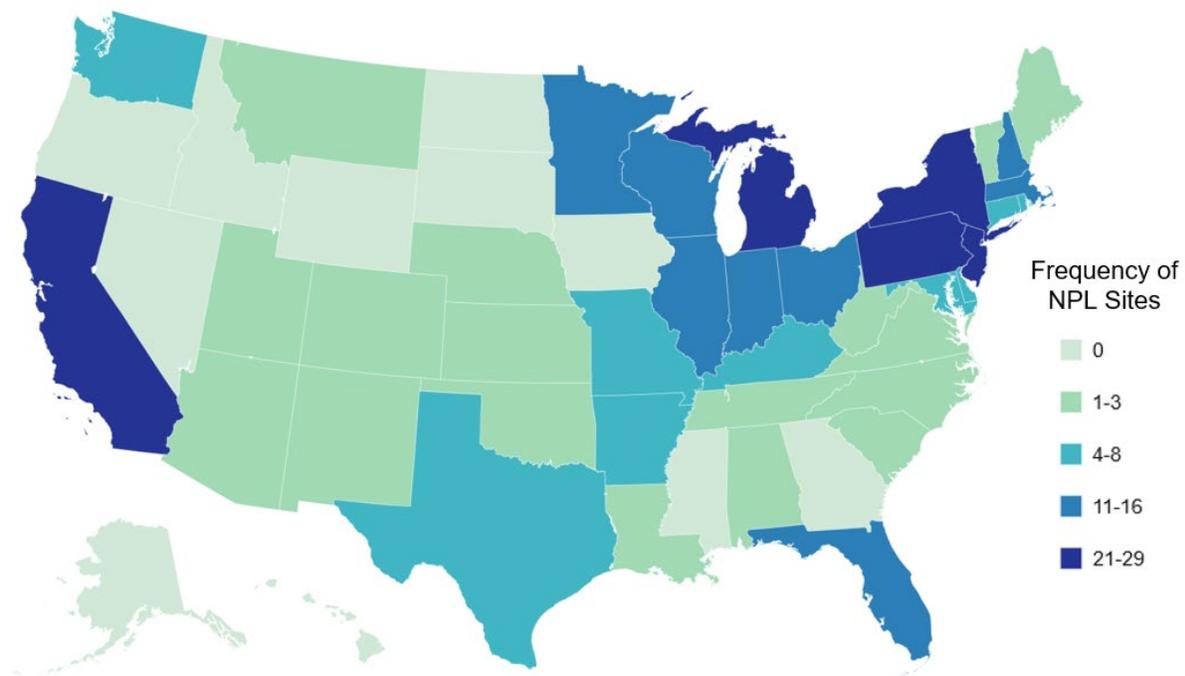


CHAPTER 5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

Chloroethane has been identified in at least 315 of the 1,868 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (ATSDR 2022a). However, the number of sites in which chloroethane has been evaluated is not known. The number of sites in each state is shown in Figure 5-1.

Figure 5-1. Number of NPL Sites with Chloroethane Contamination



Source: ATSDR 2022

- Ambient air may contain chloroethane since there are fugitive emissions from use of chloroethane as a chemical intermediate.
- Ambient air and possible consumption of contaminated drinking groundwater are the primary sources of exposure to the general population.
- Exposure can also occur from the direct use of chloroethane as a topical anesthetic.
- People have also been known to intentionally inhale chloroethane vapors from commercial products for its narcotic effects.

5. POTENTIAL FOR HUMAN EXPOSURE

- Occupational exposure where chloroethane is manufactured and used is likely to result in higher exposures than for the general population.
- Since chloroethane has a very high vapor pressure and Henry's law constant it is expected to exist primarily in the vapor phase. In the atmosphere, the main degradation pathway will be through its reaction with photochemically generated hydroxyl radicals.
- If released to soil or water, chloroethane is expected to volatilize rapidly but it may leach into groundwater since it is expected to possess high mobility in soil.
- Degradation in soil and water may occur through both biotic and abiotic mechanisms.

Chloroethane is a compound that occurs in the environment as the result of anthropogenic activity. Chloroethane exposure may occur from process and fugitive emissions from its production and use as a chemical intermediate and from landfill leaching. Chloroethane is a gas and has a very high vapor pressure, which causes it to quickly evaporate from wastewater streams, landfills, solvents, and anesthetics. The combustion of plastics, refuse, and biomass may also release chloroethane. The anaerobic biodegradation of some chlorinated solvents and chloroethane's formation during water chlorination are other sources of exposure. Most chloroethane released in the environment eventually enters the atmosphere.

When released to the atmosphere, the dominant removal mechanism is expected to be reaction with photochemically-generated hydroxyl radicals (half-life of 40 days). Potential exists for removal from the atmosphere in precipitation; however, most chloroethane removed by this mechanism is likely to reenter the atmosphere by volatilization. When released to surface water, volatilization is expected to be the primary fate process (half-life of 2.4 hours in a model river). When released to soil, chloroethane either volatilizes rapidly from soil surfaces or leaches through subsurface soil where it becomes a potential groundwater contaminant. In groundwater, chloroethane would be subject to chemical hydrolysis to give ethanol. Sufficient data are not available to establish the rate of chloroethane degradation in groundwater.

The general population may be exposed to low levels (<2 ppbv; Table 5-7) of chloroethane through inhalation of contaminated ambient air. Exposure may also occur through possible consumption of contaminated drinking water (0.1–228 ppb; Table 5-5). Dermal contact can occur from the intentional use of chloroethane as a topical anesthetic. Occupational exposure may occur by inhalation and/or dermal contact.

5. POTENTIAL FOR HUMAN EXPOSURE

5.2 PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL**5.2.1 Production**

The production of chloroethane in the United States has decreased as the use of leaded gasoline has been regulated. Production has fallen from approximately 247,000 metric tons (1 metric ton=1,000 kg) in 1960, to 69,000 metric tons in 1988, to an estimated volume <45,359 metric tons in 2019 (EPA 2022a; IARC 1991). Data from the EPA Chemical Data Reporting (CDR) database indicates that there are two domestic producers of chloroethane: Nouryon Chemicals LLC and Westlake Chemical Corporation (EPA 2022a). Table 5-1 summarizes Toxics Release Inventory (TRI) information regarding facilities that produced, processed, or used chloroethane in 2023 (TRI23 2024). TRI data should be used with caution since only certain types of industrial facilities are required to report. This is not an exhaustive list.

Table 5-1. Facilities that Produce, Process, or Use Chloroethane

State ^a	Number of facilities	Minimum amount on site in pounds ^b	Maximum amount on site in pounds ^b	Activities and uses ^c
AL	1	0	99	1, 13, 14
AR	1	1,000	9,999	9, 12
IL	1	1,000	9,999	1, 5, 13
KY	1	10,000	99,999	1, 3, 6
LA	17	0	49,999,999	1, 3, 4, 5, 6, 10, 12, 13, 14
MI	2	10,000	999,999	1, 5, 6, 12, 13
NJ	1	1,000	9,999	1, 5
TX	15	100	999,999	1, 3, 5, 6, 9, 10, 12, 13, 14
VA	1	100,000	999,999	6
WV	1	100	999	1, 5

^aPost office state abbreviations used.

^bAmounts on site reported by facilities in each state.

^cActivities/uses:

- | | | |
|----------------------|-----------------------------|--------------------------|
| 1. Produce | 6. Reactant | 11. Manufacture Aid |
| 2. Import | 7. Formulation Component | 12. Ancillary |
| 3. Used Processing | 8. Article Component | 13. Manufacture Impurity |
| 4. Sale/Distribution | 9. Repackaging | 14. Process Impurity |
| 5. Byproduct | 10. Chemical Processing Aid | |

Source: TRI23 2024 (Data are from 2023)

5. POTENTIAL FOR HUMAN EXPOSURE

5.2.2 Import/Export

From 1979 to 1988, the United States exported 8,562–13,868 metric tons, with the maximum occurring in 1986 and the minimum occurring in 1988 (IARC 1991). The recent amounts that were imported or exported by the two entities that manufactured chloroethane from 2016 to 2019 in the CDR were declared as CBI (EPA 2022a).

5.2.3 Use

In the past, the single largest use of chloroethane was in the production of tetraethyl lead. In 1984, 80% of the chloroethane consumed in the United States was used in domestic production of tetraethyl lead (IARC 1991). However, government-mandated reduction in the amount of lead additives used in gasoline in the United States and a shift to the use of unleaded gasoline caused a drastic reduction in the amount of chloroethane required to produce tetraethyl lead (CMR 1982; EPA 1985; IARC 1991). Chloroethane is also used in cleaning solvents and degreasers and in the manufacture of dyes, ethyl cellulose, and other chemicals and pharmaceuticals (Budavari et al. 1996; Fidler et al. 1987; IARC 1991; Morris and Tasto 1979; Parker et al. 1979).

Another primary use for chloroethane is as a local spray anesthetic due to the cooling sensation experienced by the patient during rapid evaporation (IARC 1991). There are documented uses for both clinical use by physicians and for home use as an over-the-counter spray to alleviate pain associated with insect bites and stings and sports injuries. Dermally applied chloroethane is used to reduce pain prior to venous or arterial puncture or cannulation (Fossum et al. 2016; Rao et al. 2019; Rüsçh et al. 2017; Schlieve and Miloro 2015; Selby and Bowles 1995). Other dermal uses include spinal injection (Firdaus et al. 2018; Walsh et al. 2010), botulinum toxin injection (Botox®) (Irkoren et al. 2015; Richards 2009), skin puncture for allergy testing (Waibel and Katial 2005), and during needle electromyography (Moon and Kim 2014).

Chloroethane is used for procedures such as skin biopsy and ear piercing that require short periods of surface anesthesia in a small area (Florentine et al. 1997; Noble 1979). It is also used topically to relieve pain in facial muscles during physical therapy for those suffering from temporomandibular pain and dysfunction syndrome (also known as temporomandibular joint disorder, or TMD) (Marbach 1996) and to reduce the pain associated with dressing changes for negative pressure wound therapy (Tank et al. 2021). Use of chloroethane spray is used to relieve muscle pain associated with exercise (Rui et al. 2017) and

5. POTENTIAL FOR HUMAN EXPOSURE

spastic torticollis (i.e., involuntary, uncontrollable positioning of head due to painful muscle spasm of the neck) (Nibhanipudi 2015), and to prevent pruritus (i.e., severe itching) in skin prick tests without affecting the flare and wheal reactions that are indicative of an allergic response (Gal-Oz et al. 2010, 2015; Waibel and Katial 2005).

Chloroethane is also used as a recreational inhalant, which is an off label and illegal use. It is desired for its narcotic effects (Juliá-Romero et al. 2021; Kuthiah and Er 2019; Pothiawala et al. 2021; Schwark et al. 2022; Senussi and Chalise 2015). The compound is manufactured in pressurized canisters and sold commercially.

5.2.4 Disposal

Chloroethane is listed as a toxic substance under Section 313 of the Emergency Planning and Community Right to Know Act (EPCRA) under Title III of the Superfund Amendments and Reauthorization Act (SARA) (EPA 1998). Disposal of wastes containing chloroethane is controlled by federal regulations (Chapter 7).

In the manufacturing of chlorinated substances such as chloroethane, waste minimization is typically undertaken first and is achieved through adoption of efficient technologies. Wastes and byproducts that are generated are reused as feedstock for other processes whenever possible (Marshall and Pottenger 2016). All chlorinated hydrocarbons, including chloroethane, are susceptible to pyrolysis at high temperatures. Chlorinated byproducts (e.g., chloroethane) from chlorohydrocarbon manufacture may be destroyed by thermal oxidation processes (Marshall and Pottenger 2016). Another disposal process is to catalytically oxidize chloroethane, which introduces oxygen into the compound and produces substances that may be useful for producing consumer goods (Marshall and Pottenger 2016). In a study of the thermal destruction of chloroethane, the minimum temperature required for 99.99% destruction with a 1-second residence time was 727°C (Fisher and Koshland 1990). Among the chlorinated methanes and ethanes studied, chloroethane had the lowest temperature required for destruction. If chloroethane is a constituent of wastewater streams, it may be removed by air stripping (Gould et al. 1983).

5. POTENTIAL FOR HUMAN EXPOSURE

5.3 RELEASES TO THE ENVIRONMENT

The Toxics Release Inventory (TRI) data should be used with caution because only certain types of facilities are required to report (EPA 2022b). This is not an exhaustive list. Manufacturing and processing facilities are required to report information to the TRI only if they employ ≥ 10 full-time employees; if their facility's North American Industry Classification System (NAICS) codes is covered under EPCRA Section 313 or is a federal facility; and if their facility manufactures (defined to include importing) or processes any TRI chemical in excess of 25,000 pounds, or otherwise uses any TRI chemical in excess of 10,000 pounds, in a calendar year (EPA 2022b).

5.3.1 Air

Estimated releases of 187,849 pounds (~85.21 metric tons) of chloroethane to the atmosphere from 41 domestic manufacturing and processing facilities in 2023, accounted for about 94.3% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). These releases are summarized in Table 5-2.

Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use Chloroethane^a

State ^c	RF ^d	Reported amounts released in pounds per year ^b						Total release		
		Air ^e	Water ^f	UI ^g	Land ^h	Other ⁱ	On-site ^j	Off-site ^k	On- and off-site	
AL	1	2,292	0	0	0	0	2,292	0	2,292	
AR	1	0.2	0	0	0	0	0.2	0	0.2	
IL	1	101	0	0	0	0	101	0	101	
KY	1	135	0	0	0	0	135	0	135	
LA	17	79,153	30	0	45	0	79,183	45	79,228	
MI	2	5,355	120	0	0	0	5,475	0	5,475	
NJ	1	9,501	1	0	0	0	9,502	0	9,502	
TX	15	42,486	11,011	0	11	0	42,561	10,947	53,508	
VA	1	47,398	3	0	0	0	47,398	3	47,401	

5. POTENTIAL FOR HUMAN EXPOSURE

Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use Chloroethane^a

State ^c	RF ^d	Reported amounts released in pounds per year ^b							Total release	
		Air ^e	Water ^f	UI ^g	Land ^h	Other ⁱ	On-site ^j	Off-site ^k	On- and off-site	
WV	1	1,427	90	0	0	0	1,517	0	1,517	
Total	41	187,849	11,255	0	56	0	188,165	10,996	199,160	

^aThe TRI data should be used with caution since only certain types of facilities are required to report. This is not an exhaustive list. Data are rounded to nearest whole number.

^bData in TRI are maximum amounts released by each facility.

^cPost office state abbreviations are used.

^dNumber of reporting facilities.

^eThe sum of fugitive and point source releases are included in releases to air by a given facility.

^fSurface water discharges, wastewater treatment (metals only), and publicly owned treatment works (POTWs) (metal and metal compounds).

^gClass I wells, Class II-V wells, and underground injection.

^hResource Conservation and Recovery Act (RCRA) subtitle C landfills; other onsite landfills, land treatment, surface impoundments, other land disposal, other landfills.

ⁱStorage only, solidification/stabilization (metals only), other off-site management, transfers to waste broker for disposal, unknown.

^jThe sum of all releases of the chemical to air, land, water, and underground injection wells.

^kTotal amount of chemical transferred off-site, including to POTWs.

RF = reporting facilities; UI = underground injection

Source: TRI23 2024 (Data are from 2023)

Chloroethane may be released to the environment through process and fugitive emissions related to its production and use as a chemical intermediate; evaporative losses from waste-water streams, landfills, solvents, and anesthetics; and emissions from combustion of plastics, refuse, and biomass (EPA 1977, 2023a; Graedel et al. 1986; Vogt and Walsh 1985; Young and Parker 1984).

EPA's National Emission Inventory (NEI) database contains information regarding sources that emit criteria air pollutants (CAPs) and their precursors, and hazardous air pollutants (HAPs) for the 50 United States, Washington DC, Puerto Rico, and the U.S. Virgin Islands. Emissions are estimated from multiple sources, including state and local environmental agencies, the TRI database, computer models for on- and off-road emissions, and databases related to EPA's Maximum Achievable Control Technology (MACT) programs to reduce emissions of HAPs. Chloroethane emissions estimated from the 2017 inventory are summarized in Table 5-3.

5. POTENTIAL FOR HUMAN EXPOSURE

Table 5-3. Pounds of Chloroethane Emitted by Sector

Emission sector	Pounds of chloroethane emitted
Agriculture; livestock waste	520,626.10
Fuel combustion; commercial/institutional; coal	52.92
Fuel combustion; commercial/institutional; other	56.16
Fuel combustion; electric generation; biomass	17,821.72
Fuel combustion; electric generation; coal	9,855.79
Fuel combustion; electric generation; natural gas	28.84
Fuel combustion; electric generation; other	256.30
Fuel combustion; industrial boilers, internal combustion engines; biomass	1.25
Fuel combustion; industrial boilers, internal combustion engines; coal	406.28
Fuel combustion; industrial boilers, internal combustion engines; natural gas	3,585.09
Fuel combustion; industrial boilers, internal combustion engines; other	278.33
Industrial processes; cement manufacturing	213.52
Industrial processes; chemical manufacturing	85,707.71
Industrial processes; ferrous metals	88.93
Industrial processes; non-ferrous metals	2,028.93
Industrial processes; not elsewhere classified	39,176.00
Industrial processes; oil and gas production	81.27
Industrial processes; petroleum refineries	40.80
Industrial processes; pulp and paper	60.26
Industrial processes; storage and transfer	250.43
Miscellaneous; bulk gasoline terminals	1.16
Miscellaneous; gas stations	1.25
Miscellaneous; waste disposal	33,968.25
Solvent; industrial surface coating and use	75,374.00
Solvent; degreasing	52.00

Source: EPA 2023a

5.3.2 Water

Estimated releases of 11,255 pounds (~5.11 metric tons) of chloroethane to surface water from 41 domestic manufacturing and processing facilities in 2023, accounted for 5.6% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). This estimate includes releases to wastewater treatment and publicly owned treatment works (POTWs) (TRI23 2024). These releases are summarized in Table 5-2.

5. POTENTIAL FOR HUMAN EXPOSURE

Limited data are available regarding the release of chloroethane to water. This compound may be released to the environment as a constituent of wastewater streams from various industries, particularly those that use chloroethane as an intermediate. There are multiple potential emission sources of chloroethane, as indicated in Table 5-3 (EPA 2023a). It is possible that chloroethane forms in some wastewater streams from chlorination (EPA 1977; Gould et al. 1983; Otson 1987). The majority of chloroethane released to surface water is expected to volatilize to the atmosphere. This compound can leach into groundwater from waste disposal sites, and it may form in groundwater as an anaerobic biodegradation product of chlorinated solvents (e.g., 1,1,1-trichloroethane and cis-1,1-dichloroethylene) (Barrio-Lage et al. 1986; Vogel and McCarty 1987).

5.3.3 Soil

Estimated releases of 56 pounds (~0.025 metric tons) of chloroethane to soil from 41 domestic manufacturing and processing facilities in 2023, accounted for <1% of the estimated total environmental releases from facilities required to report to the TRI (TRI23 2024). These releases are summarized in Table 5-2.

Chloroethane can occur in soil from the disposal of waste products that contain this compound and from formation as an anaerobic biodegradation product of various chlorinated compounds (e.g., 1,1,1-trichloroethane and cis-1,2-dichloroethylene) (Barrio-Lage et al. 1986; Vogel and McCarty 1987).

5.4 ENVIRONMENTAL FATE

5.4.1 Transport and Partitioning

Air. The relatively high water solubility of chloroethane suggests that potential exists for removal of this compound from the atmosphere via washout. However, most chloroethane removed by this mechanism is likely to reenter the atmosphere by volatilization.

Water. The dominant removal process for chloroethane in surface water is expected to be volatilization. Based on a measured Henry's law constant of 1.11×10^{-2} atm-m³/mole at 24.8°C, the volatilization half-life of chloroethane from a model river 1 m deep, flowing 1 m/second with a wind speed of 3 m/second was estimated to be 2.4 hours (Gossett 1987; Thomas 1982).

5. POTENTIAL FOR HUMAN EXPOSURE

Bioconcentration factors (BCF) of 7 and 5 have been estimated for chloroethane using linear regression equations based on a log of the octanol-water partition coefficient (K_{ow}) of 1.43 and a water solubility of 5,678 mg/L at 20°C, respectively (Bysshe 1982; Horvath 1982; NLM 2023). These BCF values indicate that this compound would not bioconcentrate significantly in aquatic organisms.

Adsorption coefficients (K_{oc}) of 143 and 33 were estimated for chloroethane using linear regression equations based on log K_{ow} and water solubility data, respectively (Lyman 1982). These values suggest that adsorption of chloroethane to suspended solids and sediments in water would not be a significant fate process.

Sediment and Soil. The likely insignificant sorption of chloroethane to soil, indicated by the relatively low K_{oc} value for the compound, suggests that it would be highly mobile in soil and might undergo significant leaching (Swann et al. 1983). The relatively high vapor pressure of chloroethane and its volatility from water suggest that it would evaporate rapidly from soil surfaces, and that volatilization would probably be a major removal process. The calculated value of K_{oc} , 0.347 at 17.5°C (Washington 1996), indicates that chloroethane in soil has a propensity to become dissolved in soil water and will then enter soil gas. The concentrations of chloroethane in soil water and the vapor phase will approach equilibrium.

5.4.2 Transformation and Degradation

Air. The dominant atmospheric removal process for chloroethane is predicted to be removal by reaction with photochemically-generated hydroxyl radicals in the troposphere. This will proceed via hydrogen abstraction; other atmospheric oxidants such as nitrate radicals and ozone will not have a significant role in the atmospheric oxidation of chloroethane (Atkinson 1985; Howard and Evenson 1976).

The half-life for this reaction has been estimated to be 40 days based on a reaction rate constant of 4.0×10^{-13} m³/molecule-second at 25°C and a typical hydroxyl radical concentration of 5.0×10^5 molecules/m³ (Atkinson 1985; Howard and Evenson 1976). This tropospheric half-life suggests that <1% of the chloroethane released to the atmosphere would diffuse into the stratosphere, where it would be destroyed by photolysis (EPA 1979). Chloroethane is not expected to photolyze in the atmosphere below the ozone layer since it contains no chromophores that absorb light in the visible part

5. POTENTIAL FOR HUMAN EXPOSURE

of the spectrum (wavelengths about 300–700 nm) (EPA 1982; Hubrich and Stuhl 1980; Jaffe and Orchin 1962).

Water. Chloroethane is susceptible to slow chemical hydrolysis and forms ethanol and hydrochloric acid as reaction products. The hydrochloric acid formed dissociates at the neutral pH of most natural waters and forms a chloride salt.

The hydrolytic half-life of chloroethane is not known with certainty. The hydrolytic half-life in water at 25°C and pH 7 was estimated to be 38 days based on a reaction rate constant extrapolated from experimental data at 100°C (Laughton and Robertson 1959; Mabey and Mill 1978).

An anaerobic dehalogenation study of 1,1,1-trichloroethane studied the formation of chloroethane as a degradation byproduct of this reaction (Vogel and McCarty 1987). The study found that chloroethane degradation rates were similar in biologically active samples and controls; based on this, the study authors concluded that abiotic hydrolysis was the primary mechanism of degradation for chloroethane. The data for the rate of decrease in chloroethane were used to estimate a pseudo first-order hydrolysis rate constant of approximately 0.37 years^{-1} , corresponding to a half-life of approximately 1.9 years, which is considerably longer than the value estimated by Mabey and Mill (1978).

In another study conducted by Jeffers and Wolfe (1996), the hydrolysis of chloroethane in 0.01 M hydrochloric acid (assumed to be the same rate constant under neutral conditions) and 0.01 M NaOH at 25°C was determined. The reaction in 0.01 M hydrochloric acid at 25°C was found to predominate, with a rate constant of 5.1×10^{-7} , resulting in an estimated half-life for chloroethane of 2.6 years. Although studies (above) report conflicting data, chemical hydrolysis may be an important fate process in groundwater when losses from other degradation and transport processes are expected to be negligible.

The high volatility of chloroethane indicates that this compound will volatilize from groundwater and enter soil as a gas. In addition, chloroethane is susceptible to biodegradation in groundwater and other media. Vogel and McCarty (1987) have shown that chloroethane, formed by the anaerobic biodegradation of trichloroethylene in a batch fermenter, was further dechlorinated by methanogenic bacteria. This study, however, provided no rate constant for this reaction that could be compared to the rate for hydrolysis.

5. POTENTIAL FOR HUMAN EXPOSURE

Oxidation of chloroethane in water via reaction with singlet oxygen or peroxy radicals is too slow to be environmentally relevant (EPA 1982). Direct photolysis in surface waters is not expected to be an environmentally relevant fate process due to lack of absorption in the environmental UV spectrum (EPA 1982).

Sediment and Soil. In moist subsurface soils, chloroethane is expected to be susceptible to chemical hydrolysis. However, this pathway is expected to be slow, and other fate and transport processes may predominate. A large body of data exists on the biodegradation of chlorinated alkenes and alkanes under anaerobic or aerobic conditions. Most of these data, however, deal with polychlorinated compounds that are biodegraded to chloroethane or a structurally similar alkane or alkene (Ahlert and Enzminger 1992; Barrio-Lage et al. 1986; Chang and Alvarez-Cohen 1996; Tabak et al. 1981; Vogel and McCarty 1987).

Chloroethane can undergo reductive dehalogenation by methanogenic bacteria in an anaerobic cell suspension or packed column environment (Baek et al. 1990; Holliger et al. 1992). Ethane and hydrochloric acid are formed by the reductive dechlorination of chloroethane (Holliger et al. 1992). In addition, chloroethane can be oxidized by aerobic nitrifying bacteria (Rasche et al. 1990). Both acetaldehyde and 2-chloroethanol are produced from the oxidation of chloroethane, with acetaldehyde predominating at >98% of the total product (Rasche et al. 1990).

Although these studies provided maximum product formation rates, first-order rate constants were not estimated; therefore, no comparisons could be made to determine which biodegradation pathway would more rapidly clear chloroethane from a contaminated environment. The pathways do not directly compete, because they occur in different environments: one in an oxygen-deficient environment and the other in an oxygen-rich environment. For example, methanogenic environments are found at landfills and deep aquifers high in nutrient rich organic compounds. Denitrifying environments are common to agricultural land use as well as areas that have onsite wastewater treatment systems (Ahlert and Enzminger 1992).

Further, optimal biodegradation of chloroethane in aquifers or saturated sediments or soils is highly dependent on the presence of appropriate metabolizing bacteria, migration of the contaminant to the bacteria, and availability and concentration of necessary reactants such as carbon sources, reducers, and/or oxidizers. While laboratory studies indicate that biodegradation can be a significant pathway for clearance of chloroethane and other contaminants from affected media, the importance of this pathway in the environment is still unknown.

5. POTENTIAL FOR HUMAN EXPOSURE

Nitrifying activity was stimulated to study co-oxidation of monohalogenated hydrocarbons by native populations of ammonia-oxidizing bacteria. These slurries actively degraded chloroethane at maximum rates of 20–30 nmol/mL/hour that could be sustained for approximately 12 hours (Duddleston et al. 2002).

Hommes et al. (1998) examined the influence of soil upon the co-oxidation of a variety of halogenated and nonhalogenated hydrocarbons by *Nitrosomonas europaea*. Small quantities of Willamette silt loam (organic carbon content, 1.8%; cation-exchange capacity, 15 mmol/kg of soil) were suspended with *N. europaea* cells in a soil-slurry-type reaction mixture. The oxidations of ammonia and chloroethane were compared to results for controls in which no soil was added. Raising the ammonium concentration in the reaction mixture from 10 to 50 mM reduced the effects of soil on nitrite production and chloroethane co-oxidation (Hommes et al. 1998).

Other Media. The dechlorinating activity of a methanogenic granular sludge from a methanol-fed upflow anaerobic sludge blanket reactor was investigated with chlorinated ethanes. Findings revealed that this unadapted methanogenic consortium degraded all chloroethanes tested and that reductive hydrogenolysis was an important dechlorinating mechanism (van Eekert et al. 1999).

Wu et al. (2013) found that a *Bacillus* strain capable of degrading chloroethane grew more readily when at a pH value of 7.0, the immobilized microorganism ratio was at 5%, and the temperature was maintained at 30°C.

5.5 LEVELS IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to chloroethane depends, in part, on the reliability of supporting analytical data from environmental samples and biological specimens. Concentrations of chloroethane in unpolluted atmospheres and in pristine surface waters are often so low as to be near the limits of current analytical methods. In reviewing data on chloroethane levels monitored or estimated in the environment, it should also be noted that the amount of chemical identified analytically is not necessarily equivalent to the amount that is bioavailable.

5. POTENTIAL FOR HUMAN EXPOSURE

Table 5-4 shows the lowest limit of detections that are achieved by analytical analysis in environmental media. An overview summary of the range of concentrations detected in environmental media is presented in Table 5-5.

Table 5-4. Lowest Limit of Detection Based on Standards^a

Media	Detection limit	Reference
Air	0.01 ppbv	EPA 2023c
Drinking water	0.008 ppb	EPA 1986a
Surface water and groundwater	0.008 ppb	EPA 1986a
Soil	24 ppm	EMMI 1997

^aDetection limits based on using appropriate preparation and analytics. These limits may not be possible in all situations.

ppbv = parts per billion based on volume

Table 5-5. Summary of Environmental Levels of Chloroethane

Media	Low	High	For more information
Outdoor air (ppbv)	0.016	1.42	Section 5.5.1
Indoor air (ppbv)	0.76	1.08	Section 5.5.1
Drinking water (ppb)	0.10	228	Section 5.5.2

ppbv = parts per billion based on volume

Detections of chloroethane in air, water, and soil at NPL sites are summarized in Table 5-6.

Table 5-6. Chloroethane Levels in Water, Soil, and Air of National Priorities List (NPL) Sites

Medium	Median ^a	Geometric mean ^a	Geometric standard deviation ^a	Number of quantitative measurements	NPL sites
Water (ppb)	23	34.8	10.1	116	78
Soil (ppb)	48	45.6	6.94	15	14
Air (ppbv)	0.330	0.399	3.76	7	7

^aConcentrations found in ATSDR site documents from 1981 to 2022 for 1,868 NPL sites (ATSDR 2022a). Maximum concentrations were abstracted for types of environmental media for which exposure is likely. Pathways do not necessarily involve exposure or levels of concern.

ppbv = parts per billion based on volume

5. POTENTIAL FOR HUMAN EXPOSURE

5.5.1 Air

Chloroethane is a pollutant monitored for in the national Air Quality System (AQS) database, which contains ambient air pollution data collected by EPA, state, local, and tribal air pollution control agencies from monitors throughout the country. Table 5-7 shows the yearly mean 24-hour ambient air concentrations of chloroethane at monitoring stations across the United States.

Table 5-7. Summary of Annual Concentration of Chloroethane (ppbv) Measured in Ambient Air at Locations Across the United States^{a,b}

Year	Number of sites	Mean of all detections for all locations	Maximum concentration
2018	83	0.022	1.19
2019	85	0.016	0.19
2020	88	0.031	0.45
2021	139	0.076	1.42
2022 ^c	65	0.048	0.63

^aValues were originally reported in parts per billion carbon (ppbC) and converted to ppbv.

^b24-hour sampling period.

^cAs of January 23, 2023.

Source: EPA 2023b

Current ambient levels of chloroethane are markedly lower than levels found during the mid-1970s and early 1980s because of a substantial decrease in the production of chloroethane in the United States and a phaseout of leaded gasoline. Monitoring data from the early 1980s indicated that levels of chloroethane in ambient air at various urban/suburban locations in the United States had maximum and minimum values of 10 and 1,248 pptv, respectively. The average concentrations ranged from 41 to 140 pptv (EPA 1981; Shepson et al. 1987). Marine air samples collected in the Northern Hemisphere during 1981 contained an average concentration of 19 pptv (Singh et al. 1983). Rural air samples collected in 1974–1975 in the northwest United States contained <5 pptv chloroethane (Grimsrud and Rasmussen 1975).

Chloroethane was detected in the air samples of landfill gas collected from a municipal/industrial landfill in the United Kingdom and a municipal landfill simulator (Vogt and Walsh 1985; Young and Parker 1984). These data indicate that chloroethane may be found in the air above some landfills. However, sufficient data are not available to determine whether elevated levels of chloroethane typically occur at, or in the vicinity of, waste disposal sites. Chloroethane was detected in indoor air of a newspaper printing operation at 0.76 ppbv (760 pptv) and a small facility that printed scientific material at 1.08 ppbv

5. POTENTIAL FOR HUMAN EXPOSURE

(1,080 pptv) (Alabdulhadi et al. 2019). Due to concerns regarding vapor intrusion due to nearby groundwater contamination, indoor air levels of chloroethane were estimated during health consultations of residential buildings in New Hampshire and Arizona (ATSDR 2005a, 2007). The average estimated chloroethane indoor air levels were 0.65 ppbv and $0.08 \mu\text{g}/\text{m}^3$ (0.03 ppbv), respectively.

Barletta et al. (2009) identified chloroethane among a suite of tracer gases (OCS, CH_3Cl , 1,2-dichloroethane, ethyl chloride, and Halon-1211) that scientists can use to trace contaminants originating in China to determine if they might be moving with wind currents into the United States, becoming a source of U.S. population exposure.

5.5.2 Water

The Water Quality Portal (WQP) is a source of discrete water-quality data in the United States and beyond. This cooperative service integrates publicly available water-quality data from the United States Geological Survey (USGS), EPA, and over 400 state, federal, tribal, and local agencies. Analysis of compiled data from the WQP that spans 4 decades (1981–2023) indicates that chloroethane is not a common surface water pollutant. Of 144,292 samples analyzed, chloroethane was detected in 19,166 (0.13% of samples). Of those 19,166 samples, only 1,060 had values $>10 \mu\text{g}/\text{L}$, with a median value of $2.5 \mu\text{g}/\text{L}$ (WQP 2023).

Chloroethane was monitored as part of the Unregulated Contaminant Monitoring Rule from 1988 to 1997 (UCMR Round 1 monitoring data). This program collects data for contaminants suspected to be present in drinking water, but that do not have health-based standards set under the Safe Drinking Water Act (SDWA). Chloroethane was subsequently regulated under the SDWA. Chloroethane was monitored in 39,180 public water systems (PWS) and was detected above its reporting level (0.10 ppb) in 0.004% of the PWS (EPA 2001). The maximum observed level was reported as 288 ppb and the mean value of all detections was 5.34 ppb.

USGS (2006) reported that chloroethane was detected at a concentration $>0.2 \mu\text{g}/\text{L}$ in 0.29% of groundwater samples from aquifer studies (1,710–3,498 samples), 0.083% of domestic water-supply wells (1,190–1,208 samples), 0.28% of public water-supply wells (828–1,096 samples), and 6.3% of statewide groundwater samples (1,305–4,086 samples) in Wisconsin. ATSDR (2005b, 2005c, 2005d, 2008a, 2008b) has reported chloroethane levels in groundwater samples ranging from 0.1 to $50 \mu\text{g}/\text{L}$ during health consultations and public health assessments conducted across the United States.

5. POTENTIAL FOR HUMAN EXPOSURE

Chloroethane contamination of groundwater has occurred at U.S. Department of Defense facilities (USGS 2006) and various waste disposal sites throughout the United States (ATSDR 1989, 1991; Cline and Viste 1985; EPA 1986b, 1986c; Myers 1983; Sabel and Clark 1984).

5.5.3 Sediment and Soil

No recent data were located regarding levels of chloroethane in sediment and soil. In a 1982 survey of U.S. wastewater treatment plants receiving both municipal and industrial waste streams, chloroethane was found in undigested sewage sludge from 2 of 13 plants at concentrations ranging from 14.5 to 24 mg/kg dry weight. Assuming that the sludge was disposed of by land application, the application rate of chloroethane to soil was projected to be 0.16–0.17 kg/hectare (dry weight) and the resulting concentration of chloroethane in the top 15 cm of soil was predicted to be 0.08–0.085 mg/kg (Naylor and Loehr 1982).

5.5.4 Other Media

Few reports are available concerning the identification of chloroethane in other media. Chloroethane at a mean concentration of 7.6 ng/g was found in oysters collected from Lake Pontchartrain, Louisiana (Ferrario et al. 1985).

5.6 GENERAL POPULATION EXPOSURE

Limited data indicate that the general population is exposed to chloroethane by inhalation of contaminated air and ingestion of contaminated drinking water (EPA 2023b; WQP 2023). Medical use of chloroethane as a topical anesthetic, results in direct dermal exposure of the general population to this compound (Gal-Oz et al. 2010, 2015; Nibhanipudi 2015; Rui et al. 2017; Tank et al. 2021; Waibel and Katial 2005). Chloroethane blood level measurements were added to the NHANES study in 2013. Blood levels above the limit of detection (i.e., 0.045 ng/mL) were <0.1%, with a maximum blood concentration reported as 0.617 ng/mL (CDC 2017, 2018, 2020). Data from the NHANES 2013–2018 survey showed that chloroethane was below the detection limits of 0.045 ng/mL for the 50th, 75th, 90th, and 95th percentiles of blood samples for all age and demographic groups considered in the survey (CDC 2024).

ATSDR's three-compartment Shower and Household-Use Exposure (SHOWER) model predicts air concentrations in the shower stall, bathroom, and main house throughout the day by estimating the contribution from showering or bathing and the contribution from other water sources in the house, such

5. POTENTIAL FOR HUMAN EXPOSURE

as the dishwasher, clothes washer, and faucets. This information, along with human activity patterns, is used to calculate a daily time-weighted average exposure concentration via inhalation exposure and from dermal uptake from skin contact. ATSDR's SHOWER model is available by sending a request to showermodel@cdc.gov. Using median treated water levels as discussed in Section 5.5.2 (2.5 µg/L, based on WQP data; WQP 2023) and representative outdoor air levels discussed in Section 5.5.1 (0.048 µg/L based on AQS; EPA 2023b) Reasonable Maximum Exposure levels for chloroethane were calculated for different exposure groups (Table 5-8).

Table 5-8. Reasonable Maximum Exposure Inhalation Daily Exposure Concentration and Administered Dermal Dose of Chloroethane for the Target Person

Exposure group	Inhalation (µg/m ³)	Dermal (µg/kg/day)
Birth-<1 year	5.3	0.0056
1-<2 years	5.3	0.0052
2-<6 years	5.3	0.0044
6-<11 years	5.3	0.0036
11-<16 years	5.3	0.0029
16-<21 years	5.3	0.0027
Adults	5.3	0.0026
Pregnant and breastfeeding women	5.3	0.0027

Source: ATSDR 2022b

Vapor intrusion may be a potential source of chloroethane exposure, although indoor and ambient sources may also contribute to indoor air levels. The EPA (2016) includes chloroethane in its Vapor Intrusion Screening Levels (VISL) Calculator, indicating that it is sufficiently volatile and sufficiently toxic to be considered a concern for vapor intrusion from soil and groundwater. A review of vapor intrusion data from ATSDR public health assessments identified two sites with chloroethane detected in indoor air at concentrations ranging from 0.08 µg/m³ (0.03 ppbv) to 0.65 ppbv (ATSDR 2005a, 2007). Accordingly, ATSDR (2016) recommends that health assessors should evaluate potential health implications of vapor intrusion for chloroethane during site risk assessments.

5.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Occupational workers who come into contact with chloroethane are expected to have higher exposure levels than the general population. Workers may be exposed to chloroethane by inhalation and/or dermal exposure. There are two chemical companies producing chloroethane in the United States according to

5. POTENTIAL FOR HUMAN EXPOSURE

the Chemical Data Reporting system (EPA 2022a). The number of workers at the manufacturing locations in Cook County, Illinois and Harris County, Texas were not reported. In addition, workers from the 41 domestic manufacturing and processing facilities that utilize chloroethane may potentially be exposed to chloroethane (TRI23 2024).

Emissions data suggest that workers in the following industries may be exposed to chloroethane: chemical manufacturing, cement manufacturing, pulp and paper, oil and gas production, petroleum refining, waste disposal, and agriculture (EPA 2023a). Since chloroethane is used in cleaning solvents and degreasers, plumbers, pipe fitters, and automotive mechanics can be exposed (Fidler et al. 1987; Parker et al. 1979). Persons working in the printing industry may have a greater potential for high exposures than the general population, as volatile organic compounds (VOCs), including chloroethane, may be used in these industries. Alabdulhadi et al. (2019) detected chloroethane levels ranging from 0.76 to 1.08 ppbv in the air of a scientific literature printing facility and a newspaper printing operation. Chloroethane is increasingly used as a blowing agent for the manufacturing of foam plastic; workers in these industries have increased potential for exposure (Matsunaga et al. 1976). Medical personnel who use chloroethane to anaesthetize the skin, or people who self-administer chloroethane for muscle or joint pain may also have a higher potential for exposure than the general population.

People who intentionally misuse chloroethane for recreational purposes typically spray it on a piece of cloth and then inhale the substance (Schwark et al. 2022). Chloroethane misuse may result in severe health effects such as slurred speech, dizziness, difficulty walking, cardiac arrhythmias, respiratory paralysis, and death. Nonfatal effects are generally reversible following cessation of exposure (Demarest et al. 2011; Hes et al. 1979; Pothiwala et al. 2021; Schwark et al. 2022; Senussi and Chalise 2015).