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MADISON & DANE COUNTY
Healthy people and places

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An Overview of PCE Contamination of Indoor Air from Vapor Intrusion

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Introduction

Tetrachloroethylene (PCE), also known as perchloroethylene or PERC, has been used commercially in the United States since the mid-1930s in dry cleaning, textile processing, and metal-cleaning operations[1, 2]. Of these industries, dry cleaners are the single largest users of PCE and continue to widely use the solvent due to its low flammability hazard and ability to dissolve greases, oils, and waxes without damaging fabric quality[1]. Unfortunately, PCE does not degrade quickly in the environment and may remain in high concentrations in the subsurface decades following a spill. As a result, environmental contamination has been reported in various communities throughout Dane County over the past three decades that have originated from historical and/or current dry cleaning operations. In fact, over the past decade, over two dozen separate dry cleaning sites in Dane County reported to the Wisconsin Department of Natural Resources (WI DNR) had PCE-related contamination identified, had environmental sampling conducted on the property, and/or were involved in remediation efforts to reduce or prevent human exposure to the chemical[3]. These investigations and remediation (if applicable) of identified soil and/or ground water contamination remain in various levels of completion; other cases have been investigated and closed involving PCE-contaminated properties. Additional sites throughout Dane County may also have PCE contamination due to usage of the solvent but these have yet to be identified and reported to WI DNR.

During the last decade there has been a growing awareness that contaminated soils and groundwater can release vapors, which have the potential to move through soils, enter indoor air of nearby buildings, and be inhaled by occupants at unacceptable concentrations. This pathway is known as "vapor migration and intrusion to the indoor air pathway", or more simply as "vapor intrusion". Due to the importance of this pathway, vapor intrusion assessment has became a necessary part of investigations where PCE and/or other volatile organic compound is involved[4,5]. More recently, high-profile examples of vapor intrusion involving PCE and a chemical breakdown product, trichloroethylene (TCE), have been reported in the City of Madison and surrounding communities that have underlined the importance of continuing efforts to identify and remediate sites reporting PCE-related contamination. Therefore, Public Health Madison and Dane County (PHMDC) have been working with the WI DNR to improve public understanding of the vapor intrusion issue and communicate public health information to impacted neighborhoods. This fact sheet provides a brief background on vapor intrusion and the health risks associated with exposure to PCE.

Vapor Intrusion

Vapor intrusion refers to the migration of toxic vapors from contaminated soils and/or groundwater into overlying buildings; structures that may include, but not limited to, homes, schools, businesses, and day care and senior centers[5, 6]. Depending upon the concentration of PCE present in the indoor air, exposure may result in the development of adverse human health conditions.

PCE is a liquid at room temperature, but easily transitions to a volatile vapor form. In soil and/or ground water, the chemical can move away from contamination sources via spaces in between soil particles and reach overlying structures due to concentration and pressure differences that tend to equalize gaseous concentration. These soil vapors can then potentially enter into overlying structures through cracks and/or holes in the foundation slab due to the lower pressure in the building compared to that of the subsurface[6]. Upon entry of the vapor into the structure, the contaminate gas(es) spread out in the indoor air and result in the potential human exposure to PCE throughout the structure and not just at the level or location of vapor entry. However, due to this spreading out of the PCE vapors into the indoor air, the concentration of the contaminate gas in the indoor air is generally much lower than the levels present beneath the foundation of the structure (referred to as sub-slab vapor)[5, 6]. Proper ventilation in the home further reduces the concentration available for human exposure[6].

In addition to inhalation of contaminated indoor air, individuals can also be exposed to PCE from contaminated properties by direct contact with contaminated soil and/or ingestion of contaminated drinking water[1, 7, 8]. However, these pathways are less common in comparison with the inhalation of contaminated indoor air. Due to this fact, the vapor intrusion pathway has become increasingly important in the design of intervention efforts and is the primary focus of this overview.

Potential Health Implications of PCE Vapor Intrusion

Human health effects resulting from the inhalation of PCE contaminated air resulting from vapor intrusion is dependent upon the concentration of the contaminant in the indoor air and the length and frequency of exposure. Short-term (acute) inhalation exposures to very high concentrations of PCE vapors can cause dizziness, headache, noise and throat irritation, sleepiness, changes in behavior, and nausea[1, 9]. Concentrations of this magnitude (1500 parts per billion or ppb) are rare for vapor intrusion cases and are typically limited to occupational exposures in poorly ventilated work areas.

Long-term exposures (greater than 14 days) at concentrations higher than 150 ppb have been associated with reduced scores on visual perception tests, reaction time, and attention. Exposures above 1500 ppb have been associated with reduced scores on color vision tests, liver and kidney damage, and cancers among workers at dry cleaners following occupation exposure[1, 8, 9]. The United States Environmental Protection Agency has labeled PCE as a “probable human carcinogen”; long-term inhalation of PCE at this level poses an increased lifetime risk of developing certain cancers.[1]

However, it must be noted that human health implications related to PCE, or any other type of contaminate exposure, are not entirely based on the concentration and time period of exposure but individual differences among the exposed population also play a role in the human health response. Individual traits including, but not limited to, differences in age, sex, diet, health status, family history of disease, and personal lifestyle choices can each impact individual sensitivity to exposure and the severity of response.

Regulatory Response to Reduce Exposure

Typically, state and local health agencies learn of PCE contamination during agency inspections, environmental assessment conducted during the sale of the property, or voluntary environmental sampling conducted by parties responsible for the contamination. However, once PCE contamination is discovered an environmental assessment is performed in cooperation with state and/or local health officials. Dependent upon the severity of contamination, this evaluation may involve various types of sampling methods including, but not limited to, the sampling of PCE levels in outdoor air, ground water, soil, sub-slab soil gas, and/or indoor air. Sampling results are then compared to existing air quality, water quality, and/or soil quality standards to determine if remediation is warranted.

PCE is regulated by both federal and state environmental laws to limit contamination of environmental resources in the State of Wisconsin. In terms of the vapor intrusion pathway, conservative action levels have been adopted by the state for the concentration of PCE in sub-slab soil gas and indoor ambient air of residential and commercial structures. In residential structures, this action level is 6.2 parts per billion by volume (ppbv) in indoor air and 62 ppbv for sub-slab soil gas; the level assumes inhalation of the contaminant 24 hours per day, 365 days per year for more than 30 years. The action level for PCE increases in commercial structures due to less total exposure due to employment schedules; the action level in commercial structures is 27 ppbv in indoor air and 270 ppbv in sub-slab soil gas[10-11].

If detected PCE concentrations in the sub-slab vapor or sub-slab vapor and indoor air exceed action levels outlined by Wisconsin Department of Natural Resources at a building, action is needed to reduce exposure to PCE. These actions may include, but are not limited to, additional sampling, excavation and removal of contaminated soils, expansion of contaminant monitoring to neighboring residential and/or commercial structures, and/or vapor mitigation[11, 12]. In most cases, mitigation involves the installation of a sub-slab depressurization system(s) at the affected structure. These systems, also known as radon mitigation systems, use a series of piping connected to a fan to produce a vacuum effect that remove soil vapors from below the foundation of the residential or commercial structure. The vapors are then vented above the roof line into the outside air where they are dispersed harmlessly; these systems remove all soil gases including PCE and radon that exist beneath the building and may have potentially entered the indoor air of the structure[11].

Where Can I Get More Information

If you have any questions about the information in this overview or would like to learn more about PCE and/or vapor intrusion, please call Public Health Madison and Dane County at (608) 266-4821 or email any questions or concerns to: health@cityofmadison.com

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