Field and Modeling Studies of Indoor Air Source Effects on Subslab Soil Gas Concentrations

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Outline

• Background: indoor air sources complicate VI pathway assessment

• Field results: variability of indoor air concentrations with constant indoor source release rate

• Modeling results: 1. subslab concentrations resulted from indoor source; 2. longevity and impact of vapor cloud resulted from indoor source

• Acknowledgements

• Questions and Suggestions
Indoor Air Sources

• It is generally understood that indoor air sources can contribute to measured indoor air chemical concentrations, e.g. TCE, PCE, benzene, etc…

• It is hard to distinguish between the contribution of subsurface vapor intrusion and indoor air sources.
Indoor Air Sources

- Fast identification of the indoor air sources: use portable GC-MS “Hapsite” to hunt down indoor air sources at home almost real-time;
- Expensive equipment, well-trained personnel, intrusive;
• Distinguishing indoor air source from subsurface source using building pressure manipulation and CSIA (McHugh, et al)

• Method has some limitations (e.g. not applicable to leaky or very large buildings, intrusive)
Contaminant: GW plume with 10-50 ug/L 1,1-DCE and TCE; Geology: silty clay with fine sand stringers; Indoor air tracer: SF6 released at 5 ml/min continuously.
Field Study: Experimental methods

- SF6 indoor releasing/sampling point
- Multi-level soil gas sampling locations

SRI-GC-PDD-Autosampling system

5 ml/min SF6 release point

PDD mounted on GC  PDD Controller
Temporal Variability: Indoor SF6

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SF6 in Subslab Soil Gas
SF6 in soil gas

Location #6 – subslab

SF6 conc. in soil gas [ppbv]

Time [d]

8/30/2011  11/06/2011  2/02/2012
SF6 in Soil Gas

Location #2 – subslab

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SF6 Conc. - Daily Variation

Frequency Spectrum

- SF6 in indoor air
- SF6 at Location #6-subslab

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Indoor Air Sources in VI Pathway Assessment

Field & simulations:
- How long does it take for IA conc. to drop to a acceptable level?
- How long does it take for the cloud to disappear?
- If the cloud persists, is the soil gas conc. of a concern?

Identify Indoor Air Sources
- Inventory
- Hunting/Sniffing

If the cloud persists, is the soil gas conc. of a concern?

Yes

No (No sources)

No (Not able to identify sources)

Remove sources

VI pathway Assessment [MLE Approach]

Indoor Air
- Is VI occurring? Is it a concern?

Soil Gas Sample

Subslab sample
Simulation of Indoor Air Sources

Scenario 1

SF6 release rate: 5 ml/min
Building volume: 174 m³
Air exchange rate: 0.5 /hr
ΔP_{out-in} = 5 Pa (↑) or -2 Pa (↓)
IA SF6 conc. = 3600 ppbv

Soil Air permeability: 1e-8 cm² (Fine sands)

Perimeter foundation cracks
Simulation: Scenario 1

- $P_{\text{outdoor}} - P_{\text{indoor}} = -2 \text{ Pa}$ and $5 \text{ ml/min SF6}$ release rate created a cloud in subslab after 60 days.
- At end of day 60, IA source removed and $P_{\text{outdoor}} - P_{\text{indoor}} = +5 \text{ Pa}$
- 30 days after IA source removed, the chemical still exists in subslab soil gas.
Simulation: Scenario 1

- Indoor SF6 concentration dropped very fast to a low level (~6 h)
- Attenuation factor also dropped from 10 to 10^{-3} level (~6 h)
- SF6 conc in soil gas decreased by 40% after the first day
Simulation of Indoor Air Sources

Scenario 2

PCE release rate: 9 ug/min
Building volume: 465 m³
Air exchange rate: 0.42 /hr
$\Delta P_{\text{out-in}} = -2 \text{ Pa (↓)}$ or $5 \text{ Pa (↑)}$
GW source: 300 ug/m³ at 8 m bgs
IA PCE conc. 2.78 ug/m³

Soil Air permeability:
$1e-8 \text{ cm}^2$ (Fine sands)

Perimeter foundation cracks
Simulation: Scenario 2

a.) IA source only
P_{out} - P_{in}: -2 Pa
Simulated time: 165 d
IA PCE = 2.78 ug/m³

b.) GW source only
P_{out} - P_{in}: -2 Pa
Simulated time: 500 d
IA PCE = 0.01 ug/m³

The cloud was created from indoor air PCE source but is not significant comparing to those created by GW source;

Indoor air PCE conc. is mainly resulted from IA PCE source in this scenario.
Simulation: Scenario 2(a)

- $P_{\text{outdoor}} - P_{\text{indoor}} = -2$ Pa and 9 ug/min PCE release rate created a steady cloud in subslab after 165 d, after that, IA source removed and $P_{\text{outdoor}} - P_{\text{indoor}} = +5$ Pa
- 7 days after IA source removed, the chemical still exists in subslab soil gas
- Based on $10^{-3}$ AF, soil gas conc. may not be of a concern
- IA conc. dropped to ND after ~8 h
Conclusions

**Field study showed that:**
- Indoor air source may cause a cloud of chemicals in the subslab soils;
- There is a seasonal variability in indoor concentrations even with a steady indoor source release rate;
- Future plan in this field study is to remove the SF6 source and monitor the response of indoor air and soil gas concentration.

**Simulation study showed that:**
- After indoor air source removed, indoor air concentration drops to very low level approximately after 3 building volume change (hours);
- After indoor air source is removed, the subslab soil gas may respond much slower than indoor air concentration (days).
- Maximum indoor air concentration after source removed will be $C_{\text{indoor}} \times AF$, which may not be detected under some situations.
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QUESTIONS? SUGGESTIONS?
Just-in-case slides 😊

Hopefully, I'm still smiling...
SF6 in soil gas - Seasonality

Diamonds indicate indoor SF6 conc. [ppbv] with ΔP= P_{5-ss} - P_{indoor} and indoor air SF6. The observed "VI season" is from 8/30/2011 to 12/08/2011.
SF6 in soil gas - Seasonality

Delta T [°C] = T_{outdoor} - T_{indoor}

Delta P [Pa] = P_{outdoor} - P_{indoor}

“VI season”

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SF6 in soil gas - Seasonality

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Simulation

- If IA source is not removed, it will remain in the soils for a much longer time under the same condition.

- In this case, 60 days after ΔP changed to 5 Pa, significant amount of SF6 still stays in the subsurface.