

Vapor Intrusion

The Hidden Indoor Air Health Hazard: National And International Perspectives and Case Studies

Overview:

Vapor intrusion (VI) refers to the upward transport of toxic volatile organic compounds (VOCs) from contaminated soil and/or groundwater into overlying buildings through floor slabs and foundation joints or cracks, subsequently accumulating and persisting in the indoor air at concentrations posing health risks to building occupants. VI is an “emerging” public health hazard which should be taken seriously for the following reasons:

- VI often overlooked by the general public and regulators as a potential exposure pathway while focusing mostly on contaminant ingestion and dermal contact;
- Many schools and childcare facilities are often sited on former toxic waste sites because of cheaper land, without adequate investigation of VI exposure potential. Children are especially vulnerable and more sensitive to potential VI health risks;
- VI exposure risks can be exacerbated during winter when fresh air circulation inside homes is reduced to conserve heat. VI exposure can also be higher in confining situations such as correctional facilities where building openings are minimized for security purposes.
- VI hazards in the future at currently uncontaminated (“clean”) areas can result from the migration of groundwater contamination from off-site sources;
- VI can be equally associated with soil as well as groundwater contaminant sources;

Case Studies:

Case studies from local and overseas communities are presented highlighting how previously overlooked vapor intrusion risks have resulted in the most immediate public health risks at contaminated sites:

Case Study A – Vapor Intrusion Risk from Groundwater Contamination at Superfund Site in Northern New Jersey

- Groundwater contaminant plume of VOCs, primarily trichloroethylene (TCE) and perchloroethylene (PCE) encompassing approximately 6,000 acres and affecting several municipalities in a predominantly rural setting;
- Groundwater used as drinking water source, and TCE and PCE detected in public water wells in the 1970’s;
- Maximum TCE and PCE concentrations ranged in thousands parts per billion. Depth to water as low as 40 feet below grade;
- Site placed on the Superfund List in 1989;
- Record of Decision (ROD) in 2006 focused only on ingestion and dermal exposure with no mention of VI risks; and,
- Personal communication with EPA Project Manager revealed that VI pathway assessment was only initiated in 2007. Affected public still has little or no awareness of the potential health risks lurking in their basements.

Lesson Learned: A major discharge of toxic VOCs (TCE and PCE) identified in 1970’s should not have waited until 2007 to trigger a VI investigation. While regulatory agencies focused on ingestion exposure, the public may have been exposed to significant VI inhalation risks for over 30 years.

Case Study B – Groundwater Contamination, Vapor Intrusion and Potential Linkage to Rare Genetic Disorder at Industrial Site in Central New Jersey

- Discharge in the 1950’s of VOCs, primarily TCE and PCE at printing facility in mixed urban residential/commercial neighborhood;
- Investigation in early 1990’s indicated groundwater concentrations of TCE and PCE in hundreds parts per billion. Depth to groundwater shallower than 10 feet below grade. Groundwater pump and treat initiated in late 1991;
- Diagnosis of rare genetic lysosomal disorder, mucopolipidoses, affecting child resident triggered VI investigation in 2007; and,
- VI risk assessment findings indicated cancer risks exceeding guideline limits. Health effects assessment identified birth defects, impaired fetal growth and oral cleft defects as potential health effects associated with site contaminants.

Lesson Learned: More than 50-year time frame elapsed between discharge of toxic VOCs into the groundwater and investigation of VI exposure. Since site groundwater is not (currently) used for potable supply, VI posed the principal public health threat for decades. The cause-effect linkage between VI exposure and rare genetic disorder in child resident cannot be ruled out.

Case Study C – Vapor Intrusion from Extensive Soil and Groundwater Contamination at a Military/Industrial site in a Middle Eastern Country

- Site investigation at munitions manufacturing site that operated between 1950 and 1998 revealed extremely high levels of TCE and other chlorinated solvents in soil and groundwater;
- Highest detected TCE concentrations ranged in the hundreds of parts per billion in both groundwater and soil gas. Groundwater contamination became regional issue, with contributions from other sources in the region. Depth to groundwater ranged down to 40 feet below grade;
- Regulators were aware of the groundwater contamination and implemented point of entry treatment prior to potable use of the water, but VI investigation was not initiated until early 2000’s;
- Subsequent VI risk assessments found cancer and non-cancer risks significantly exceeding guideline limits, under various exposure scenarios;
- Based on VI risk assessment findings, VI exposure from uncontrolled subsurface vapor transport has been recognized as most immediate public health threat, requiring immediate implementation of remedial measures to minimize exposure risk.

Lesson Learned: Potential VI exposure was not addressed for decades due to lack of awareness of the danger while regulators focused on ingestion. The failure to recognize the VI hazards is especially critical in overseas developing countries where environmental awareness in general is often rudimentary.

Suggestions for Early Detection and Minimization of Potential VI Exposure Risks:

- Groundwater fate and transport modeling to delineate current as well as future extent of groundwater plume;
- Development of approximate VI iso-risk contours via modeling, based on the groundwater contaminant isopleths to identify high VI risk areas for implementation of further investigation/remedial measures and guidance for locating future developments;
- Aggressive vapor intrusion pathway assessment through indoor air and sub-slab sampling in potentially impacted structures, and implementation of vapor mitigation measures, where necessary;
- Regulatory requirement for continuing periodic (annual) screening of targeted structures for VOCs. A “clean” structure today may become affected by a mobile plume in the future;
- Installation of Vapor barriers and/or sub-slab venting systems as standard requirement for all new homes and buildings; and,
- Public education to increase awareness of VI risks.

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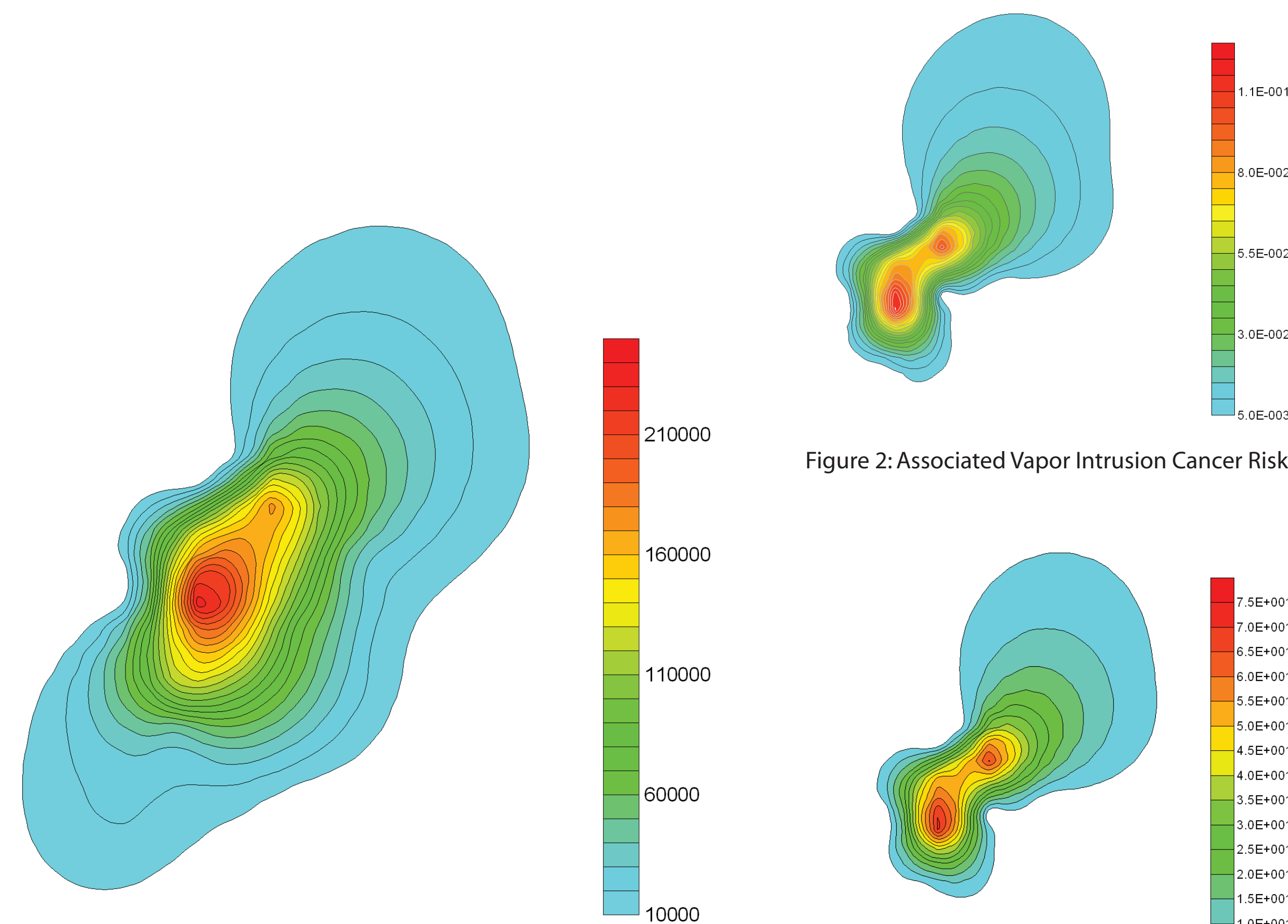


Figure 1: Groundwater Contaminant Concentration Isoleths in Parts Per Billion

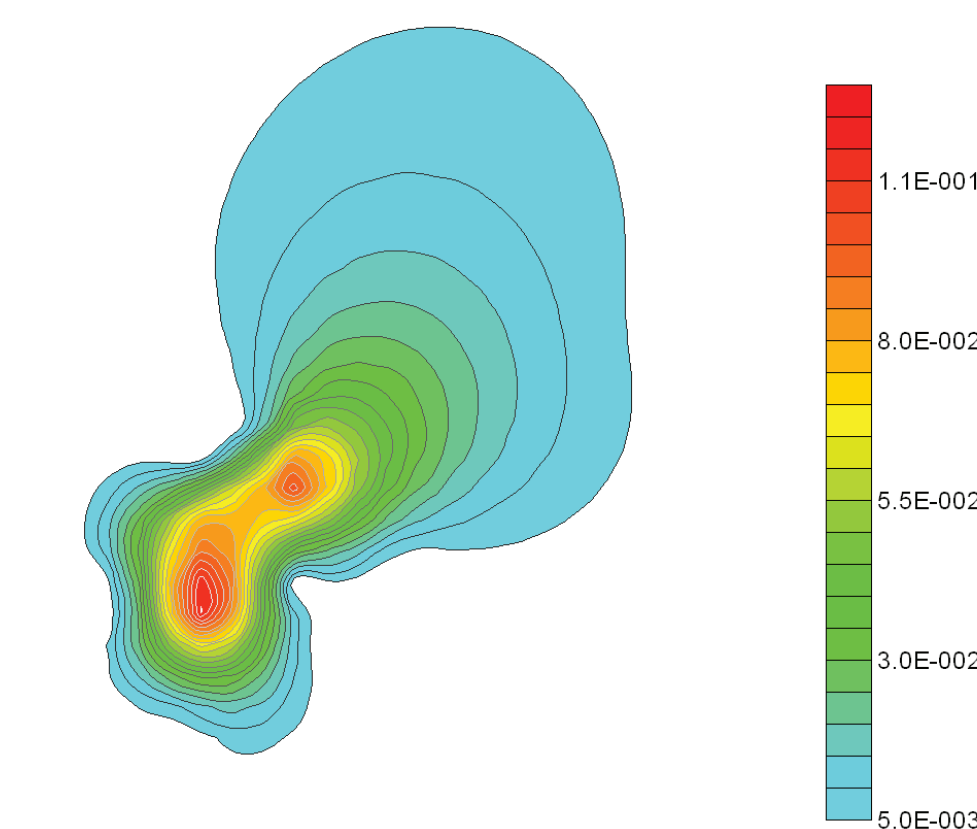


Figure 2: Associated Vapor Intrusion Cancer Risks

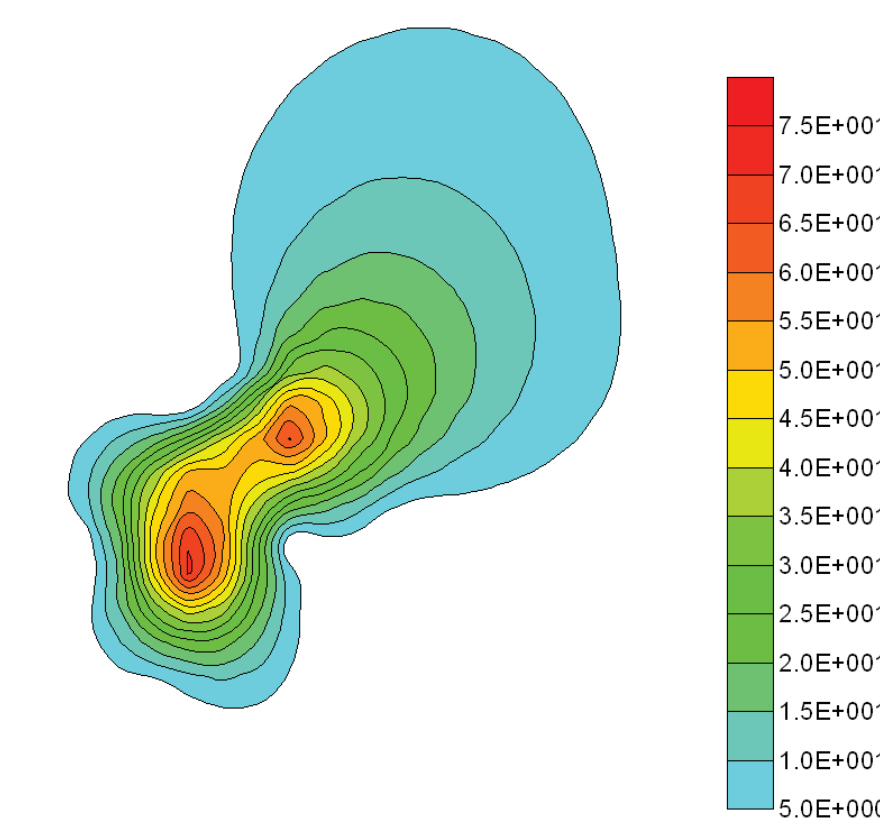


Figure 3: Associated Vapor Intrusion Hazard Index