Waterloo Membrane Sampler: Passive Sampling in Remediation Projects; Soil Gas, Outdoor Air and Implications for Vapor Intrusion Studies

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SiREM

SMART Remediation
Ottawa, ON | February 6, 2020
Introduction to SiREM

- Founded in 2002
- Located in University of Guelph Research Park
- Provide products and testing services to support and improve site remediation
- Further information: www.siremlab.com
SiREM Service Areas

**Remediation Testing**

- Bioaugmentation
- Characterization/Monitoring
  - Molecular Genetic Testing
  - Passive Sampling

**Benefits of Passive Sampling**

- Quick & easy protocols
- Cost effective vs. active sampling
  - Labor & shipping
- Unobtrusive installation & retrieval
- Time-integrated sampling
  - Adjustable sensitivity
  - Minimizes sampling variability
  - Quantitative results
- Broad range of compounds
  - VOCs, SVOCs, PAHs, etc.
- Most soil & moisture conditions
- No electricity, mechanical parts, connections or calibrations
What’s wrong with Conventional Samples?

Canisters / TO-15

- Bulky (expensive to ship)
- Expensive to replace
- Subject to potential leaks
- Not well suited to long sample duration
- Looks like a “bomb”

Active Sorbent Tubes / TO-17

- Not well suited to long sample duration (breakthrough)
- Power requirements
- Pump calibration

Shipping and Handling

72 Summa canisters 72 passive samplers

Key Point: passive samplers are much easier to work with
Passive Sampling

For Kinetic Samplers

\[ C_0 = \frac{M}{UR \times t} \]

The mass (M) and time (t) are measured accurately. The key is to know the uptake rate (UR).

UR has units of mL/min

What about Acute Risks?

Ontario’s Ambient Air Quality Criteria:

Trichloroethene (TCE):
- Annual = 2 μg/m³
- 24-hr = 12 μg/m³

Consider a 10-day passive sample with TCE = 1.0 μg/m³ or less

No single 24-hr day could have had TCE >10 μg/m³ – therefore, no risk!

https://www.ontario.ca/page/ontarios-ambient-air-quality-criteria-sorted-contaminant-name
Passive Sampling Options

Differences: size, uptake rates, sorbents, medium of uptake, method of analysis

The Waterloo Membrane Sampler™ (WMS™)

Crimp cap
polydimethylsiloxane (PDMS) membrane
Glass vial
Sorbent
WMS™ Fine-Tuning Options

Opening Size  Membrane Thickness  Sorbent options

Tune the sampler to high or low concentrations, short or long durations
Quantitative Passive Soil Vapour Sampling

Soil Gas Sampling
Increase membrane thickness to reduce the uptake rate

Microscope photo of cross-section of PDMS membrane
Thick membrane sampler plus duplicate being deployed in a soil gas probe
Semi-Quantitative Passive Sampling

Beacon Be-Sure™

Petrex Tube (Petroleum Exploration)

Amplified Geochemical Imaging® Survey (Formerly the Gore Module or GoreSorber)

Key Point: Uptake rates are not quantified or controlled

Comparison: Semi-quantitative vs. Quantitative

Gore Module

Waterloo Membrane Sampler

Whetzel et al., 2010

http://events.awma.org/education/Posters/Final/Whetzel_Poster.pdf

Soil Gas Sampling – data presentation

Key Point:
Passive Sampling manages temporal variability

Vapor Intrusion Challenge

Key Point:
Passive Sampling manages temporal variability
Perimeter Fenceline Monitoring (EPA Method 325)

U.S. Federal Register 40 CFR63 – requires all refineries to monitor benzene (June 20 2013) 14-day samples by passive ATD tube (325A) – analysis by TD/GC/MS (325B)


Canada: similar regulations as of 2018


Challenges: 14-day samples (constrained by retention capacity) – 26 rounds per year
Potential biases from wind, moisture

Outdoor Air Sampling: R&D with the Ontario MECP

Evaluation of a Passive Sampling Method for Long-Term Continuous Monitoring of Volatile Organic Compounds in Urban Environments

Robert M. Healy,1 2 3 Julie Bennett,1 Jonathan M. Wang,1 Nicholas S. Kavadas,1 Colman Wong,1 Aaron Teddi,1 Uwe-Oliver Soffen,1 Yuhan Su,1 Linda Di Federico1 Anthony Munoz,1 Jean-Pierre Charland,1 Dennis Herold,1 May Suu,1 and Luc White,2 3

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2Air Quality Research Division, Environment and Climate Change Canada, Ottawa, Ontario, K1A 0L8, Canada.

• Modified sorbent to be a thermal desorption-strip or cartridge
• Allows for thermal desorption GC-MS analysis (increased sensitivity)
• Thicker membrane for lower uptake
Outdoor Air Sampling: R&D with the MECP

Continuous Real-time Monitoring via AMA GC 5000 series on-line GC-FID by MECP
VOCs directly sampled onto a concentrator then sends to a GC column with an FID detector at the column exit.
Outdoor Air Sampling: Continuous Roadside Monitoring

Average = 0.19 ppb  
COV = 62%

Average = 0.58 ppb  
COV = 108%

Average = 0.08 ppb  
COV = 115%

Average = 0.3 ppb  
COV = 112%

COV = Coefficient of Variability  
= Standard Deviation / Mean

Outdoor Air Sampling: Passive Samplers

14 Day Sampling (EPA 325)

Regular ATD Tubes*  
4% < COV < 9%

Low Flow ATD Tubes  
3% < COV < 8%

WMS-TM Cart Temp Corr UR  
2% < COV < 6%

WMS-TM Strip Temp Corr UR  
1% < COV < 10%*

* Benzene excluded

The green line represents a perfect correlation between passive and active samples
Summary of WMS™ Benefits

- Ability to predict uptake rate for less common compounds
- Ability to do TPH/GRO
- Minimal effect of moisture (benefit for soil vapor monitoring)
- Insensitive to wind velocity (benefit for outdoor and vent-pipe)
- Ability to modify uptake rate to avoid:
  - "starvation effect"
  - sorbent saturation/poor retention
- Small diameter (easier to put in vent-pipes or sub-slab probes)
- Competitive pricing

WMS™ Resources
