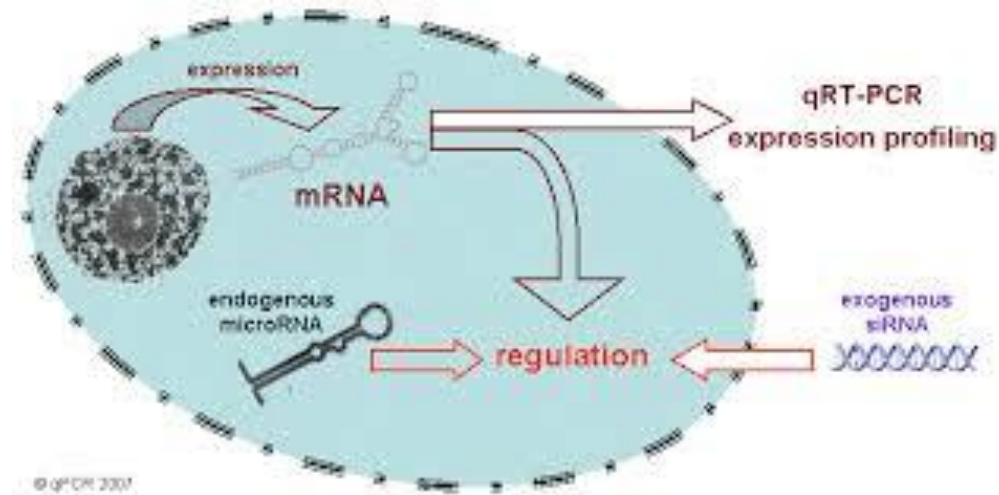


(q)Polymerase Chain Reaction

PCR - Amplifies genetic material of microbes to levels that can be further analyzed using other techniques.

qPCR - Quantifies a target gene based on DNA or RNA.

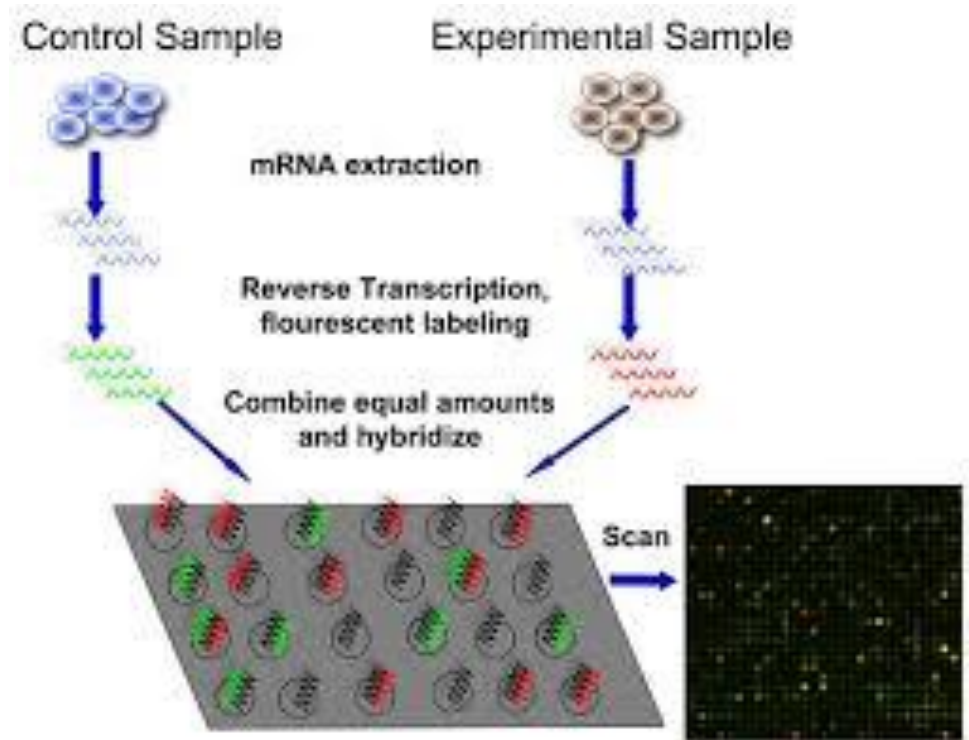
- Quantify the abundance and expression of specific functional genes, microorganisms, or groups of microorganisms responsible for contaminant biodegradation.



Microarrays/Quantarrays

Microarrays/Quantarrays - Detects and estimates the relative abundance of hundreds to tens of thousands of genes simultaneously.

- Provide a comprehensive evaluation of the microbial diversity and community composition



Cost, Cost, Cost!

- For most projects budget is a constraint
- Which lines of evidence are most appropriate
- Rough estimate of data collection cost/well ~ \$10K for a full suite
- Not sustainable over the lifespan of a typical bio project



Field Collected Soil Gas Data

- Borrowing methods for monitoring landfills
- Four gas meter; oxygen, carbon dioxide, hydrogen sulfide and methane
- Relatively simple to collect and obtain real-time data from existing monitoring wells
- Most effective if well has some open screen above the water table



Field Collected Soil Gas Data, Cont'd

- Monitor for changes in subsurface before and after bioremediation
- Aerobic conditions indicated by oxygen and carbon dioxide
- Anaerobic conditions indicated by methane and hydrogen sulfide



Former Manufacturing Site

| | |
|------------------------|--------------------------------|
| Client: | Confidential |
| Location: | MidAtlantic |
| Remediation: | ARD biostim/bioaug |
| Field Duration: | ~3 months |
| Man Hours: | 11,000 no recordable incidents |



| | |
|--------------------|--|
| Background: | <ul style="list-style-type: none"> • Small former manufacturing Site in urban area • Operated from 1940's to the 1990's • Converted to warehouse |
| Headlines: | <ul style="list-style-type: none"> • Chlorinated ethene plume under building, geology tight silt and clay, some sand stringers • 15 injection points, 10 monitoring wells • Injected 12,000 gallons EVO solution and 15 liters bugs • 9 months later ethene/ethane observed • Only monitoring semi-annually • Soil gas data shows 21% O2 in wells outside TZ with ND CH4, <5% O2 in MW's in treatment zone with ~0.9% CH4 |

Power Plant

| | |
|------------------------|---------------------------------------|
| Client: | Confidential |
| Location: | MidAtlantic |
| Remediation: | ISCO/Bio/MPE |
| Field Duration: | ~12 months |
| Man Hours: | 21,000 no recordable incidents |



Background:

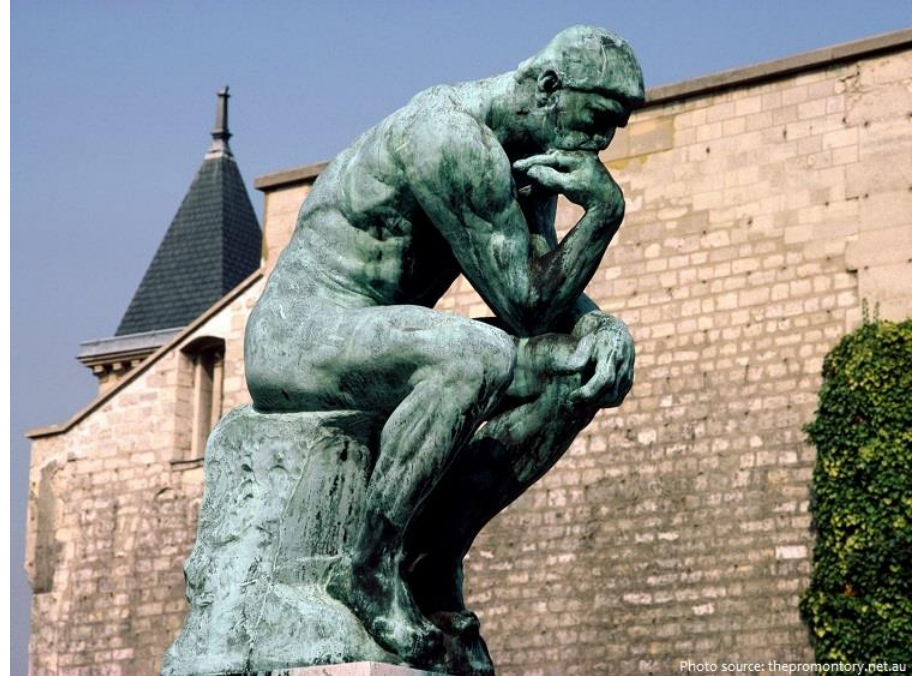
- Operating power plant
- Fuel oil release in the late 1990's
- Initial response was excavation, trenching, recovery wells

Headlines:

- Needed to protect adjacent tidal river
- Used LIF to identify residual LNAPL
- Implemented ISCO and MPE in source area
- MNA for dissolved phase plume
- GW Monitored quarterly
- Soil gas data shows 22% oxygen in wells inside TZ with ND CH₄, <5% O₂ in MW's outside treatment zone, with ~1% methane
- NFA received in 2016

Next Steps

- More thorough evaluation
- Laboratory analysis correlation
- CSIA?
- Alternative monitoring points



Questions?

