1,4-Dioxane in the Environment

A publication of the Hazardous Substance Research Centers' Technical Outreach Services for Communities (TOSC) Program.

TOSC Program

The Technical Outreach Services for Communities (TOSC) program promotes community involvement in environmental decision-making through educational and technical assistance services, and is funded under a grant from the U.S. Environmental Protection Agency. TOSC is housed in the Midwest Hazardous Substance Research Center. TOSC program services seek to build community understanding of site contamination problems and empower citizens and local government to participate more effectively in the decision making process. Additionally, TOSC reviews documents and provides professional guidance on site cleanup work. For more information write B100A Engineering Research, Michigan State University, East Lansing, MI 48824, visit www.toscprogram.org or call 1-800-490-3890.

The Midwest Center is a consortium of the Purdue University, Michigan State University and Kansas State University

Introduction

Chemicals can be released to the environment as a result of their manufacture, processing, and use. This fact sheet provides information on 1,4-dioxane, a solvent used in manufacturing paper and other products. (A solvent is a substance, usually a liquid, in which other substances are dissolved; the most common solvent is water.) This fact sheet describes the ways in which people or ecological receptors (plants, animals, microbes) may become exposed to dioxane, the effects of the exposure to humans and the environment, and the fate of 1,4-dioxane in the environment.

What is 1,4-dioxane, how is it used, and how might one be exposed to it?

1,4-dioxane (also called dioxane) is a flammable liquid. It may form explosive chemicals, especially when in anhydrous form (very dry). It is produced in large amounts (between 10 million and 18 million pounds in 1990) by three companies in the United States. Information of future U.S. demand for dioxane is not known. Companies use dioxane as a solvent for paper, cotton, and textile processing, and for various organic products. It is also used in automotive coolant liquid, and in shampoos and other cosmetics.

Exposure to dioxane can occur in the workplace or in the environment following releases to air, water, land, or groundwater. It enters the body when animals breathe air or consume water or food contaminated with dioxane. It can also be absorbed through skin contact. It does not remain in the body due to its breakdown and removal.

Physical Properties

- Appearance: colorless liquid
- Melting point: 11.8 C
- Boiling point: 100 - 120 C
- Vapor density: 3
- Vapor pressure: 27 mm Hg at 20 C
- Density (g cm-3): 1.034
- Flash point: 12 C
- Explosion limits: 2% - 22%
- Auto ignition temperature: 180 C
- Stability: Stable. Incompatible with oxidizing agents, oxygen, halogens, reducing agents, moisture.
- Highly flammable - note wide explosive range. May form explosive peroxides in storage (rate of formation increased by heating, evaporation or exposure to light).

What happens to 1,4-dioxane in the environment?

1,4-dioxane evaporates readily when exposed to air, and also mixes easily with water. It is therefore most commonly found in air sampling or groundwater or surface water sampling. Once in the air, it breaks down to other chemicals. 1,4-Dioxane can evaporate from dry soil exposed to air. It is not likely to evaporate as readily from water or moist soil. Because it does not bind well to soil, dioxane that makes its way into the ground can move through the ground and enter groundwater. Plants and animals are not likely to store 1,4-dioxane. The environmental release, transport and transformation/persistence of dioxane is explained further below.

A. Environmental Release

Of the total 1.13 million pounds of 1,4-dioxane released into the U.S. environment in 1992, as reported to the Toxics Release Inventory by certain types of U.S. industries, 680 thousand pounds were released into the atmosphere, 450 thousand pounds were released into surface waters, and 33 hundred pounds were released onto the land (TRI92, 1994). 1,4-Dioxane at a concentration of 1 microgram/liter has been detected in drinking water in the U.S., (no specific locations given); the chemical was detected in 37% of well water samples collected near a solid waste landfill located 60 miles southwest of Wilmington, DE. 1,4-Dioxane at 1 microgram/L was detected in the Chicago Sanitary and Ship Channel.

B. Transport

Dioxane will leach readily through soils and towards groundwater sources. Volatilization of dioxane from *moist* soils will be slow. Based on its vapor pressure, volatilization from *dry* soils should be fast. 1,4-dioxane is not expected to adsorb significantly to (or stay "stuck to") suspended sediments (Howard, 1990). Dioxane thus "prefers" to stay in the water phase or, where water is not present, it tends to volatilize (evaporate).

C. Transformation/Persistence

1. **Air**
   1,4-Dioxane in the atmosphere is expected to degrade fairly quickly. The half-life of the reaction of 1,4-dioxane with photochemically produced hydroxyl radicals in the atmosphere was estimated to be 6.7-9.6 hours. Experimental results of sunlight-irradiated mixtures of 1,4-dioxane/NO suggest similar half-lives (Howard 1990).

2. **Soil**
   No adsorption data are available, but the low estimated log soil-sorption coefficient (Koc) (that is, the tendency of a compound to stay "stuck" to soils) suggests that 1,4-dioxane should readily leach to ground water. No data concerning the volatilization of 1,4-dioxane are available, but the estimated Henry's Law constant suggests that volatilization from moist soils will be slow; however, based on its vapor pressure, volatilization from dry soils should be fast. 1,4-dioxane is not expected to biodegrade in soil (Howard 1990). (Henry's Law states that the amount of a gas that will be absorbed by water increases as the gas pressure increases.)

3. **Water**
   No hydrolysis (or decomposition of a chemical by reaction with water) data on 1,4-dioxane are available. Because ethers in general have been classified as generally resistant to hydrolysis, 1,4-dioxane is not expected to hydrolyze significantly. The estimated Henry's Law constant for 1,4-dioxane and its miscibility (or capability of being mixed in any concentration without separation of phases) in water suggest that volatilization will be slow. From its estimated Koc, 1,4-dioxane is not expected to significantly adsorb to suspended sediments. 1,4-Dioxane is not expected to biodegrade in water (Howard 1990).

4. **Biota**
   Based on its water-partition coefficient (that is, the portion that stays in the water phase), 1,4-Dioxane is not expected to bioconcentrate in fish (Howard 1990).

How does 1,4-dioxane affect human health and the environment?

Effects of 1,4-dioxane on human health and the environment depend on how much 1,4-dioxane is present and the length and frequency of exposure. Effects also depend on the health of a person or the condition of the environment when exposure occurs.

Breathing 1,4-dioxane for short periods of time causes irritation of the eyes, nose and throat in humans. Exposure to large amounts of 1,4-dioxane can cause kidney and liver damage. Accidental worker exposure to large amounts of 1,4-dioxane has resulted in several deaths. Symptoms associated with these industrial deaths suggest 1,4-dioxane causes adverse nervous system effects. These acute effects are not likely to occur at concentrations of 1,4-dioxane that are normally found in the U.S. environment.

Limited evidence suggests that repeatedly breathing small amounts of 1,4-dioxane over long periods of time causes no adverse effects in workers. Laboratory studies show that exposure to 1,4-dioxane over a lifetime causes cancer in animals. 1,4-dioxane may likewise cause cancer in humans. Laboratory studies show that repeat exposure to large amounts of 1,4-dioxane in drinking water, in air, or on the skin causes liver and kidney damage in animals.

1,4-Dioxane has low toxicity to aquatic life. It is not likely to cause environmental harm at levels normally found in the U.S. environment.

References

Howard, P.H., Ed. 1989. Handbook of Environmental Fate and Exposure Data. Lewis Publishers, Chelsea, MI.

This fact sheet has been adapted from U.S. EPA's website.
For more information on 1,4-dioxane see:
http://www.epa.gov/chemfact/dioxa-fs.txt.