Approaches to Consider the Influence of Building Infiltration and Ventilation on Vapor Intrusion Exposure Risks

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Background/Objectives. Vapor intrusion (VI) models have been developed to predict vapor transport through the soil into indoor spaces. Building air exchange rate (AER) is an important factor that controls indoor air quality. AER is a combination of infiltration, exfiltration and ventilation rate in buildings. In this study, we investigate the influence of building ventilation, including both mechanical and natural on VI process. Mechanical and natural ventilation are a function of occupant behavior, building characteristics and weather condition. In this study we develop a comprehensive model in which we combine three different domains: the atmospheric domain (outdoor above-ground), indoor domain, and subsurface domain. We investigate the influence of weather conditions, mechanical and natural ventilation on AER and indoor air pressure. Ultimately, we consider how vapor intrusion exposure risks are influenced by these factors.

Approach/Activities. This research presents a comprehensive VI model that couples a multizone indoor air model with a CFD program that calculates airflow rates at the building interfaces caused by infiltration, exfiltration and ventilation rates. The CFD model solves the Reynolds Averaged Navier-Stokes equations to calculate the distribution of wind pressure on building surfaces for the multizone indoor air model simulations. The multizone program solves air mass balance equations to predict the indoor air pressure which is later used as boundary condition in the VI model. The VI model then solves the chemical transport equation coupled with continuity equation allowing for both convective and diffusive transport and calculates contaminant distribution in subsurface and mass entry rate through the building foundation cracks. VI exposure risk is estimated based on the indoor air concentration, which is calculated by solving mass balance equations using the indoor air multizone indoor air model.

Results/Lessons Learned. Our results show that VI exposure risks vary depending on the specifics of different scenarios (e.g. Weather condition, building-specific features, as well as occupant behavior). Occupant behavior plays an important role in changing AER value and consequently influences contaminant indoor air concentration. Bathroom fans, kitchen hoods and other airflow devices, which are part of mechanical ventilation, can have relatively high flow rates, as compared to whole-house ventilation rates. While these components may only be operated intermittently, if operated while measuring IA concentrations, VI exposure risk assessments may not be accurate. Further, weather events can influence sampling results. Our research shows that dominant wind direction and speed, as well as the location of building characteristics prone to leakage, can influence VI exposure risk assessments.