Passive Sampling Approaches and Tools for Sediment Pore Water and Soil Gas Surveys

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SiREM

SMART Remediation
Ottawa, ON | February 15, 2018

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Passive Sampling Approaches and Tools for Soil Gas Surveys and Sediment Pore Water

SMART
Ottawa, ON
15 February 2018

Presented by:
Jeff Roberts

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Let's Talk About…

1. Why Passive Sampling?
2. Soil Gas Sampling
3. Pore Water Sampling
4. Pore Water Case Studies
5. Recent Advancements in Deployment
6. Wrap up

Why Passive Sampling?

- Provides results as time weighted average
- Broad range of compounds
- Ease of use
- Lower cost
- Discrete location sampling

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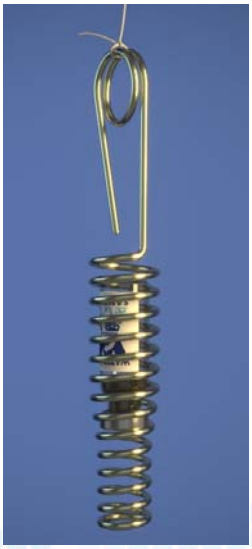
Waterloo Membrane Sampler™

- Passive Permeation air sampler for VOCs (for vapor intrusion studies/soil gas surveys)
- Manufactured by SiREM – Analyzed by commercial analytical laboratories
- Awarded a US patent for soil gas sampling

WATERLOO MEMBRANE SAMPLER



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Why Use Passive Permeation Samplers

- Much smaller than Summa canisters
  - **More discrete, easier to ship**
- Membrane provides resistance to water and water vapor (unlike competing passive soil gas samplers)
  - **WMS sampler data are more representative of actual site conditions**
- Very simple sampling protocols
  - **Sampling can be done with much less training**
- Long-term (weeks, months) sampling possible
  - **Better estimate of chronic exposure**
- Inexpensive
  - **Essentially disposable**
- Long shelf-life
  - **Simplifies planning for field events**

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WMS™ Sampler Designs

- Regular
  - **For soil gas and indoor air**
- Low uptake
  - **For soil gas when quantitative results are desired**
- Thick membrane
  - **For soil gas when wet and/or clayey conditions are expected**
  - **For long-term indoor air sampling**

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Soil Gas Sampling - Patented

Microscope photo of cross-section of PDMS membrane

Increase membrane thickness to reduce the uptake rate

Thick membrane sampler plus duplicate being deployed in a soil gas probe

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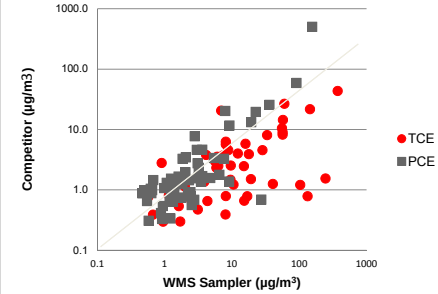
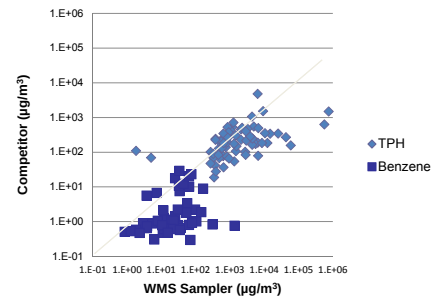
Soil Gas Sampling WMS™ vs Competitor





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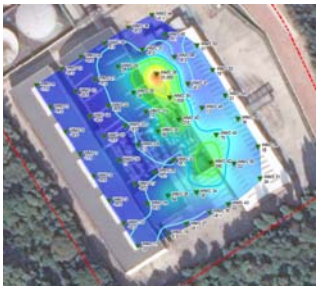
Soil Gas Sampling – data presentation

PCE



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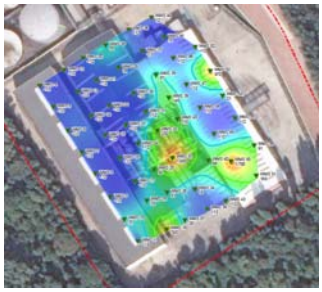

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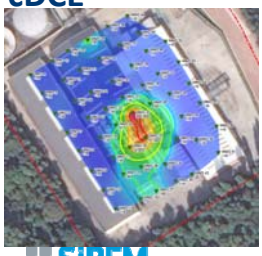

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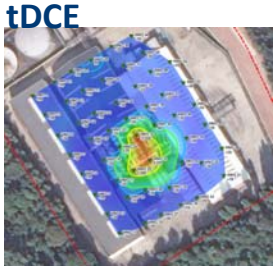

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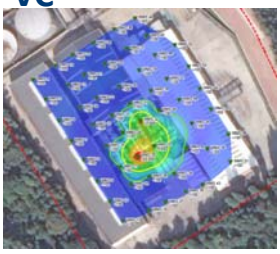

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Why Pore Water By Passive Sampling?

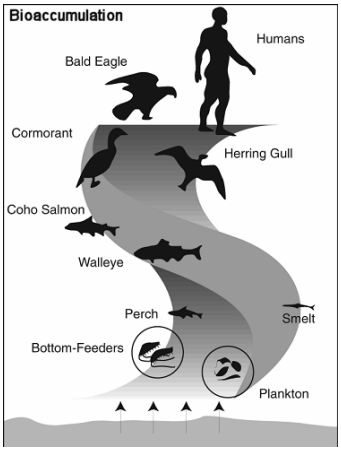

Image: Wisconsin Department of Natural Resources

- Bulk sediment measurements over estimate toxicity
- Source uncertainty with mechanical pore water sampling
- Passive sampling is discrete and sensitive
- Passive sampling provides the best method to represent bioavailability

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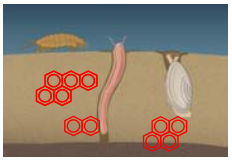
Why Pore Water by Passive Sampling?

- Millions of dollars in contaminated sediment site liability
- Understanding availability is key to efficient investigations and cleanups



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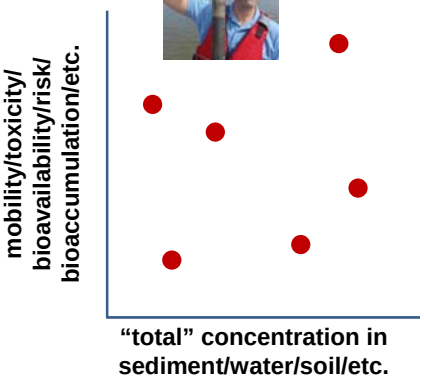
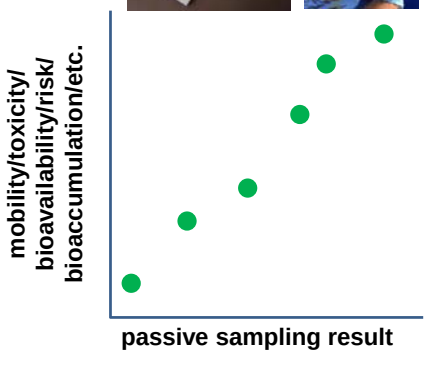
Availability





…dozens and dozens of papers over the past 20 years

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SP3 Passive Sediment Porewater Sampling Service

- Polyethylene Porewater sampler for dissolved organic compounds
- Easy to use off the shelf sampler ready for deployment
- Includes Performance Reference Compounds
- Manufactured by SiREM – Analyzed by commercial analytical laboratories

SP3

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The Sampler - How it works

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The Sampler - How it works

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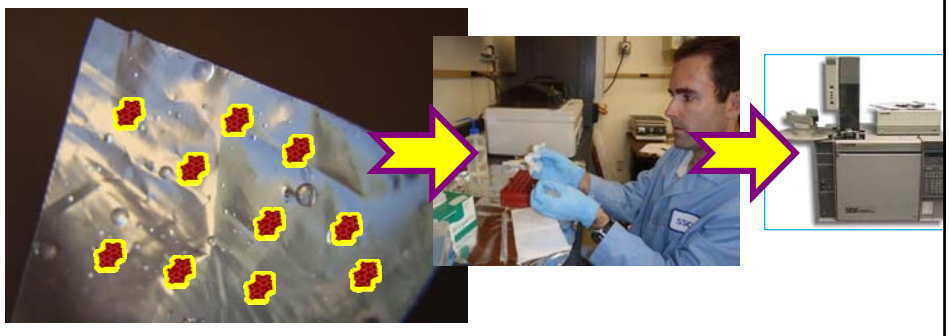
The Sampler - How it works

- Sample extracted and analyzed
  - Concentration in polyethylene (e.g., ng/g polyethylene)



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The Sampler - How it works

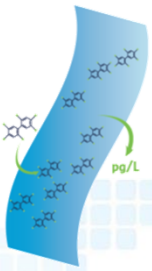
- Concentration in the polyethylene converted to a liquid concentration (e.g., pg/L)
  - → "available concentration"
  - → "porewater concentration"
  - → "freely-dissolved concentration (*Cfree*)"

- **Food-web/risk models**
- **Predict/understand bioaccumulation**
- **Risk-based threshold concentrations**
- **Fate/remediation models**
- **Etc.**

$$C_{free} = \frac{C_{sampler}}{(1 - e^{-k_e t}) \times K_{sampler}}$$

$$k_e = \ln\left(\frac{C_{PRCi}}{C_{PRCf}}\right) \times \frac{1}{t}$$

$$COC_D = \frac{COC_{PS}}{K_{PS-D}} * 1000$$



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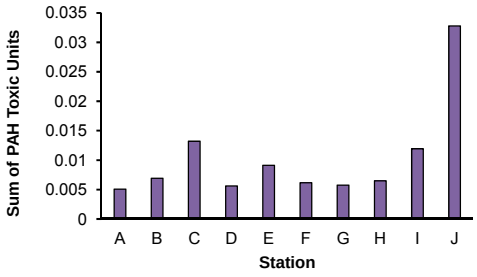
Site Investigation Case Study: Active Shipyard

- Passive samplers used to determine Cfree measurements (ng/L) of 16 PAH compounds in sediment
- Cfree results for each PAH divided by EPA's Final Chronic Value criteria (toxicity criteria) to generate Toxic Units
- Summing Toxic Units indicate that PAH toxicity well below the threshold (TU = 1), indicating no PAH risks to benthic invertebrates



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Treatability Testing

- Laboratory based studies
- Batch or column reactors constructed
- Many treatment options can be evaluated at the same time
- Measurement of pore water and/or sediment
- Evaluate the use of passive samplers under site specific conditions

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Treatability Studies: California Case Study

- Evaluate amount of activated carbon to add to a PCB-impacted sediment to achieve 75% reduction
- SP3™ samplers deployed in site sediment amended with different carbon loading rates
- Assess by PCB availability – not total concentrations in system

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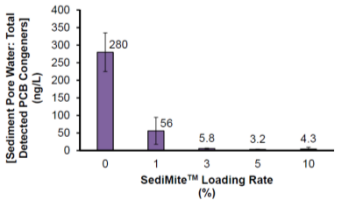
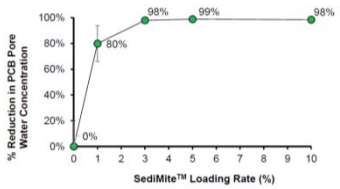
Treatability Studies: California Case Study

- Revealed significant reduction in PCB availability even at low loadings (1-3%)
- Client saved ~$100K in excess PAC use





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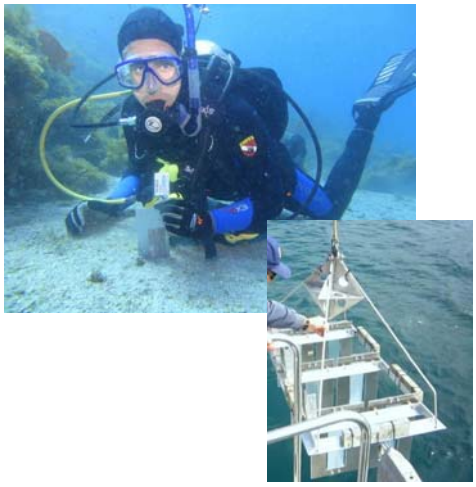
Passive Sampling Deployment



- SCUBA divers are expensive (big part of a passive sampling project's costs) and are slow
- Remote deployment and retrieval gear can be expensive and complicated
- Now we can eliminate divers and complicated custom deployment devices

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Diverless Deployment System

- Push Pole device developed in cooperation with US NAVY
- Allows deployment from boat in up to 30 feet of water

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Loading Samplers into Push Pole

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Deploying Sampler – Boat Side

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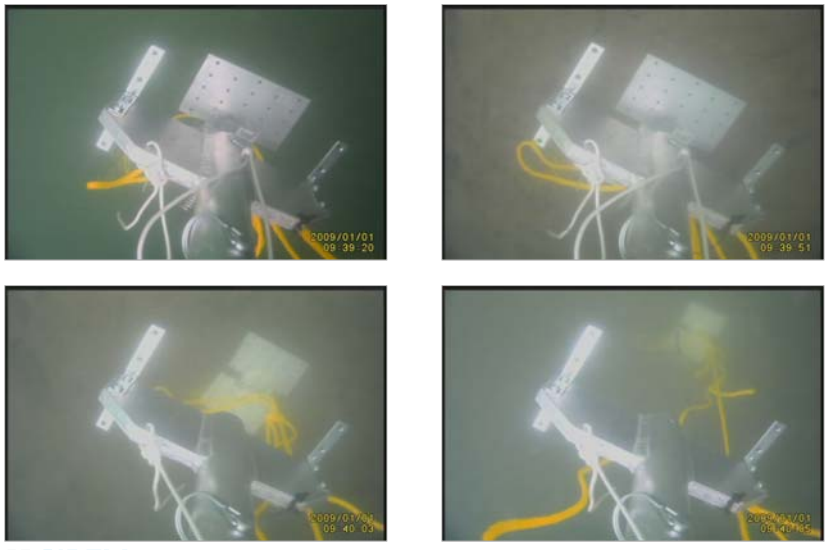
Deploying Sampler – Underwater View



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Retrieving Sampler

Diverless retrieval can be as simple as trawling for the weighted lines attached to the passive sampler

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Processing Samplers for Analysis

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Wrap up

- Passive Sampling for both vapor and pore water increasingly being used to make site decisions
- Samplers are easy to use and cost effective
- On going R&D will allow more widespread use of the samplers
- Deployment options available to save costs

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Further Information

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