Developing a Quantitative Decision Framework for Residential Vapor Intrusion Evaluations

Christopher Lutes (Jacobs, Raleigh, NC, USA)
Loren Lund (Jacobs, Shelley, Idaho, USA)
Keri Hallberg (Jacobs, Charlotte, NC, USA)
Chase Holton (Chase.Holton@ch2m.com) (Jacobs, Denver CO, USA)
Donna Caldwell (NAVFAC Atlantic, Norfolk, VA, USA)
Ed Corl (NAVSEA Laboratory Quality & Accreditation Office, Portsmouth, VA, USA)

Background /Objectives. In 2015, Naval Facilities Engineering Command (NAVFAC) published a vapor intrusion (VI) research report providing a data-driven quantitative decision framework (QDF) for prioritizing VI investigations and assessing VI for chlorinated solvent sites at industrial buildings. The QDF was developed through analyzing 49 military structures at 12 different installations, where measurements of chlorinated VOCs were available in indoor air, subslab soil gas, and/or groundwater. The QDF consists of flow charts, scorecards, and interpretation keys that can be used at different stages of the project life cycle, and can be used to prioritize buildings, evaluate indoor air data, and determine long-term stewardship approaches, weighing data from different factors according to their observed predictive power. United Stated Environmental Protection Agency's (EPA's) 2015 final VI guidance states that buildings must be weighted according to multiple lines of evidence until concordance is reached, but provides little actionable guidance. This presentation will discuss development of a QDF for residential VI evaluations.

Approach/Activities. A quantitative decision framework for residential VI evaluations was developed through re-analyzing the EPA residential database, along with multiple published papers, literature, and reports. Findings on more than 30 potential predictor variables for residential VI were compared from more than 25 database, single building, multiple building/single site, and modeling studies. Insights from radon susceptibility studies involving thousands of buildings were also used. The residential framework focuses on evaluating the causes of spatial variability and provides a defensible means to prioritize VI investigations at a subset of buildings.

Results/Lessons Learned. It is well established that no single variable or measurement can predict variation in indoor air concentrations across a population of buildings. As discussed by Suuberg et al., and Yao, the empirical relationships between subslab concentration and indoor air concentration do not fit simple linear mechanistic models. However, current VI investigative strategies are based on these simple models, including using attenuation factors to predict VI. A log-transformed reanalysis of the EPA (2012) screened residential dataset shows a reasonable fit between subslab concentrations raised to a power of ~0.5 and indoor air concentrations. Analyzing groundwater-to-indoor air concentrations shows little direct correlation; however, log-transformed groundwater and subslab concentrations are correlated, with vadose zone grain size serving as an important moderator variable. Multiple literature studies also indicate that the presence of a subslab gravel layer, presence of neighborhood scale atypical pathways, and horizontal separation distance from the source are also defensible predictor variables for inclusion in the residential QDF scorecard. This presentation describes the technical basis for a residential VI QDF and how it can be applied.