Assessing the significance of subsurface hydrocarbon vapour migration into a building with an earthen basement: a case study

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The move toward a more structured approach to assessing contaminated sites has led to a growing interest in the U.S. and other developed countries on the potential risks posed by the migration of chemical vapours from subsurface contamination into enclosed spaces located above it. Vapours accumulating in inhabited enclosed spaces pose two levels of concern. First, vapours may be present in the enclosed space at high enough levels to present immediate flammability and/or health risks. The second and more common scenario involves lower concentrations and the concern is more on long-term health risks to the inhabitants. For this second class of sites, time is available to adequately address the problem on a more site-specific basis.

A site-specific approach was used to assess the significance of subsurface hydrocarbon vapour migration into a building with an earthen basement located above a light non-aqueous phase liquid (LNAPL) plume originating from a nearby former gas station in Green River, Utah. The role of mathematical fate and transport modelling in assessing the significance of this pathway is highlighted. Specifically, the use of a popular screening-level model developed by Johnson and Ettinger (1991) for modelling the migration of subsurface hydrocarbon vapours into the building is discussed in the context of the risk assessment. The model relates the steady-state indoor air concentration of a volatile compound to its steady-state soil gas concentration at some depth in the subsurface. The original model algorithm couples vapour diffusion through the vadose zone, vapour diffusion and convection through cracks or small openings in a foundation slab and mixing of vapours inside a building. Model input requirements include distance between the contaminant source and building, chemical properties, soil properties and building properties.

Site-specific soil gas concentrations intended to be protective of the long-term health of the workers inside the building were developed for a range of petroleum constituents, including benzene, toluene, ethybenzene and xylenes (collectively, BTEX), methyl tert-butyl ether (MTBE), naphthalene, and Total Petroleum Hydrocarbons (TPH), using risk assessment methods recommended by the U.S. Environmental Protection Agency (USEPA) and Utah Department of Environmental Quality (UDEQ). As an initial evaluation of the potential health risks to indoor workers, the calculated soil gas concentrations were compared to measured soil gas concentrations obtained from nearby soil vapour monitoring wells. Based on this preliminary assessment, benzene and hydrocarbons in the C_4-C_{10} range were identified as the primary constituents of health concern. A qualitative evaluation of soil gas concentration profiles obtained from the soil vapour monitoring wells indicated that aerobic biodegradation of the hydrocarbons vapours may be occurring at shallow depths in the vadose zone although this may not be the case beneath the building. Vapour attenuation due to biodegradation was not considered in the mathematical modelling. Lastly, some recommendations for refining the assessment of the pathway are provided, including the collection soil gas samples beneath the building and monitoring of indoor air quality.

Reference

JOHNSON, P.C. AND ETTINGER, R.A., 1991. Heuristic model for predicting the intrusion rate of contaminant vapours into buildings. *Environmental Science and Technology, 25(8),* 1445–1452.