Proper Collection of Soil Vapour Intrusion Samples for Health-Based Risk Assessment Studies of Indoor Air at Contaminated Sites

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Soil Vapour Intrusion (SVI) Assessment

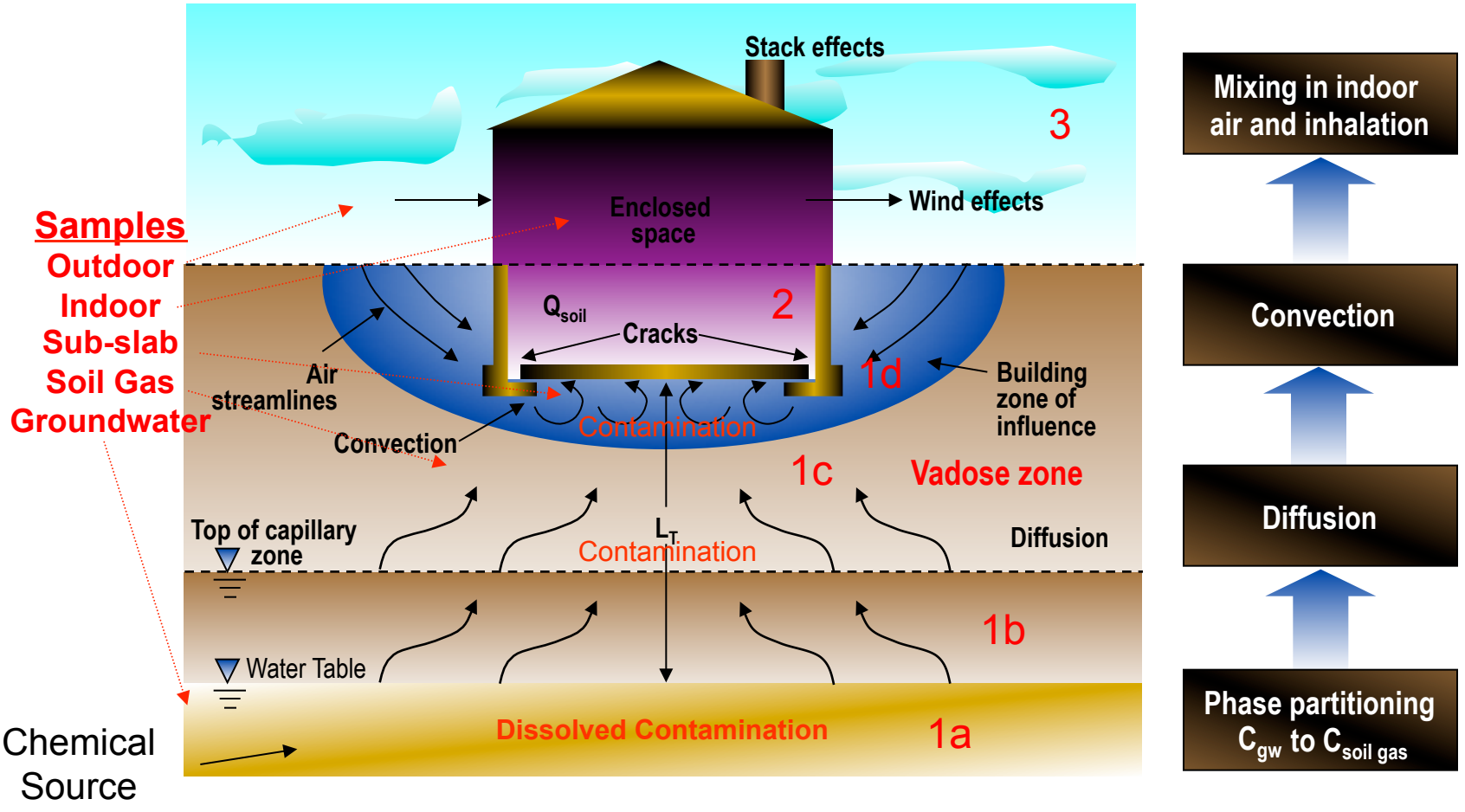
- SVI assessment is intended for use where there are currently occupied buildings at a site, or where there is potential for occupied buildings in the future
  - **At sites where there is contamination below existing occupied buildings (i.e. exposures are current & ongoing), focus is on near building soil vapour & indoor air characterization**
  - **At Brownfield sites where there are no buildings, potential future exposures are predicted based on subsurface concentration measured near to contamination sources**
- Given the limitations of using soil data for VOCs, SVI sampling should be conducted whenever there is contamination within the unsaturated soil zone

Soil Vapour Intrusion (SVI) Assessment

- Involves site characterization and on-going development of the conceptual site model (CSM)
- Makes use of a tiered decision based approach, except where H&S risks warrant indoor air quality evaluation of the VI pathway at early stages of the investigation process or proactive implementation of exposure controls
  - **Tier 1: Preliminary screening** - for chemicals of potential concern, with comparison of results to **MOE generic Site Condition Standards**
  - **Tier 2: Screening level SVI assessment** - determine CSM attenuation factor; conduct soil vapour characterization of site as part of the **multiple lines-of-evidence**
  - **Tier 3: Detailed SVI assessment** – concurrent **indoor, outdoor & sub-slab air testing;** interpretation of site-specific data enables further adjustment of the CSM

A Conceptual Site Model (CSM) Showing Soil Vapor Intrusion (SVI) Exposure Pathways

Modified Slide of H. Schuver, USEPA, Adapted from M. Bolas, Ohio EPA, Feb. 24, 2009)



Why Use Multiple Lines-of-Evidence?

- Reduces uncertainty & improves assessments by helping to determine if the vapour intrusion pathway is complete
- Factors to consider include:
  - Source – concentration, distribution, composition
  - Pathway - geology, soil type, biodegradation
  - Receptor - building construction & operation
  - Confounding factors – background VOCs, incomplete site characterization, seasonal variability, etc.
- Professional judgement should be used to evaluate all data available & how it fits with the CSM

Reporting Limits – Soil Gas, Sub-Slab or Health-Based Indoor Air Sampling?

- Meeting SVI limits requires proper sampling & analysis
- Some health-based indoor air target levels for selected VOCs (O. Reg. 153/04 objectives & assumptions):

  Res = Residential; **I-C-C** = Industrial-commercial-community

  - **Benzene** – **0.506 µg/m³** (Res) & **1.63 µg/m³** (I-C-C)
  - **1,2-Dichloroethane** – **0.0428 µg/m³** (Res) & **0.138 µg/m³** (I-C-C)
  - **Trichloroethylene** – **0.278 µg/m³** (Res) & **0.401 µg/m³** (I-C-C)
  - **Naphthalene** – **0.772 µg/m³** (Res) & **2.65 µg/m³** (I-C-C)
  - **1,1,2-Trichloroethane** – **0.0695 µg/m³** (Res) & **0.223 µg/m³** (I-C-C)
  - **Vinyl Chloride** – **0.126 µg/m³** (Res) & **0.406 µg/m³** (I-C-C)
- For sub-slab & soil gas samples, appropriate attenuation factors *generic* (e.g. Ontario MOE: Res=0.02; I-C-C=0.004) or *site specific* are applied to the HBIA criteria to obtain applicable target/trigger levels

Sampling Media for Health-Based Indoor Air Risk Assessments

- Health-based SVI VOC target levels can be very low (ppb, ppt) – Identify target list & criteria
- Silica coated canisters offer best VOC stability & recoveries (e.g. sulfur gases, polar VOCs)
- Multi-sorbent TD tubes that offer wide VOC molecular range, large safe sampling volumes (SSV), good water management & low media background
- Use properly cleaned & proofed canisters or TD tubes for criteria target levels

Complimentary Techniques – Why Use Canisters or TD Tubes?

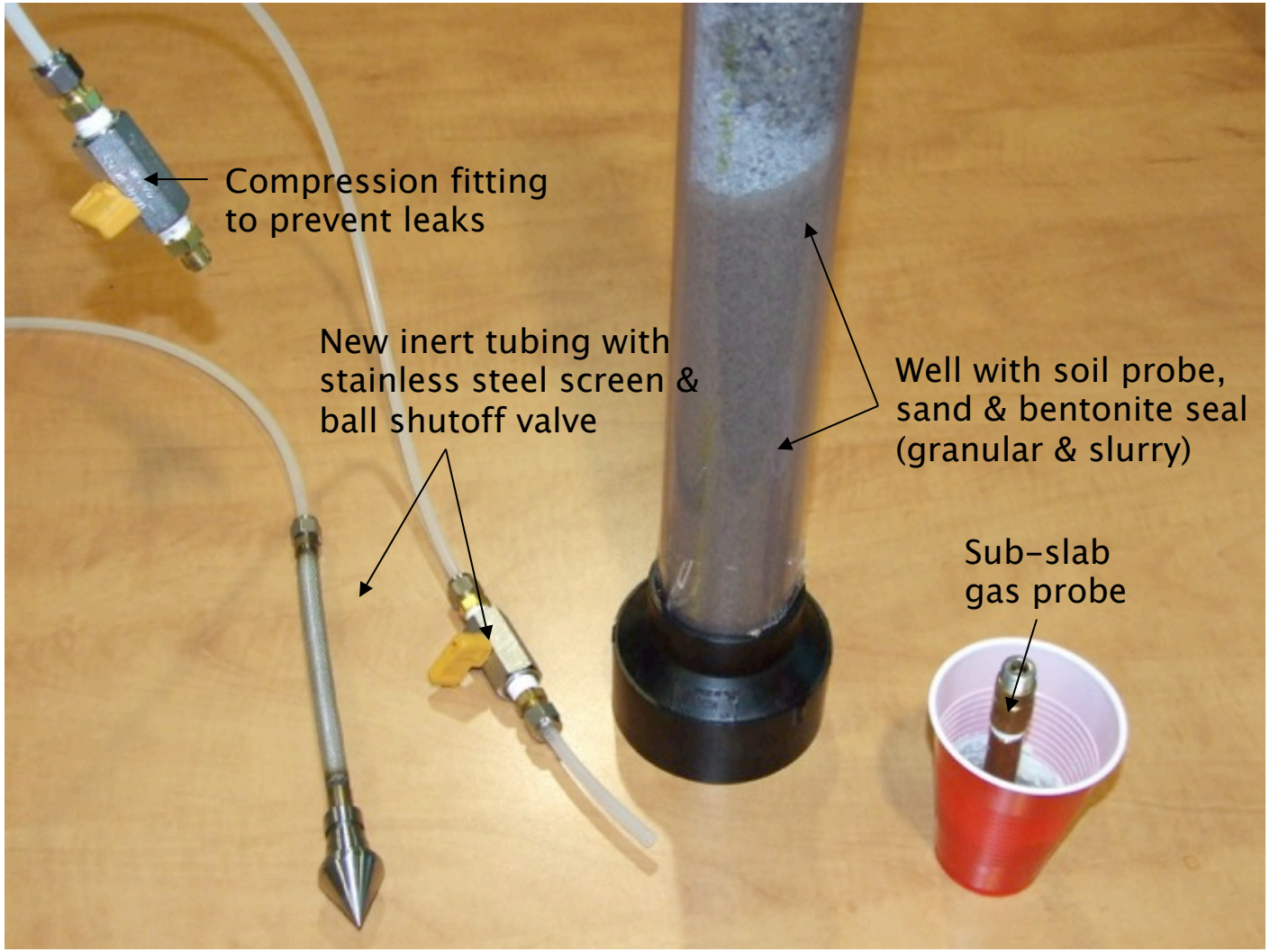
Canisters:

- Quantitative recovery of low MW VOCs (C1-C3 range)
- Prior knowledge of VOCs air concentration is not a controlling factor in sampling (no saturation or safe sampling volume issues)
- Silica coated canisters provide best stability of VOCs, including sulphur & other reactive compounds
- Multiple (sample dilutions) & different (instruments) analyses are possible from the same canister

TD Tubes:

- Good recovery of higher MW VOCs (e.g. siloxanes, low MW PAHs, etc.)
- Good recovery of polar VOCs through adsorption on tube media
- Volume of air collected can be adjusted to meet low regulatory limits
- Small size (unobtrusive) & passive sampling capabilities enable various uses & different sampling locations (walls, ducts, fences, wells, etc.)

Soil Gas Sampling Train – Well & Sub-Slab Sampling Probes



Soil Gas Sampling Train – Purging & Helium Detection

Well packing/sealing materials

Lung box – Tedlar bag sample
(Handheld monitor – helium, gases & VOCs)

Quality Control Protocol – Testing for Probe Leaks (Short-Circuiting)

- Shut-In Test
  - Sensitive vacuum gauge used to detect leaks in sample train
  - Train should hold initial vacuum for >30 sec after closing valves at vapour probe & other end of the train
- Tracer Test – HP Helium is the preferred gas
  - During purging, helium (He) is introduced into shrouded sample train, collected into a Tedlar bag using a lung sampler & measured in real-time using a field detector (e.g. MGD-2002)
  - Soil gas leak of ≤2% is considered acceptable

    (**Leakage** = He soil gas / He shroud x 100%)
  - Small amount of He in canister doesn't interfere with the lab analysis or result in raised VOCs reporting limits

Quality Control Protocol – Sampling Materials

- Use clean & dedicated sample train materials
- No glue or tape except Teflon tape
- Select tubing that doesn't off-gas VOCs which could exceed regulatory limits:
  - Use Teflon or Nylaflow T (good for most VOCs)
  - Do not use: Tygon®, Low Density Polyethylene (LDPE), Silicone, Polyvinyl Chloride (PVC) or Nylon (Extra-Flex)
- Soil Gas Probes – Seal when not sampling
  - Stainless Steel is best, but rigid PVC (sufficiently old to have low levels of VOCs) is a practical alternative
  - Do not use freshly cut or scratched rigid PVC
  - Use small diameter probes & tubing to reduce purge volume

Quality Control Protocol – Blanks

- Travel/trip blank
  - Evacuated canister **or** canister filled close to -5" of Hg with UHP air or nitrogen. Both options are representative of half of the canister's sample journey.
  - TD tube left unopened (normally field blank is done)
- Field blank
  - Canister filled in the field with UHP air or nitrogen in a similar manner to sample
  - TD tube opened & closed at sampling location
- Background blank
  - Ambient air collected near building being sampled
- Equipment blank
  - Ambient air drawn through entire sampling train

Quality Control Protocol – Duplicate Samples

Considerations

- Type of sample taken?
- Same or different flow?
- Same or different time?

Suggestions

- Co-located (side-by-side) for indoor air
- Simultaneous for sub-slab & soil gas using one flow controller
  - Equalized pressure in joined canisters provides uniform filling
  - Potential contamination from different flow controllers not an issue
  - Same sampling time requires flow controller set to double the flow rate

Quality Control Protocol – Proofing & Sampling Equipment Checks

- Canister & TD Tube Proofing
  - Batch proofed – Ensure media are proofed to meet low Health-Based SVI detection limits required & reported
  - Individually proofed - good idea when sampling is for a legally driven Health-Based Risk Assessment study
- Sampling Equipment Checks
  - Canister sampling – Four possible pressures measured: laboratory shipping, field pre-sampling, field post-sampling & laboratory receipt
  - TD Tube sampling – Three possible calibration flows: Initial calibration of air sampling pump, check of actual flow in field & post-calibration of air sampling pump

SVI Sampling – Fixed & Hydrocarbon Gases

- Fixed & hydrocarbon gases are useful in Soil Gas studies:
  - The CO_2 to O_2 ratio can be used to identify biodegradation of hydrocarbons in the soil or leaking of a probe seal packing
  - Vertical gradients of petroleum hydrocarbons (PHC), O_2, CO_2 & methane should be internally consistent
- When fixed gases & VOCs are being analyzed from a canister, the procedure of analysis is important

SVI Sampling – Petroleum Hydrocarbons (PHC)

- PHC Target Compounds
  - Analysis based on EPA TO-15 method
  - BTEX or other PHCs target list
- PHC F1 and F2
  - Analysis based on CCME standard method (water & soil)
  - Total F1 & F2 and corrected for BTEX & naphthalene
- PHC Sub-Fractions (aliphatic & aromatic)
  - No standardized methodology, ALS Waterloo method based on Atlantic RBCA (water, soil) & BCMOE (air) methods
  - C6-C8, C>8-C10, C>10-C12 & C>12-C16 aliphatic & aromatic sub-fractions

SVI Sampling – Chlorinated Compounds

- Chlorinated solvents are considered recalcitrant chemicals that don't easily undergo biodegradation
- The two main chlorinated compounds widely used as cleaners in industry are: tetrachloroethene (PCE) & trichloroethene (TCE)
- In the environment, depending on time & conditions, PCE & TCE can create various breakdown products that are more toxic than the parents
- Beakdown products monitored include: 1,1-dichloroethene, vinyl chloride, cis- & trans-1,2-dichloroethene, 1,1- & 1,2-dichloroethane, 1,1,1-trichlorethane

SVI Sampling – Reduced Sulfur Compounds (RSC)

- RSC, such as hydrogen sulfide (H_2S), exhibit toxic/acute health effects & offensive odours
- Due to reactivity & short hold-times, samples are best collected into silica coated canisters
- Analysis by gas chromatography with sulfur chemiluminescence detector (GC-SCD) is best
    - **Specific:** Equimolar detector allows detection of individual RSC & total reduced sulfur as H_2S
    - **Sensitive:** low ppbv for health-based criteria
    - **Accurate:** Applicable to wide range of sample matrices
- Environment Canada **NRPI list**: H_2S, methyl mercaptan, dimethyl sulfide, dimethyl disulfide, carbon disulfide, carbonyl sulfide & total reduced sulfur (TRS)
- Other packages available

Thank You!
Questions?

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