



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}. The chemical continues to be widely used due to the low flammability hazard and high boiling point of the solvent and its ability to dissolve greases, oils, and waxes¹.

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 sites that have historically and/or currently use PCE for normal business operation.

This is especially true for current and former dry cleaning facilities. In fact, over the past decade, over a dozen separate dry cleaning sites in Dane County listed by the Bureau for Remediation and Redevelopment Tracking System (BRRTS) 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 chemical³. 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^{2,3}. 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.

Soils and groundwater contaminated with volatile chemicals can release vapors into the surrounding environment. These vapors have the potential to move through soils, enter the 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”^{1,4,5}. Due to the importance of this pathway, vapor intrusion assessment has become a necessary part of investigations where PCE and/or other volatile organic compound may be involved^{2,4,5}. Several high-profile examples of vapor intrusion involving PCE and a chemical breakdown product, trichloroethylene (TCE), have been reported in recent years in the City of Madison and surrounding communities that continue to underline the importance of 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. Following is a brief background on vapor intrusion and the health risks associated with exposure to PCE.

Soil and groundwater contamination from Tetrachloroethylene (PCE), a solvent used in drycleaning, textile processing, and metal-cleaning has been reported in various communities throughout Dane County over the past three decades. When this happens, these chemicals may release gases or vapors, which travel from the contaminated groundwater or soil and move into nearby homes or businesses. This is vapor intrusion.

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 subsurface⁶. Upon entry of the vapor into the structure, the contaminate gas(es) spread throughout the building in the indoor air that results in potential human exposure to PCE. However, due to the dilution of the PCE vapors into the indoor air throughout a structure, the concentration of the contaminate gas in the indoor air is generally much lower than the levels present beneath the foundation (referred to as sub-slab vapor)^{5,6}. Proper ventilation in the home further reduces the concentration available for human exposure⁶.

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^{1,4,7}. However, these pathways are less common in comparison with inhalation exposure. 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.

HEALTH RISKS 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, nose and throat irritation, sleepiness, changes in behavior, and nausea. Concentrations of this magnitude, over 100 parts per million (ppm) or 100,000 parts per billion by volume (ppbv), are rare for vapor intrusion cases and are typically limited to occupational exposures in poorly ventilated work areas^{1,9}.
- Long-term exposures (greater than 14 days to years) at much lower concentrations have been associated with reduced scores on visual perception tests, reaction time, and attention due to the greater length of exposure to the contaminant. Several investigations of chronic exposures have also associated PCE with, liver and kidney damage and cancers among workers at dry cleaners following occupation exposure; these levels of contamination were considerably higher than those typically found in indoor or outdoor air^{1,7,8}. 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 assessments conducted during the sale of the property, or voluntary environmental sampling conducted by parties responsible for the contamination. However, once PCE contamination has been 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, water, and/or soil quality standards to determine if remediation is warranted².

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 vapor action level (VAL) is 6.2 ppbv in indoor air and a vapor risk screening level of 210 ppbv for sub-slab soil gas¹⁰⁻¹². The VAL is a value that represents a potential health hazard risk of 1 in 100,000 people during a lifetime of exposure; the VRSL is similar and identifies the concentration of a contaminant that could be harmful if vapor enters the structure¹². The action level for PCE increases in commercial structures due to less total exposure due to employment schedules; the VAL in commercial structures is 27 ppbv in indoor air and the VRSL is currently 900 ppbv in sub-slab soil gas for small commercial structures and 2,700 ppbv for large commercial structures¹².

If detected PCE concentrations in the sub-slab vapor or sub-slab vapor and indoor air exceed the VRSL and/or the VAL 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 mitigation¹⁰⁻¹². 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^{2,10}.

INFORMATION AND REFERENCES

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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