# Vapor Intrusion: The Pathway of Greatest Potential Risk

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**Resumo**

Para propriedades contaminados com compostos orgânicos voláteis, o caminho de maior risco potencial à saúde humana é muitas vezes a intrusão de vapor subterrâneo para o ar interior, também conhecida como o caminho de intrusão de vapor (VI). Em média, as pessoas inalam cerca de 20.000 L de ar a cada dia, em comparação a beber cerca de 2 L de água ou a ingestão de alguns gramas de solo, o que significa que as concentrações alvo de risco para o ar interior deve ser muito baixo quando comparado com outros meios de comunicação. Como resultado, os métodos utilizados para a amostragem e de análise deve ser mais cuidadoso para evitar a influência de contaminação do equipamento. Além disso, existem diversas substâncias químicas comuns que são frequentemente presentes no ar interior de produtos de consumo e materiais de construção, por isso fontes ambientes geralmente dificultam a interpretação dos dados do ar interior. As concentrações do ar interior também tendem a ser altamente variável ao longo do tempo em resposta a mudanças nos gradientes de pressão causados por mudanças na pressão barométrica, o vento, as flutuações do nível da água, e construção de sistemas de ventilação. Variabilidade espacial e complexidade geológica também faz a amostragem do gás do solo difícil. Este trabalho apresenta novos métodos de amostragem e técnicas para minimizar o preconceito e variabilidade dos dados coletados para avaliar o caminho VI e novos métodos para projetar sistemas de mitigação de baixo custo.

**Abstract**

For properties contaminated with volatile organic compounds, the pathway of greatest potential human health risk is often subsurface vapor intrusion to indoor air, also known as the vapor intrusion (VI) pathway. On average, people inhale about 20,000 L of air each day, compared to drinking only about 2L of water or ingesting a few grams of soil, which means the risk-based target concentrations for indoor air must be very, very low compared to other media. As a result, the methods used for sampling and analysis must be more careful to avoid bias from equipment contamination. Furthermore, there are several common chemicals that are often present in indoor air from consumer products and building materials, so background sources commonly complicate the interpretation of



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indoor air data. The indoor air concentrations also tend to be highly variable over time in response to changes in pressure gradients caused by natural barometric pressure changes, wind, water table fluctuations, and building ventilation systems. Spatial variability and geologic complexity also make soil gas sampling challenging. This paper presents new sampling methods and techniques to minimize the bias and variability in the data collected to assess the VI pathway and new methods for designing cost-effective mitigation systems.

**Keywords**: vapor intrusion, sampling, innovative, waterloo

## 1 – INTRODUCTION

The issuance of the United State Environmental Protection Agency (USEPA) Draft Vapor intrusion (VI) Guidance in 2002 brought the concerns related to the VI pathway to the spotlight in environmental investigations. Since 2002, the VI pathway has become and continues to be a pathway of great concern. The primary driver in this concern relates to the dosing one could potentially receive from breathing. On average, people inhale about 20,000 L of air each day, compared to drinking only about 2L of water or ingesting a few grams of soil. This large volume of potential exposure causes risk-based target concentrations for the air we breathe to very low compared to other media. This in turn correlates to very low indoor air target concentrations. The concentrations in indoor air are affected by storage of chemicals and materials, end to be highly variable over time due to variations in pressure, and spatially as well.

## 2 – SOURCES OF BACKGROUND IN INDOOR AIR

Everyone uses chemicals in their day-to-day lives, from hair spray, detergents, polishes, spot removers, gasoline, etc. These are all sources that affect the quality of the air we breathe and cause background concentrations during a VI assessment. These background chemicals interfere with understanding potential impacts to the quality of the indoor air, and if the cause of the degraded quality is due to sources in groundwater and/or soil. Table 1 provides a summary of some the main chemicals of concern (COCs) and the background levels typically observed. Typical background levels of COCs in the USA are above the most stringent risk levels, and highlights the importance of collection of unbiased samples through the removal of background sources, use of multiple lines of evidence in the VI assessment, and minimization of other temporal and spatial affects.

TABLE 1 Risk-Based Target Concentrations versus Typical Background Levels

| *Compound* | *$10^{-6}$ Risk Level ($\mu g/m^3$)* | *Background Concentration* | |
|---|---|---|---|
| | | *$50^{th}$ Percentile ($\mu g/m^3$)* | *$95^{th}$ Percentile ($\mu g/m^3$)* |
| Tetrachloroethene | 0.41 | 0.9 | 7.4 |
| Trichloroethene | 1.2 | 0.3 | 1.6 |
| Methylene Chloride | 5.2 | 1.1 | 20 |
| Benzene | 0.31 | 2.5 | 17 |

Many techniques are available to understand the influences of background chemicals. If sampling of the indoor air quality is required, then removal of these background chemicals is always the best practice to observe. The best practice is use a multiple line of evidence approach, which could include the following: review of the chemicals of concern, building construction and condition assessments, sub-slab soil gas data, evaluation of the ratios of COCs, etc. Though these techniques are useful in understanding the interference and/or influence of background chemicals during a VI assessment, the indoor air concentrations tend to be both temporally and spatially variable.

## 3 – TEMPORAL VARIABILITY OF INDOOR AIR CONCENTRATIONS

Indoor air concentrations tend to be highly variable over time in response to changes in pressure gradients caused by natural barometric pressure changes, wind, water table fluctuations, and building ventilation systems. The variability one may observe is illustrated in Figure 1, where a total of 36 consecutive indoor air samples were collected. These samples were collected over a 24 hour period using a flow regulated 6L SUMMA canister analyzed via USEPA Method TO-15, with results ranging from ~60 to >380pptv

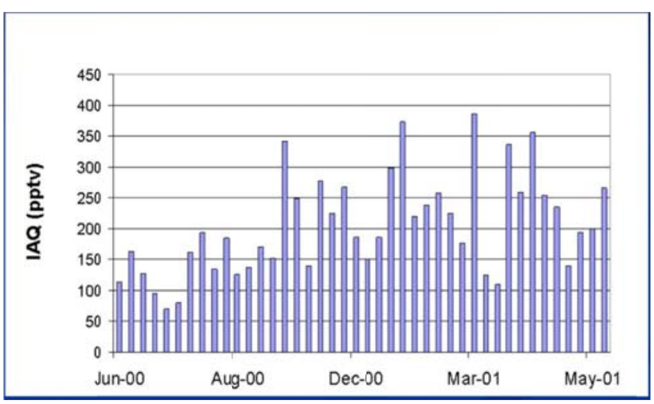


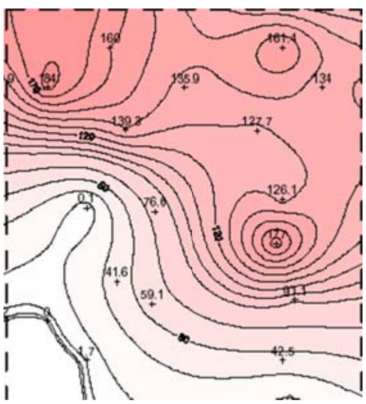

FIGURE 1: Temporal Variability (Indoor Air). 36 consecutive 24 hour samples.

The main cause of the temporal variability is due to the length of the sampling period. SUMMA canisters are only able to collect samples over an 8 or 24-hour period. Longer sampling periods are possible; however, the inflow orifice would be susceptible to clogging. One method is the use of diffusion samplers such as the Waterloo Membrane Sampler.

## 4 – SPATIAL VARIABILITY OF INDOOR AIR CONCENTRATIONS

Spatial variability and geologic complexity also make soil gas sampling challenging. The variability spatially is affected by temporal changes and how these change over the air of the building foundation. The spatial variability is best illustrated in Figure 2 which shows both the variability beneath the sample (see Figure 2a), and the variability of the direction of air flow in a building relative to the measured pressure within the building (see Figure 2b). One way to overcome this variability is to increase the volume of sample collected as part of these sampling activities.

a.




b.

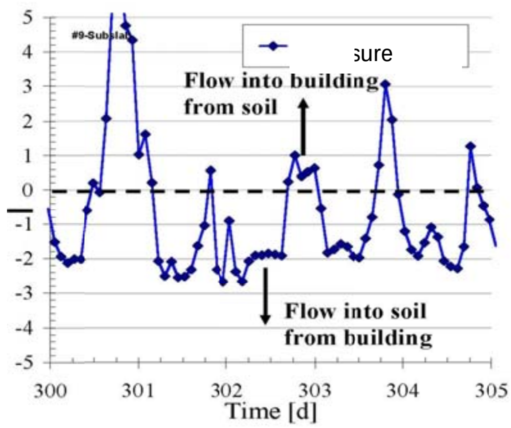



FIGURE 2 Spatial Variability (Sub-Slab). a. concentration variability of 45 ft by 50ft building, b. pressure variability between building and sub-slab over time

## 5 – CONCLUSIONS

Given the heightened concern of indoor air, one needs to understand and how to minimize the effects of background, temporal and spatial variability on the sampling results. The use of multiple lines of evidence aids in understanding the impacts background chemicals have on the VI results. Additionally, the collection of samples over a longer period of time (e.g., Waterloo Membrane Sampler) and of greater volume (e.g., High Volume Sampling) will aid in minimizing if not eliminating the effects of temporal and spatial variability.