

Volatile Organic Compounds (VOCs) in Minnesota's Ground Water

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What are Volatile Organic Compounds (VOCs)?

VOCs are carbon-containing compounds that readily evaporate at normal air temperature. Fuel oils, gasoline, industrial solvents, paints, and dyes are the major sources of VOCs. Currently, 68 of the most common VOCs detected in ground water are analyzed in a typical sample submitted for analysis. These 68 VOCs cover a range of chemical compounds that have different chemical and physical properties and different levels of toxicity.

What are sources of VOCs in ground water?

Most VOCs found in the environment are a result of human activity. VOCs are very mobile and readily dissolve and leach into ground water. The most common sources of VOCs in ground water include gasoline and fuel oils from leaking tanks and spills; solvents, paints, pigments, and dyes from leaking tanks and improper waste storage and disposal; leaching of chemicals from atmospheric deposition of automotive and industrial emissions; and residuals from well disinfection. Recent studies indicate there are low concentrations of naturally occurring VOCs, such as chloroform and toluene, in some aquifers.

What types of VOCs are most commonly found in ground water?

Chlorinated VOCs are associated with commercial and industrial use and include dozens of chemicals that are typically very mobile, persistent, and toxic in the environment. Nonchlorinated VOCs are associated with gasoline, fuel oils, and industrial solvents. These chemicals are also mobile, but are generally less toxic and persistent than the chlorinated solvents. Chlorofluorocarbons (CFCs) are found in a variety of industrial and commercial applications. They are mobile but are not persistent, nor are they found in concentrations toxic to humans in most aquifers. Chloroform can be a by-product of well disinfection and other uses of chlorine. Chloroform is mobile, persistent, toxic, and is found at low concentrations when associated with well disinfection.

What is considered a safe level of VOCs in ground water?

The Minnesota Department of Health has established Health Risk Limits (HRLs) for 48 VOCs. A HRL is the concentration of contaminant in ground water that is safe to ingest daily over a human lifetime without other chemical exposures. Each VOC with a HRL has potentially different health effects. HRLs for most chlorinated solvents are very low, generally less than 30 parts per billion (ppb). Many of the chlorinated solvents are known or suspected carcinogens. Some of the more common chlorinated VOCs and their respective HRLs include trichloroethylene (30 ppb), tetrachloroethylene (7 ppb), and vinyl chloride (0.2 ppb). HRLs for most nonchlorinated VOCs are higher and have a wide range of health effects. Some of the more common nonchlorinated VOCs and their respective HRLs are benzene (10 ppb), naphthalene (300 ppb), acetone (700 ppb), and xylene (10,000 ppb). HRLs for CFCs are greater than 1000 ppb, while the HRL for chloroform is 60 ppb. In wells with more than one detectable VOC, it is important to consider the cumulative health effects of the different VOCs.



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How are VOCs distributed in Minnesota ground water?

VOCs were detected in 11.4 percent of wells sampled in the Ground Water Monitoring and Assessment Program's statewide baseline network of 954 wells. Twenty wells (2.1 percent) had more than one VOC detected. Chloroform was detected in 55 wells, nonchlorinated VOCs in 46 wells, chlorinated solvents in 23 wells, and CFCs in eight wells. Four wells had an exceedance of a HRL. Detection rates in the Jordan, Prairie du Chien, Upper Carbonate, Cretaceous, Precambrian, buried drift, and surficial drift aquifers were 6, 3, 8, 24, 21, 11, and 13 percent, respectively. A recent study of shallow ground water in the St. Cloud area revealed low level concentrations of VOCs in nearly all samples collected under commercial and residential areas. The most common VOCs were toluene and xylene, which are products of gasoline, fuel oils, and industrial solvents. Tetrachloroethylene, a chemical widely used by dry cleaners, was found at three of the 17 sampled sites.

Which aquifers are most sensitive to contamination by VOCs?

Because of the mobility and persistence of most VOCs, aquifers are at risk of contamination if a source of VOCs exists nearby. Aquifers are at risk to contamination in areas of concentrated industrial and residential activity, in areas where underground storage tanks exist, and near landfills, dump sites, and other waste disposal areas. Sensitive hydrologic settings, such as glacial sand and gravel aquifers close to the land surface or aquifers that occur in fractured bedrock, greatly increase the risk of contamination. Aquifer physical properties also affect sensitivity. Large portions of an aquifer can quickly become contaminated downgradient of a VOC source. Finally, sensitivity varies within an aquifer because of geochemical conditions. For example, benzene is degraded in the presence of oxygen but is persistent when oxygen is absent. Consequently, in shallow, oxygenated portions of an aquifer, benzene can be rapidly degraded, even though these portions of an aquifer are more susceptible to initial contamination resulting from leaky tanks or spills. The geochemical factors affecting natural attenuation of VOCs vary from compound to compound.

What are some management strategies for reducing ground water risks from VOCs?

Pollution prevention is the best way of avoiding risk posed by VOCs in ground water. Waste reduction and use of less persistent and less toxic chemicals are effective pollution prevention tools. Some Best Management Practices (BMPs) to decrease risk of contamination include proper storage of VOC-containing chemicals, proper disposal of VOC-containing waste, locating water supply wells upgradient of VOC sources, and locating industries in areas where aquifers are less sensitive. Ground water contaminated with VOCs is often very difficult to clean. A variety of treatment technologies exists to clean up different groups of VOCs. These technologies may reduce VOCs to acceptable levels but do not eliminate them from ground water.

For more information

For more information about VOCs in ground water or to request other fact sheets in this series, contact GWMAP, c/o Minnesota Pollution Control Agency, 520 Lafayette Road, St. Paul, MN 55155 or call toll-free/TDD at (800) 657-3864. Also, visit the MPCA web site for various ground water studies and data at <http://www.pca.state.mn.us/water/groundwater/index/html>.

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