A Review of Preferential Pathway Case Studies: Lessons-Learned for Vapor Intrusion Site Assessment

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Agenda

• Example Vapor Intrusion (VI) Assessment Challenges
• Introduction to VI Preferential Pathways
• Case Studies: VI Preferential Pathways
  - Sewer VI: Pennell et al. (2013) and Hallberg et al. (2018)
• Summary and Looking Forward
Example Vapor Intrusion (VI) Assessment Challenges

• Indoor air sampling results subject to high variability
  - Difficult to capture upper percentile of concentration distribution with conventional sampling schemes
  - May result in false negative decisions

• Background sources can impact indoor air sampling results
  - Sometimes difficult to identify through conventional surveys
  - May result in false positive decisions

• Preferential vapor pathways are more common than we used to think
  - May result in inadequate characterization, inadequate or unnecessary mitigation

Image sources: Holton et al. (2013) and photos by C. Holton
Introduction to VI Preferential Pathways

• Vapor intrusion (VI) preferential pathways are natural or anthropogenic features that enhance vapor migration and/or vapor entry into buildings
  - Definitions and terminology are not consistent in guidance

• Other terms used by VI practitioners include...
  - *Atypical VI pathways* or *Atypical Preferential Pathways (APP)*
  - *Alternative VI pathways*
  - *Utility VI pathways*
Conventional VI Conceptual Site Model

Updated VI Conceptual Site Model

Image source: Guo et al., 2015
VI Preferential Pathways – Sewer VI

- Gravity sewers have large headspaces, facilitate vapor flow
- Most sewers leak (in/out)
- Sewers receive flow from smaller pipe networks
  - Larger receiving pipes can be over 20-ft below ground surface
- Numerous potential vapor entry points on building interior

Image source: Nielsen and Hvidberg, 2017
Case Study: Sewer Gas Study by Pennell et al. (2013)
Pennell et al. (2013)

- Residential building adjacent to former chemical handling facility
  - Resident complained of sewer odors, following first sampling event
Pennell et al. (2013): Lessons-Learned

- Study highlighted sewer VI pathway, need for updating VI conceptual site model
- Sewer gas odors can be *indicator* of complete sewer-to-indoor air pathway
  - Absence of odor does not confirm pathway does not exist
- VI practitioners should target sampling of sewer connections, cleanouts, and piping to screen for sewer VI pathway

Reference: Pennell et al., 2013
Case Study: DoD Installation (Site A), Hallberg et al., 2018
Site A: Background

- Upgradient source area
  - PCE ~600 µg/L and TCE ~300 µg/L; residual soil NAPL
- TCE periodically detected in indoor air
  - Indoor concentrations did not correlate with soil gas concentrations
- Additional investigation to determine source
  - Uncapped pipe in mechanical room
  - Dry or damaged P-traps
  - HAPSITE GC/MS investigation confirmed PCE and TCE inside plumbing

Reference: Hallberg et al., 2018
Site A: Phase 1 Sewer Ventilation Pilot Study

- Conducted to assess whether ventilation of the sewer line can:
  - Reduce PCE and TCE concentrations within manholes
  - Reverse the flow of vapors to potential entry points inside Building

- Conducted confirmation sampling at manhole locations MH-1, MH-2, and MH-3, the mechanical room plumbing, and within sink plumbing

Reference: Hallberg et al., 2018
Site A: Sewer Venting System Design

- 4” ventilation pipe from sewer, connected to skid mounted blower; 240 cfm

Reference: Hallberg et al., 2018
Site A: Phase 2 Performance Monitoring, PCE

Reference: Hallberg et al., 2018
Site A: Lessons-Learned

• Sewer ventilation was effective at mitigating VI through sewer pathway
  - Intercepts vapors between source area and building
  - Concentrations of PCE and TCE in sewer manholes and building plumbing reduced up to 99%
  - Conventional mitigation approaches would probably not work for Site A CSM
Case Study: Sun Devil Manor (SDM), Layton, UT
Source: GW plume with 10-50 μg/L TCE; GW deep gradient 0.23 ft/ft across property; Geology: silty clay with sand stringers
SDM: Indoor Air TCE Concentration – Natural Conditions

Reference: Holton et al., 2013
SDM: Building Pressure Cycling

Reference: Holton et al., 2015
SDM: Soil Gas Contours, Natural vs. BPC Conditions

Reference: Guo et al., 2015
SDM: Discovery of Land Drain Pathway

Reference: Guo et al., 2015
SDM: Emission Rate Under Different Test Conditions

Reference: Guo et al., 2015
SDM: Lessons-Learned*

- VI observed at SDM was primarily due to pipe flow VI pathway
- Conventional sampling approaches may not indicate presence of preferential pathway(s)
  - Building pressure cycling, multi-depth soil gas monitoring, and screening model calculations provided evidence of land drain pathway (see Guo et al., 2015)
Summary and Looking Forward

• VI Pathway data interpretation and decision-making are influenced by our conceptualization of VI processes
  - Need to consider potential for preferential vapor transport; may not be obvious using conventional sampling methods (e.g., SDM results under natural conditions)

• Review utility maps and details early in investigation process, compare to location of source area(s) and other high concentration areas

• Apply next generation VI tools to identify preferential pathways and improve understanding of VI CSM

• Need to validate common presumptive remedy assumptions
  - Typical mitigation approaches may not be effective for Sewer VI and Pipe Flow VI
References


References (cont.)


Thank you!

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