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5.1 OVERVIEW

1,2-Dichloroethene is a compound produced by human industrial activities. Sources of environmental exposure to 1,2-dichloroethene include: process and fugitive emissions from its production and use as a chemical intermediate; evaporation from waste water streams, landfills, and solvents; emissions from combustion or heating of polyvinyl chloride and some vinyl copolymers; formation via anaerobic biodegradation of some chlorinated solvents; and leaching from landfills. Most of the l,2dichloroethene released in the environment will eventually enter the atmosphere or groundwater, where it may be subject to further biotic or abiotic degradation processes.

1 ,2-Dichloroethene is removed from the atmosphere chiefly through reaction with photochemically-generated oxygenated species (e.g., hydroxyl radicals). The estimated atmospheric lifetimes for cis- and trans-1,2-dichloroethene due to this removal process are 12 and 5 days, respectively (Goodman et al. 1986). Precipitation may also remove it; however, most 1,2-dichloroethene thus removed will probably reenter the atmosphere by volatilization. When released to surface water, volatilization is expected to be the primary fate process, with an estimated half-life of about 3-6 hours in a model river (Thomas 1982). When released to soil, 1,2-dichloroethene volatilizes rapidly from moist soil surfaces and leaches through subsurface soil, where it could become a groundwater contaminant. In groundwater, 1,2-dichloroethene is susceptible to anaerobic biodegradation. Experimental data indicate that the anaerobic biodegradation half-life of 1,2-dichloroethene is about 13-48 weeks (Barrio-Lage et al. 1986). Aerobic or facultative biodegradation processes have also been documented (Vannelli et al. 1990). Since 1,2-dichloroethene will often be found in mixtures with other chlorinated solvents, half-lives for degradation processes can be estimated only approximately.

The general population may be exposed to low levels (0.013-0.076 ppb) of 1,2-dichloroethene through inhalation of contaminated air in urban areas (EPA 1983a). These exposure levels correspond to an average daily intake of l-6 μg/day assuming an average daily intake of 20 m^3 of air. Additional exposure may occur from contaminated tap water, through consumption, inhalation during showering, and dermal contact. Occupational exposure may occur by inhalation and/or dermal contact. According to a 1981-1983 NIOSH survey, an estimated 215 workers in the United States are

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potentially exposed to 1,2-dichloroethene in the workplace (NIOSH 1988). This figure does not include firefighters and landfill workers.

Cis-1,2-dichloroethene has been identified in at least 146 of the 1,430 current or former EPA National Priorities List (NPL) hazardous waste sites and trans-1,2-dichloroethene has been identified in at least 563 of the current or former NPL sites. In 336 of the NPL sites, 1,2-dichloroethene was identified but the isomer was not specified (HazDat 1996). However, the number of sites evaluated for 1,2-dichloro-ethene is not known. The frequency of these sites can be seen in Figures 5-1, 5-2, and 5-3, for cis, trans, and unspecified, respectively. Two of the sites where trans-1,2-dichloroethene was found are located in the Commonwealth of Puerto Rico (not shown) and all other sites are located in the United States.
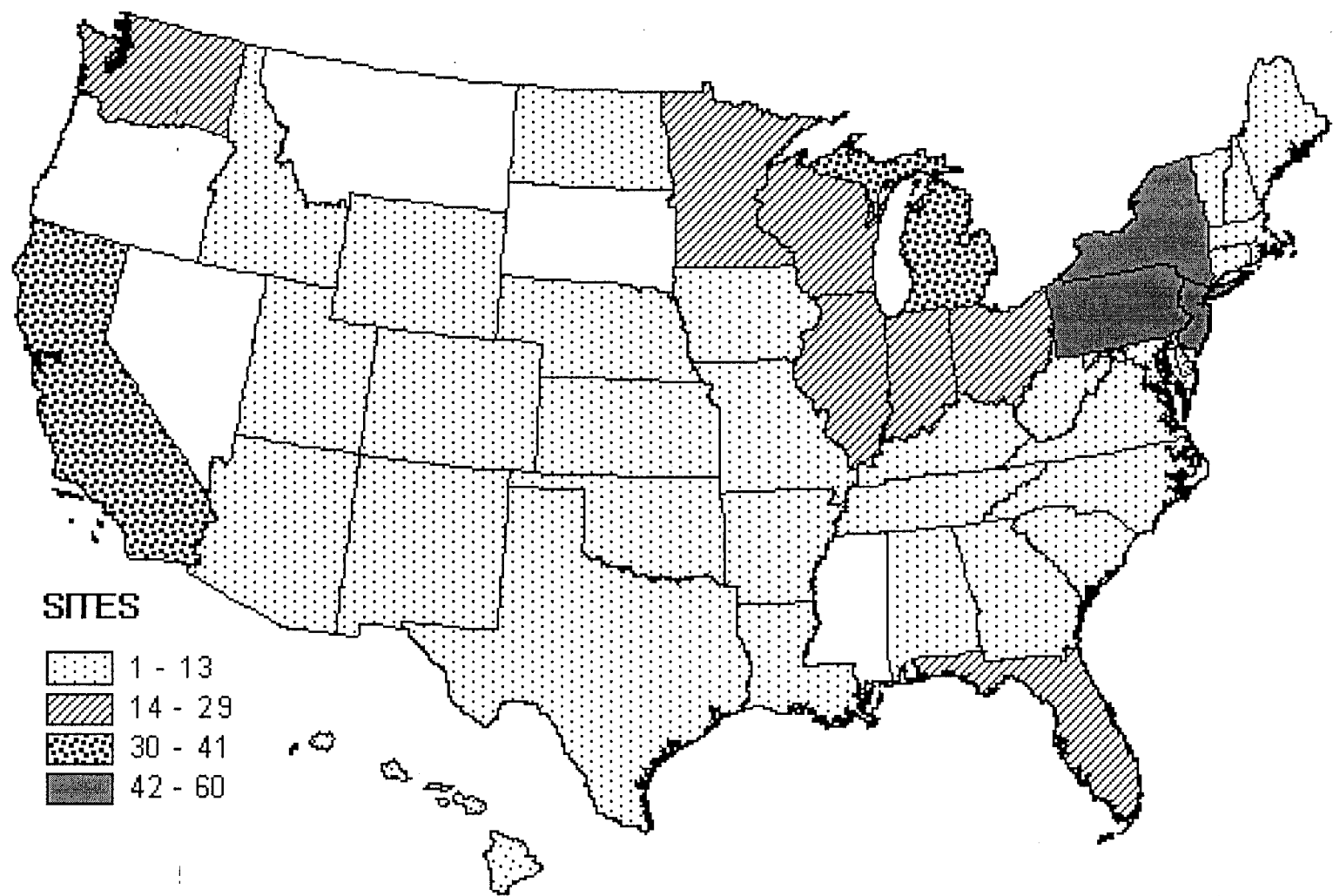
5.2 RELEASES TO THE ENVIRONMENT

5.2.1 Air

1,2Dichloroethene may be released to the atmosphere in emissions from production facilities, contaminated waste waters, contaminated waste disposal sites, and the pyrolysis and combustion of polyvinyl chloride and some vinyl copolymers. It may also be released during its use as a solvent and extractant, in organic synthesis, and in the manufacture of perfumes, lacquers, and thermoplastics. (HSDB 1995; Michal 1976; Shen 1982b). Not enough data are currently available to estimate the total amount of 1,2-dichloroethene released to the atmosphere.

According to the Toxics Release Inventory (TRI), an estimated total of 29,478 pounds of 1,2-dichloro-ethene representing >99.9% of the total environmental release was discharged to air from manufacturing and processing facilities in the United States in 1993 (TR193 1995). Table 5-l lists the amounts released from each of these identified facilities. The TRI data should be used with caution since only certain types of facilities are required to report. Therefore, this is not an exhaustive list.

There is a potential for atmospheric release of 1,2-dichloroethene from hazardous waste sites. Cis-1,2-dichloroethene has been detected in air samples from 3 of the 146 NPL sites where cis-1,2-dichloroethene has been identified in some medium (HazDat 1996). Tram+1,2-dichloroethene

Figure 5-1. Frequency of Sites with cis-1,2-Dichloroethene Contamination

SITES

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20

Derived from HazDat 1996

Figure 5-2. Frequency of Sites with trans-1,2-Dichloroethene Contamination

SITES

1 - 13
14 - 29
30 - 41
42 - 60

Derived from HazDat 1996

Figure 5-3. Frequency of Sites with 1,2-Dichloroethene (Unspecified) Contamination

SITES

- 1 - 7
- 8 - 15
- 16 - 23
- 24 - 31
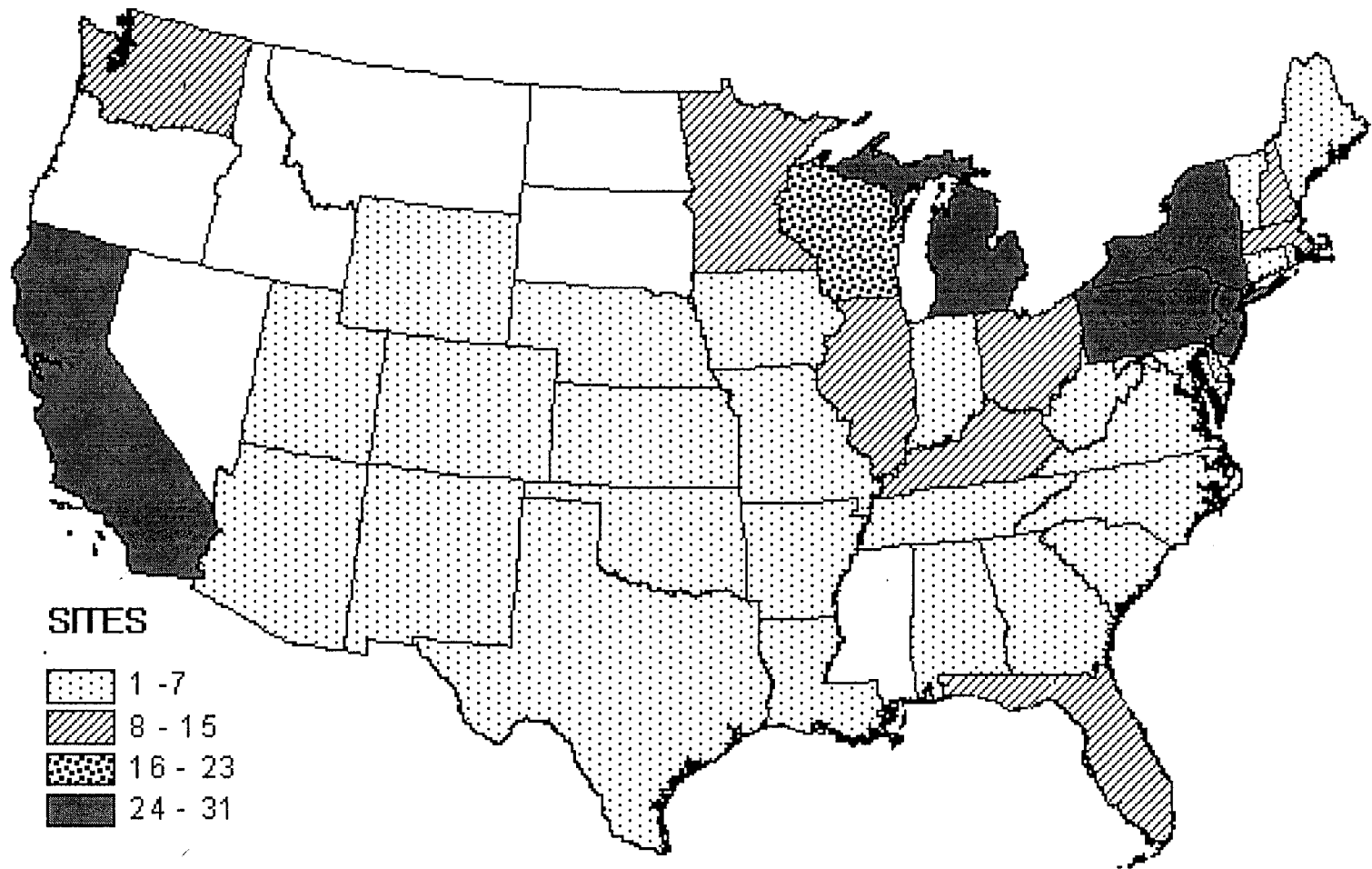
Derived from HazDat 1996

Table 5-1. Releases to the Environment from Facilities That Manufacture or Process 1,2-Dichloroethene

State[a]	City	Facility	Reported amounts released in pounds per year						
			Air	Water	Land	Underground injection	Total environment[b]	POTW transfer	Off-site waste transfer
KS	WICHITA	VULCAN CHEMICALS	385				385		
KY	CALVERT CITY	WESTLAKE MONOMERS CORP.	40				40		2,110
LA	GEISMAR	VULCAN MATERIALS CO.	970	8			978		500
LA	LAKE CHARLES	PPG IND. INC.	19,900	3			19,903		11
LA	NA	NA							2
LA	NA	NA	1,528				1,528		
LA	NA	DOW CHEMICAL CO.		12			12		
TX	FREEPORT	DOW CHEMICAL CO.	4,808	5			4,813		
TX	LA PORTE	GEON CO.	44				44		
TX	NA	OCCIDENTAL PETROLEUM CORP.							
TX	NA	OCCIDENTAL PETROLEUM CORP.	190				190		
TX	TEXAS CITY	UNION CARBIDE CORP.	1,613				1,613		
		Totals	29,478	28			29,506		2,623

Source: TRI93 1995

[a] Post office state abbreviations used
[b] The sum of all releases of the chemical to air, land, water, and underground injection wells by a given facility

NA = not available; POTW = publicly owned treatment works

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has been detected in air samples from 17 of the 563 NPL sites where trans-1,2-dichloroethene has been identified in some medium (HazDat 1996). 1,2-Dichloroethene (isomer unspecified) has been detected in air samples from 15 of the 336 NPL sites where 1,2-dichloroethene has been identified, without specifying the isomer, in some medium (HazDat 1996).

While there is disagreement in the literature on the persistence of 1,2-dichloroethene released to the atmosphere, the half-lives would likely be measured in days, allowing for transport over large regional or even continental areas (Hall et al. 1989; Winer and Atkinson 1987). However, areas like southern California, where 1,2-dichloroethene is not commonly used as an end product or a chemical intermediate, have not shown detectable levels of 1,2dichloroethene in ambient air.

5.2.2 Water

1,2-Dichloroethene may be released to surface waters via surface runoff from contaminated waste disposal sites, waste water from a variety of industrial sources, and from some publicly owned treatment works (POTWs). 1,2-Dichloroethene may be found in effluents from manufacturing and processing sites and from industries involved in its use as a solvent and extractant, in its use in organic synthesis, and in its use in the manufacture of perfumes, lacquers, and thermoplastics (Hawley 1981). As part of a comprehensive EPA survey of industrial facilities and POTWs, 4,000 samples of waste water were analyzed. The findings indicate that cis- or trans.-1,2-dichloroethene is sometimes found in waste water from: petroleum refining; coal mining; foundries; nonferrous metal manufacture; POTWs; paint and ink formulation; rubber processing; steam electricity generation; leather tanning; iron and steel manufacture; textile mills; auto and other laundries; explosives factories; and production of inorganic chemicals, mechanical products, plastics and synthetics, electrical components and electronics, pharmaceuticals, organic chemicals and plastics, and transportation equipment (EPA 1980b; Shackelford et al. 1983). Effluents from iron, steel, and nonferrous metal manufacturing; and organics, plastics, and rubber processing exceeded 100 ppb of cis-1,2-dichloroethene. Effluents of iron and steel manufacturing, electronics, and POTWs also contained trans- 1,2-dichloroethene (see Section 5.4.2) (Shackelford et al. 1983). It has been estimated that between 1982 and 1984, trans-l,2dichloro-ethene was loaded into the Niagara River at an average of 13.6 pounds per day (Spagnoli 1986). Insufficient data are available to estimate the amount of 1,2-dichloroethene released to other surface waters in the United States.

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During the 1980s as steady progress was made in negotiating final discharge permits for POTWs under EPA's National Pollutant Discharge Elimination System (NPDES) permitting program, the incidence of 1,2-dichloroethene inputs to surface waters from point source discharges may have substantially decreased. Improved levels of waste treatment have the potential to remove virtually all VOCs from final effluents. These materials will become air emissions or become immobilized in sludges (Bennett 1989).

According to TRI93 (TRI93 1995), an estimated total of only 28 pounds of 1,2-dichloroethene, Representing <0.1% of the total environmental release, was discharged to water from manufacturing and processing facilities in the United States in 1993. Table 5-l lists the amounts released to water from each of the identified facilities. The TRI data should be used with caution since only certain types of facilities are required to report; therefore, this is not an exhaustive list.

1,2-Dichloroethene may be released to groundwater as a result of leaching from contaminated waste disposal sites, and by anaerobic degradation of other more highly chlorinated ethenes and ethanes present in groundwater (Cline and Viste 1985; HSDB 1995; Parsons et al. 1984; Smith and Dragun 1984). Barber et al. (1988) reported 280 ppb of 1,2-dichloroethene (isomer unspecified) in groundwater under a sandy rapid infiltration site that had received secondary sewage effluent since 1936.

1,2-Dichloroethene in drinking water may result from raw water source contamination (Otson et al. 1982). There is very little documentation of direct 1,2dichloroethene contamination of groundwater. Research suggests that most 1,2-dichloroethene detections in groundwater involve biodegradation processes related to primary pollution from trichloroethylene (TCE) or tetrachloroethylene (PCE) (see Section 5.3).

In addition to spills or leachates from waste disposal sites, groundwater may be contaminated by cracked sewer interceptors carrying industrial wastes. Especially after rains, substantial loadings may leave the interceptor system through infiltration and inflow (I&I) processes and enter groundwater supplies. Such phenomena have been documented in Europe (Milde et al. 1988) and similar I&I problems are common in most older U.S. cities.

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There is also a potential for release of 1,2-dichloroethene to water from hazardous waste sites. Cis-1,2-dichloroethene has been detected in groundwater samples collected at 130 of the 146 NPL sites, in surface water samples collected at 14 of the 146 NPL sites, and in leachate samples collected at 8 of the 146 NPL sites where cis-1,2-dichloroethene has been identified in some medium (HazDat 1996). Trans-1,2-dichloroethene has been detected in groundwater samples collected at 487 of the 563 NPL sites, in surface water samples collected at 137 of the 563 NPL sites, and in leachate samples collected at 48 of the 563 NPL sites where trans-1,2-dichloroethene has been identified in some medium (HazDat 1996). 1,2-dichloroethene (isomer unspecified) has been detected in groundwater samples collected at 263 of the 336 NPL sites, in surface water samples collected at 57 of the 336 NPL sites, and in leachate samples collected at 29 of the 336 NPL sites where 1,2-dichloroethene (isomer unspecified) has been identified in some medium (HazDat 1996).

5.2.3 Soil

Cis- and trans-1,2-dichloroethene are released to soil from the disposal of waste materials containing these compounds (Barber et al. 1988; Fain et al. 1987). They also may be formed in landfills, aquifers, or sediments as anaerobic biodegradation products of tetrachloroethene, trichloroethene, 1,1,1-trichloroethane, and 1,1,2,2-tetrachloroethane, solvents commonly found in municipal and industrial landfills (Parsons et al. 1984; Smith and Dragun 1984). In muck and sediment microcosms, tetrachloroethylene is converted to 1,2-dichloroethene with a preponderance of the cis isomer (Parsons et al. 1984). Cis-1,2-dichloroethene apparently is the more common isomer found, although it may be mistakenly reported as the trans isomer. Because it is a priority pollutant, the trans isomer is more commonly analyzed for, and the analytical procedures used generally do not distinguish between isomers (Cline and Viste 1995). Insufficient data are available to estimate the amount of 1,2-dichloroethene released to soil.

According to TRI93 (TRI93 1995), no 1,2-dichloroethene was released to land from manufacturing and processing facilities in the United States in 1993. Table 5-l lists the amounts released from these facilities. The TRI data should be used with caution since only certain types of facilities are required to report; therefore, this is not a comprehensive list.

Available information for aquatic sediments is also very limited. Some researchers feel that the subsurface behavior of 1,2-dichloroethene would be similar in groundwater, soils, and sediments (Yeh

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and Kastenberg 1991). Most empirical information, however, derives from groundwater remediation studies, usually involving controlled laboratory microcosm studies. For some highly polluted waterbodies, for instance the Delaware and Raritan Canal, 1,2-dichloroethene detections in the water column probably reflect extensive contamination with chlorinated toxics in the sediments (Granstrom et al. 1984). Analyzing cause-source pathways in such complicated systems can be extremely difficult.

There is also a potential for release of 1,2-dichloroethene to soils and sediments from hazardous waste sites. Cis-1,2-dichloroethene has been detected in soil samples collected at 12 of the 146 NPL sites, in sediment samples collected at 1 of the 146 NPL sites where cis-1,2-dichloroethene has been identified in some medium (HazDat 1996). Trans-1,2-dichloroethene has been detected in soil samples collected at 179 of the 563 NPL sites, in sediment samples collected at 61 of the 563 NPL sites, in sludge samples collected at 14 of the 563 NPL sites where trans-1,2-dichloroethene has been identified in some medium (HazDat 1996). 1,2-Dichloroethene (isomer unspecified) has been detected in soil samples collected at 76 of the 336 NPL sites, in sediment samples collected at 30 of the 336 NPL sites where 1,2-dichloroethene (isomer unspecified) has been identified in some medium (HazDat 1996).

5.3 ENVIRONMENTAL FATE

5.3.1 Transport and Partitioning

Occurrence of 1,2-dichloroethene in rainwater samples (Kawamura and Kaplan 1983) indicates thatthis compound may be removed from the atmosphere by precipitation; however, most of the1,2dichloroethene so removed is likely to reenter the atmosphere by volatilization. Organics with avapor pressure of $>10^{-4}$ mmHg should exist almost entirely in the vapor phase in the atmosphere(Eisenreich et al. 1981). Thus, cis- and trans-1,2-dichloroethene, which have vapor pressures of 215 and 336 mmHg at 25 °C, respectively (Stevens 1979), are not expected to partition from the vapor phase to particulates in the atmosphere. Because it is relatively long-lived in the atmosphere, significant transport from source areas should occur (HSDB 1995).

The dominant removal mechanism for 1,2-dichloroethene in surface waters is volatilization (EPA 1979). Henry's Law constants are 4.08×10^{-3} atm-m^3/mol at 24.8 °C for cis-1,2-dichloroethene and 9.38×10^{-3} atm-m^3/mol at 24.8 °C for trans-1,2-dichloroethene (Gossett 1987). Based on these values, the volatilization half-life from a model river 1 m deep, flowing 1 m/second with a wind speed of

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3 m/second is estimated to be 3 hours, using the method of Thomas (1982). Dilling (1977) experimentally determined that the volatilization half-life in an open beaker containing 1 ppm of test compound at a solution depth of 6.5 cm under continuous stirring (200 rpm) was 19 minutes for the cis isomer and 24 minutes for the trans isomer. These values correspond to volatilization half-lives of 5.0 and 6.2 hours, respectively, from a body of water 1 m deep.

In fish, bioconcentration factors (BCFs) ranging between 5 and 23 have been estimated for the 1,2-dichloroethene isomers using linear regression equations based on log K_{ow}, and water solubility data (Bysshe 1982; Hansch and Leo 1985; Horvath 1982; Lyman et al. 1982). A BCF value of 6 for the fathead minnow (*Pimephales promelas*) was estimated in ASTER (1994) using the method of Veith and Kosian (1983). These estimated BCFs suggest that 1,2-dichloroethene does not bioconcentrate significantly in aquatic organisms. Based on this information, there is little potential for biomagnification within aquatic food chains.

Soil adsorption coefficients (K_{oc}) of 32-49 were estimated for the 1,2-dichloroethene isomers using a linear regression equation based on water solubility data (Lyman 1982) and the structure-activity relationship developed by Sabljic (1984). These K_{oc} values suggest that adsorption of the 1,2-dichloroethene isomers to soil, sediment, and suspended solids in water is not a significant fate process. Without significant adsorption to soil, 1,2-dichloroethene can leach into groundwater where very slow biodegradation should occur (HSDB 1995). The presence of 1,2-dichloroethene in groundwater, especially under sandy soil (Barber et al. 1988), substantiates its leachability. The relatively low K_{oc} and high vapor pressure of 1,2-dichloroethene indicate that this compound should also readily volatilize from moist soil surfaces (Swann et al. 1983).

5.3.2 Transformation and Degradation

5.3.2.1 Air

The dominant atmospheric removal process for 1,2-dichloroethene is predicted to be reaction with photochemically generated oxygenated species (e.g., hydroxyl radicals) in the troposphere. The estimated atmospheric lifetimes for cis- and trans-1,2-dichloroethene due to this removal process are 12 and 5 days, respectively (Goodman et al. 1986). These estimates are based on experimentally determined hydroxyl reaction rate constants of 2.0×10^{-12} cm^3/molecules-sec at 25 °C for the cis

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isomer and 4.5×10^{-12} cm^3/molecules-sec at 25 °C for the trans isomer. Formyl chloride has been positively identified as a product of this reaction. Experimental data indicate that the reaction of cis and trans-1,2-dichloroethene with ozone, nitrate radicals, or singlet oxygen in the troposphere is too slow to be environmentally significant (Atkinson and Carter 1984; Sanhueza and Heicklen 1975a, 1975b). The half-life resulting from ozone attack of the double bond is 44 days for the trans isomer and 129 days for the cis isomer (Tuazon et al. 1984). There also is evidence that cis-1,2-dichloroethene will be scavenged by rain (HSDB 1995)

The primary ultraviolet (UV) absorption band for cis-1,2-dichloroethene is at 190 nm, which extends to about 240 nm (Ausbel and Wijnen 1975). The primary UV absorption band for the trans isomer also extends to about 240 nm (Dahlberg 1969). A minute amount of light is absorbed in the environmentally significant range (wavelengths greater than 290-380 nm). However, such absorption is insufficient for direct photolysis to be a significant fate process in the atmosphere.

Gtirtler et al. (1994) investigated the photochemical decomposition and oxidation of the chloroethenes in the gas phase by irradiation with a low-pressure mercury lamp in an oxygen atmosphere. Trans-1,2-dichloroethene slowly disappears after several hours of irradiation at 254 nm. After a period of restrained degradation, sudden decomposition is observed, probably resulting from the start of a chain mechanism. Trans-1,2-dichloroethene decomposes more slowly at low concentrations than at high ones. The primary photooxidation products are formyl chloride and, in small amounts, monochloro-acetyl chloride and dichloroacetaldehyde. Further photooxidation leads to the formation of phosgene, additional formyl chloride, formaldehyde, carbon monoxide, carbon dioxide, and hydrochloric acid.

In polluted urban airsheds, photolytic processes are a major factor in generating free radicals. Several studies summarized in Hall et al. (1989) emphasize that 1,2-dichloroethene degradation will proceed 2-4 times faster in polluted urban air exposed to UV radiation than with "pure air" contained no free radical precursors. Tuazon et al. (1988) and Jeffers et al. (1989) provide other convenient summaries of the reaction chemistry of chloroethenes and OH radicals.

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5.3.2.2 Water

There is relatively little literature dealing with 1,2dichloroethene fate and transport in surface waters. Since 1,2-dichloroethene is appreciably volatile, the usual assumption is that 1 ,2dichloroethene introduced into surface waters will rapidly be transferred to the atmosphere (see Section 5.3.1). Chemical hydrolysis and oxidation are probably not environmentally important fate processes for 1,2-dichloroethene (EPA 1979, 1981a, 1984). Kinetic data pertaining specifically to the abiotic degradation of the 1,2-dichloroethene isomers in the environment were not located. Direct photolysis of 1,2dichloroethene is also not likely to be important in sunlit natural waters (EPA 1979) (see Section 5.3.2.1).

When dealing with surface waters, 1,2-dichloroethene and other chlorinated ethenes generally resist biodegradation under aerobic conditions (Fogel et al. 1986; Mudder 1981; Mudder and Musterman 1982). However, in one study, the 1,2-dichloroethene isomers were susceptible to aerobic biodegradation. In this study (Tabak et al. 1981), settled domestic waste water was used as the inoculum with 5 ppm each of the cis and trans isomers. Losses in 7 days were 54% of the cis isomer and 67% of the trans isomer. Losses due to volatilization over a lo-day period were 34 and 33% for the cis and tram isomers, respectively. The inoculum may have contained a facultative methanotroph capable of degrading the dichloroethenes (Fogel et al. 1986). No information was found regarding biodegradation in biological waste treatment plants.

There is a growing body of literature dealing with fate and transport processes in groundwater. These studies are related to programs under the EPA Safe Drinking Water Act that address health risks from VOC contaminants in community drinking water systems, and to efforts to mitigate pollution at older waste disposal sites and remediate areas showing smaller-scale spills. While work through the early 1980s focussed on the biodegradation of 1,2-dichloroethene itself, it quickly became apparent that 1,2dichloroethene contamination at many sites was part of a complicated series of biotransformations where such solvents- as trichloroethylene or tetrachloroethylene were the principle driving-forces (Vogel et al. 1987).

1,2-Dichloroethene undergoes slow reductive dechlorination under anaerobic conditions (Barrio-Lage et al. 1986; Fogel et al. 1986). In one study, anoxic microcosms containing uncontaminated organic sediment and water to simulate the groundwater environment were spiked with 5 mg/L of test

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compound. First-order rate constants were obtained that correspond to half-lives of 88-339 and 132-147 days for the cis and trans isomers, respectively. No degradation occurred in sterile microcosms; thus, loss of the compounds was assumed to be due entirely to anaerobic biodegradation. The cis isomer degraded to chloroethane and vinyl chloride (a human carcinogen), while the tram isomer degraded to vinyl chloride only (Barrio-Lage et al. 1986). When cis- and trans-1,2-dichloroethene were incubated with methanogenic aquifer material from a site near a landfill, at least 16 weeks passed before trans isomer degradation began (Wilson et al. 1986). During the same time, the cis isomer was reduced to <2% of the concentration in the autoclaved control, and vinyl chloride appeared after only l-2 weeks incubation; therefore, the cis isomer degrades more rapidly. After 40 weeks, the tram isomer concentration fell to 18% of that in the autoclaved control containing the trans isomer. Trace amounts of the cis isomer remained in the unsterilized microcosm beyond 40 weeks. Tandoi et al. (1994) found that an anaerobic enrichment culture, using methanol as an electron donor, rapidly metabolized cis-1 ,2dichloroethene to vinyl chloride with near zero-order kinetics and apparent inhibition of subsequent vinyl chloride dechlorination. Trans- 1 ,2dichloroethene was converted to vinyl chloride more slowly with first order kinetics and an estimated half-life of 9.5 hours and did not inhibit vinyl chloride dechlorination.

Hopkins and McCarty (1995) performed an evaluation of the aerobic cometabolism of dichloroethene isomers, using phenol and toluene as the primary substrates, in a shallow aquifer at a pilot test facility. In an earlier study, a methane substrate was highly successful at transforming trans-1,2-dichloroethene in groundwater, but removal efficiency was rather low for cis-1,2-dichloroethene. Phenol was found to be superior to methane for *in situ* degradation of cis-1,2-dichloroethene, providing up to 90% removal in one pass at concentrations up to 1 mg/L. Removal of trans-1,2-dichloroethene was 74% when phenol was used. Semprini (1995) also demonstrated in pilot scale field studies of aerobic cometabolic transformations that indigenous microbes grown on phenol are more effective at degrading cis- 1,2-dichloroethene than are microbes grown on methane.

A study was performed on a sand aquifer at an industrial site near the town of St. Joseph; Michigan, to improve the understanding of the distribution of chlorinated aliphatic hydrocarbons (CAHs) years after contamination occurred (Semprini 1995). Groundwater concentrations varied significantly with depth. Relatively high concentrations of CAHs existed at all locations within 20 m of the center of the plume. The dominant dichloroethene isomer present was the cis isomer, with maximum

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concentrations of the cis and trans isomers of 133 and 3.9 mg/L, respectively. Cis-1,2-dichloroethene was observed in a transition zone between high and decreasing trichloroethene concentrations.

Anaerobic biotransformation by methanogenic bacteria was the earliest documented research on the biodegradation of 1,2-dichloroethene. In addition to studies in the United States (Barrio-Lage at al. 1986; Ehlke et al. 1992; Parsons et al. 1984; Silka and Wallen 1988), there has been good documentation of similar phenomena in sandy aquifers near Berlin, Germany (Kastner 1991; Leschber et al. 1990) and in groundwater supplies near a landfill in Ottawa, Canada (Lesage et al. 1990). In addition to anaerobic pathways, laboratory studies suggest that ammonia-oxidizing aerobic bacteria (Vannelli et al. 1990) and facultative sulfur-bacteria (Bagley and Gossett 1990) can biodegrade chlorinated aliphatic hydrocarbons. Burback and Perry (1993) demonstrated that 1,2-dichloroethene, when added singly to groundwater, is catabolized by *Mycobacterium vaccae*. At 100 ppm, 1,2dichloroethene was catabolized <50%. A wide range of estimates for reaction rates and pollutant half-lives have been reported. The biodegradation processes appear to be highly site specific, and influenced by the types of bacteria present, the presence of aerobic or anaerobic conditions, the presence of other substrates such as methane or sulfide, and the toxicity impacts from the various metabolites (Janssen et al. 1988).

5.3.2.3 Sediment and Soil

Studies showing that cis- and trans-1,2-dichloroethene degrade in nonsterile groundwater microcosms (Barrio-Lage et al. 1986; Wilson et al. 1986) suggest that these compounds undergo anaerobic biodegradation in soil and that this process may be the sole mechanism by which 1,2-dichloroethene degrades in soil. Hallen et al. (1986) found that when cis- and trans-1,2-dichloroethene were incubated in a system inoculated with anaerobic sludge from a municipal digester to simulate anaerobic conditions in a landfill, vinyl chloride appeared within 6 weeks. Biodegradation of trans- 1,2-dichloroethene was studied in microcosms containing uncontaminated organic sediment from the Everglades and allowed to stand to ensure oxygen depletion. Under these anoxic conditions, 50% of the chemical was lost within 6 months (Barrio-Lage et al. 1986). The fact that ethyl chloride as well as vinyl chloride are produced indicates that there are different pathways in the sequential dechlorination of cis- 1,2-dichloroethene.

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There are no transformation and degradation studies dealing with sediments. 1,2-Dichloroethene does not show significant bioconcentration or bioaccumulation tendencies, and outside groundwater would tend to volatilize and move to the atmosphere. Some researchers feel that the behavior of 1,2dichloroethene in sediments would be similar to patterns documented for soils or groundwater (Yeh and Kastenberg 1991).

5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

5.4.1 Air

1,2Dichloroethene has been frequently detected in air samples from urban locations throughout the United States and in landfill gas. Data in Table 5-2 represent available air monitoring data for 1,2-dichloroethene. Only one rural air monitoring study was located (Grimsrud and Rasmussen 1975). Maximum 1,2-dichloroethene concentrations detected in landfill gas ranged from 3,260 ppb (Vogt and Walsh 1985) in a municipal landfill simulator to 75,600 ppb at two Long Island landfills (Lipsky and Jacot 1985).

In 1986, EPA carried out an update to its National Ambient Database, with a focus on updating the coverage for VOCs (Shah and Singh 1988). Based on information from 161 data points, outdoor 1,2-dichloroethene daily ambient air concentrations averaged 0.326 ppb, with a median of 0.037 ppb and with 75% of the values falling below a concentration of 0.113 ppb.

With steady improvements in the efficiency of waste water treatment plants, the loadings of various toxics to receiving waters has substantially decreased over the last decade (Bennett 1989). However, reductions to surface water loadings have often resulted in increased emission to the atmosphere as volatile constituents of the waste influents are removed through techniques such as air stripping. Wastes, including organics like 1,2-dichloroethene, will also be transferred to sludges generated from biotic digestion processes or the use of chemical coagulants. Where sludge drying beds are located. close to waste water plants, volatile constituents in the residuals will be vented to the air. These phenomena can present toxic exposure risks to workers at the treatment plants and to populations living close to these facilities.

Table 5-2. Air Monitoring Data for 1,2-Dichloroethene

Media	Location	Sampling date	Isomer	Concentration (ppb)[a]	Comments	Reference
Ambient air	Houston, TX		cis	0.071 (mean)	General urban atmosphere	EPA 1983a
	St. Louis, MO	May 1980		0.039 (mean)		
	Denver, CO	May-June 1980		0.076 (mean)		
	Riverside, CA	June 1980		0.060 (mean)		
	Staten Island, NY	July 1980		0.018 (mean)		
	Pittsburgh, PA	March-April 1981		0.013 (mean)		
	Chicago, IL	April-May 1981		0.019 (mean)		
	Edison, NJ	NS	NS	1.3 (max.)	Kin-Buc disposal site	Pellizzari 1978
	Tulsa, OK	NS	NS	<0.1		Pellizzari 1978
	Kanawha Valley, WV			0.08		
	Front Royal, VA			0.1		
	So. Charleston, WV			<0.08		
	Birmingham, AL			<0.1		
	Baton Rouge, LA			<0.1		
	Upland, CA			<0.1		
	Magna, VT			0.08		
	Grand Canyon, AZ			0.065		
	Geismar, LA			2.6 (max.)		
	Niagara Falls, NY	1978	NS	trace	Detected in air outside 3 of homes in Old Love Canal hazardous waste site (detection limit not stated)	Barkley et al. 1980
	New Jersey	NS	NS	NS	4 NPL sites and 1 municipal landfill; detected in air samples collected at 3 of 5 sites; occurred in 75 to 100% of samples collected at these sites (detection limit ≥0.1 ppb)	LaRegina et al. 1986

Table 5-2. Air Monitoring Data for 1,2-Dichloroethene (continued)

Media	Location	Sampling date	Isomer	Concentration (ppb)[a]	Comments	Reference
Ambient Air	Edison, NJ	NS	trans	0.93		Brodzinsky and Singh 1982
	Urban/suburban (669 sites)	NS	cis	0.068 (median) 3.5 (max)		
	Source areas (101 sites)	NS	cis	0.3 (median) 6.7 (max)		
	Pullman, WA (rural area)	December 1974 to February 1975	NS	ND	Detection limit 5 ppt	Grimsrud and Rasmussen 1975
Indoor air	Niagara Falls, NY	1978	NS	0.015	Air in a basement of a home in Old Love Canal	Barkley et al. 1980
	Knoxville, TN	Winter 1982	NS	8.1 (mean)	Detected in 16 of 16 samples (detection limit not stated)	Gupta et al. 1984
Landfill gas	Selected U.S. landfills	NS	NS	70 (mean) 3,600 (max.)	Secondary source	Vogt and Walsh 1985
	Municipal landfill simulator	February 1983 to February 1984	NS	210 (mean) 3,260 (max.)	Simulation	Vogt and Walsh 1985
	Long Island, NY	NS	trans	75,600 (max.)	Air samples collected from methane vents at 2 sanitary landfills	Lipsky and Jacot 1985
	California	NS	trans	59,000 (max.)	20 class II landfills	Wood and Porter 1987

[a] Unless otherwise specified.

ND = Not detected; NS = Not stated

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5.4.2 Water

1,2-Dichloroethene has been detected in surface, ground, and drinking waters, as well as in industrial and municipal effluents, urban runoff, and leachate from landfills throughout the United States. Table 5-3 shows the available monitoring data for 1,2dichloroethene in these media. In some of the studies, only one of the 1,2-dichloroethene isomers was monitored; while in several of the studies the authors did not mention the specific isomer monitored. Concentrations of 1,2-dichloroethene detected in surface water ranged from 0.43 ppb in the Quinipiac River in Connecticut (Hall 1984) to 1,307.5 ppb in New Jersey (Table 5-3).

1,2-Dichloroethene has been detected in groundwater in several states and U.S. territories including Colorado, Connecticut, Florida, Maryland, Michigan, Nebraska, New Jersey, Pennsylvania, Puerto Rico, Washington, and Wisconsin (Table 5-3). Concentrations of 1,2dichloroethene isomers detected in groundwater ranged from 0.25 to 0.28 ppb (range of average concentrations) from 6 areas near Miami, Florida (Singh and Orban 1987) to a maximum of 500,000 ppb in Southington, Connecticut (Hall 1984). Groundwater contamination has been reported at numerous waste disposal sites in the United States. In a detailed study, the Wisconsin Department of Natural Resources sampled groundwater at 20 municipal and 6 industrial landfills in Wisconsin. 1,2Dichloroethene was detected in samples from 5 of 26 landfills at a maximum concentration of 3,900 ppb, and in leachate from 8 of 26 landfills at a maximum concentration of 310 ppb (Friedman 1988).

Since 1,2-dichloroethene can be produced from biodegradation of a variety of VOCs, screening tests for VOCs or tests for such widely used solvents as TCE or PCE can provide useful screening tools for follow-up testing for 1,2-dichloroethene. For instance, a study of 19 landfill sites in Wisconsin showed that while the incidence of 1,2-dichloroethene in all test wells was 19%, approximately two-thirds of the wells showing detectable VOCs also showed detectable 1,2dichloroethene (Battista and Connelly 1989). In a study of a western Connecticut manufacturing plant that used large quantities of high quality trichloroethylene for degreasing, it was found that 7 of 9 monitoring wells contained 1.2-320.9 ppb of trans-1,2-dichloroethene (Stuart 1983). More localized problems from leaking underground storage tanks or chemical spills may also show up in screens for VOCs (Stenzel and Gupta 1985). Where pollution levels are not excessive, remediation or permanent treatment technologies involving combinations of granular activated carbon or air stripping can remove over

Table 5-3. Water Monitoring Data for 1,2-Dichloroethene

Media	Location	Sampling date	Isomer	Concentration (ppb)	Comments	Reference
Surface water	Hylebos Waterway in the Puget Sound	1979	NS	0.8–2.4		Riley et al. 1980
	Potomac River in Quantico, VA	Spring 1986	trans	<2	1 sample analyzed (detection limit not reported)	Hall et al. 1987
	12 sites in the Delaware and Raritan Canal in New Jersey	August 1979 to January 1980	NS	ND	Detection limit not reported	Granstrom et al. 1984
	Indian River in Vero Beach, FL	May 1981 to May 1982	NS	ND	13 samples (detection limit 4.0 µg/L)	Wang et al. 1985b
	Drainage canal discharging into the Indian River in Vero Beach, FL	May 1981 to May 1982	NS	4.0–48.1 15.7 (mean)	Canal receiving contaminated groundwater; detected in 23 of 39 samples (detection limit 4.0 µg/L)	Wang et al. 1985b
	New Jersey	1977–1979	trans	1307.5 (max.)	Detected in 172 of 273 samples (detection limit not reported)	Page 1981
	Quinipiac River in Southington, CT	1980	trans	0.43 (mean)	Detected in 4 of 5 samples (detection limit not reported)	Hall 1984
	Wilson Creek (adjacent to hazardous waste site in Bullit County, KY	February 1979	NS	75 (max.)		Stonebraker and Smith 1980
Groundwater	178 CERCLA sites (Comprehensive Environmental Repose, Compensation, and Liability Act)	1981–1984	trans	NS	Frequency of detection = 29.1%	Plumb 1987
	New Jersey	1977–1979	trans	818.6 (max.)	Detected in 193 of 378 samples	Page 1981
	Wisconsin	Sampling results as of June 30, 1984	NS	NS	Detected in 5 of 1174 community wells and 12 of 617 private wells (detection limit 1.0–5.0 µg/L)	Krill and Sonzogni 1986
	Wausau, WI	NS	cis	83.3	Raw well water	Hand et al. 1986

Table 5-3. Water Monitoring Data for 1,2-Dichloroethene (continued)

Media	Location	Sampling date	Isomer	Concentration (ppb)	Comments	Reference
Groundwater (cont.)	Wisconsin	1985–1987	NS	3,900 (max.)	Detected at 5 of 26 sites	Friedman 1988
	Montgomery County, MO	1983	trans	27–320 158 (mean)	Detected in 4 samples	Dever 1986
	Southington, CT	1980	trans	50,000 (max.) 16 (median)	Detected in 29 of 35 samples (detection limit not reported)	Hall 1984
	Potomac-Raritan-Mogathy aquifer system (adjacent to the Delaware River	1980–1982	trans	NS	Detected in 12 of 179 wells in the outcrop area and not detected in 115 wells in the downdip of the outcrop (detection limit 1 µg/L)	Fusillo et al. 1985
	Nebraska	Summer 1982	NS	2.1 (max.) 0.50 (median)	Detected in 3 of 63 samples (detection limit 0.2 µg/L); private wells	Goodenkauf and Atkinson 1986
	Nebraska	1983–1984	NS	2.9	Detected in 1 of 97 samples; sources for public water system	Goodenkauf and Atkinson 1986
	Western CT manufacturing plant	NS	trans	1.2 to 320.9	Detected in 7 of 9 monitoring wells	Stuart 1983
	Biscayne aquifer, Miami, FL	November 1982 and March 1983	trans	0.25–28 (range of average concentration fron the mix areas)	12 total samples from 6 geographical areas defined within the study area	Singh and Orban 1987
	Miami Drum Services in Miami, FL	1981	cis	839 (max.)	Hazardous waste site	Myers 1983
	Biscayne aquifer in vicinity of Miami Drum site	1983	NS	19 (mean)	Detected in 2 of 3 samples (detection limit not reported)	Myers 1983
	Piper Aircraft Corp. in Vero Beach, FL	April 1981 to December 1983	NS	1000–4000	At site of a leaking subsurface trichloroethylene storage tank	Wang et al. 1985a
	Lakewood, WA	December 1983	trans	250–435 330 (mean)	Detected in 11 of 11 samples; in the vicinity of an NPL site	Wolf and Gorelik 1984

Table 5-3. Water Monitoring Data for 1,2-Dichloroethene (continued)

Media	Location	Sampling date	Isomer	Concentration (ppb)	Comments	Reference
	Western Processing, Kings County, WA	November 1982	trans	Qualitatively identified	Hazardous waste site	Aldis et al. 1983
Groundwater (cont.)	Marshall landfill in Boulder County, CO	NS	trans	530 (onsite) 66 (offsite)	NPL site	EPA 1986f
	Minnesota	NS	cis	0.5 - 20000	Detected in contaminated groundwater from 7 of 13 sites	Sabel and Clark 1984
			trans	0.6 to 98	Detected in contaminated groundwater from 3 of 13 sites	
	Forest Waste Disposal site in Otisville, MI	NS	trans	100 (max.)	NPL site	EPA 1986b
	Lang Property site in Pemberton Township, NJ	NS	trans	942 (mean) 2,500 (max.)	NPL site	EPA 1987a
	Vega Alta Public Supply Wells in Puerto Rico	NS	NS	74 (max.)	NPL site; detected in 89 of 168 samples (detection limit not reported)	EPA 1988a
	Ponders Corner in Pierce County, WA	1984–1985	trans	85 (max.)	NPL site	EPA 1986c
	Hollinsworth Solderless Terminal Co. in Fort Lauderdale, FL	1983	NS	2,160 (max.)	NPL site; level of dichloroethene (there was no indication whether this was 1,1- or 1,2-dichloroethene)	EPA 1986d
	Lakewood Utility District near Tacoma, WA	NS	trans	200	Production wells near a commercial facility	Boateng et al. 1984
Drinking water (using ground-water sources)	United States	NS	NS	2.0 (max.)	Detected in samples collected from 16 of 466 randomly selected sites using groundwater as a raw water source (detection limit 0.2 µg/L)	Westrick et al. 1984
Drinking water	Miami, FL	NS	trans	1		EPA 1980d

Table 5-3. Water Monitoring Data for 1,2-Dichloroethene (continued)

Media	Location	Sampling date	Isomer	Concentration (ppb)	Comments	Reference
Drinking water (Private wells)	Winnebago Co., IL	NS	trans	ND - 64 (8 median)	5 homes tested	Wehrmann 1985
Drinking water (Private wells) (cont.)	Philadelphia, PA	February 1975 to January 1977	NS	NS	Detected in 1 of 17 samples (detection limit not reported)	Suffet et al. 1980
	5 U.S. cities	1975	cis and trans	NS	U.S. EPA National Organics Reconnaissance Survey; cis isomer positively identified in samples from Miami, FL, Philadelphia, PA, and Cincinnati, OH; trans isomer positively identified in samples from Miami, FL	EPA 1975a
Raw and treated drinking water	10 potable water treatment plants in Canada	July 1982 to July 1983	NS	trace	Positively identified in 3 raw and 3 treated water samples (detection limit not reported)	Otson 1987
Leachate	30 potable water treatment plants in Canada	August 1979 to December 1979	NS	raw water - 23 (max.) treated water - 32 (max.)	Positively identified in 2 raw and 11 treated water samples	Otson et al. 1982
	NS (landfill containing mixed industrial waste)	NS	trans	45 - 800 (average concentration of leachates)	Detected in 2 of 8 leachates (detection limit not reported)	Ghassemi et al. 1984
	Minnesota	NS	cis	1.4 - 470	Detected in leachate from 5 of 6 sites (detection limit not reported)	Sabel and Clark 1984
			trans	3.8 - 88	Detected in leachate from 3 of 6 sites (detection limit not reported)	Sabel and Clark 1984
	Lyon, MN, municipal landfill	NS	trans	3.8 (mean)		Brown and Donnelly 1988

Table 5-3. Water Monitoring Data for 1,2-Dichloroethene (continued)

Media	Location	Sampling date	Isomer	Concentration (ppb)	Comments	Reference
	Meeker, MN, municipal landfill	NS	cis	190 (mean)		Brown and Donnelly 1988
Leachate (cont.)			trans	170 (mean)		Brown and Donnelly 1988
	Rochester, MN, municipal landfill	NS	cis	470 (mean)		Brown and Donnelly 1988
	Rochester, MN, municipal landfill	NS	trans	88 (mean)		Brown and Donnelly 1988
	Wisconsin, 20 municipal and industrial landfills	1985–1987	NS	310	Detected in leachate from 8 of 26 sites	Friedman 1988
Aqueous lagoon	Forest Waste Disposal site in Otisville, MI	NS	trans	50	NPL site; estimate level (compound detected below quantification limit)	EPA 1986b
Urban storm water runoff	15 U.S. cities	as of July 1982	trans	1–3 (in positive samples)	Detected in runoff from Little Rock, AR, and Eugene, OR	Cole et al. 1984
Waste water	Los Angeles, CA	NS	NS	5.2 (mean)	Effluent from a county sewage treatment plant	Gossett et al. 1983
	NS	1980/1981	trans	untreated: 52–60 effluent: 31–43	Municipal sewage treatment plant; detected in 5 of 5 samples	Lao et al. 1982
	Chicago, IL	NS	trans	<50	Effluent from a municipal sewage treatment plant	Lue-Hing et al. 1981
	NS	NS	trans	20 (max.)	Treated effluent from a petroleum refinery	Snider and Manning 1982
	Owensboro, KY	August 1975	cis	NS	Chemical plant effluent	EPA 1976
	Calvert City, KY	October 1975	cis	NS	Chemical plant effluent	EPA 1976

Table 5-3. Water Monitoring Data for 1,2-Dichloroethene (continued)

Media	Location	Sampling date	Isomer	Concentration (ppb)	Comments	Reference
	United States	NS			Industry:	EPA 1980d
			trans	10 (max.)	coal mining	
			trans	46 (max.)	electrical electronic components	
			trans	10 (max.)	foundries	
			trans	10 (max.)	pharmaceutical manufacturing	
Waste water (cont.)			trans	75 (max.)	nonferrous metals manufacturing	
			trans	12 (mean)	organic chemicals and plastics manufacturing	
			trans	190 (max.)	paint and ink formulation	
			trans	<10 (max.)	petroleum refining	
			trans	290 (max.)	rubber processing	
			cis	1.6	steam electric (detected in 1 sample)	Shackelford et al. 1983
			cis	3.3	leather tanning (detected in 1 sample)	
			cis	1400.8 (median)	iron and steel manufacturing	Shackelford et al. 1983
			trans	2265.9 (median)	(detected in 2 samples)	
			cis	314.6	nonferrous metal (detected in 1 sample)	
	United States	NS	cis	121.5 (median)	organics and plastics [(detected in	Shackleford et al. 1983
			trans	14.6 (median)	2 samples) (cis) and 3 samples	
			trans	3.9	(trans)]	
					inorganic chemicals (detected in 2 samples)	
			cis	8.3	textile mill (detected in 1 sample)	
			cis	20.1 (median)	plastics and synthetics (detected in 3 samples)	
			cis	712.0	rubber processing	

Table 5-3. Water Monitoring Data for 1,2-Dichloroethene (continued)

Media	Location	Sampling date	Isomer	Concentration (ppb)	Comments	Reference
			trans	19.0 (median)	[detected in 1 sample (cis) and 2 samples (trans)]	
			trans	60.6	auto and other laundries (detected in 1 sample)	
Waste water (cont.)			cis	1.5	explosives (detected in 1 sample)	
			trans	3.9		
			trans	140.7 (medium)	electronics (detected in 7 samples)	
			trans	13.7 (median)	mechanical products (detected in 2 samples)	Shackelford et al. 1983
			trans	29.3	transportation equipment (detected in 1 sample)	
			trans	16.3 (median)	publicly owned treatment works (POTW)(detected in 63 samples)	Shackelford et al. 1983
	NS	NS	trans	260 (mean) 1700 (max)	metal finishing	EPA 1980b
			trans	2200 (max)	photographic equipment/supplies	
			trans	75 (mean) 260 (max)	non-ferrous metal manufacturing	
			trans	150 (mean) 290 (max)	rubber processing	
Rain water	UCLA campus, Los Angeles, CA	3/26/82	NS	0.230	1 sample	Kawamura and Kaplan 1983

ND = Not detected; NS = Not stated

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96% of VOCs such as cis-1,2-dichloroethene (Clark et al. 1988; Lee et al. 1988; Stenzel and Gupta 1985).

In a comprehensive survey of United States drinking water derived from groundwater, 16 of 466 randomly selected sites and 38 of 479 purposely selected sites contained 1,2-dichloroethene. The maximum concentration was 2 ppb at random sites and 120 ppb at the nonrandom sites (Westrick et al. 1984). Trans-1,2-dichloroethene was found in Miami, Florida, drinking water at 1 ppb. Cis-1,2-dichloroethene was found in Miami drinking water at 16 ppb; and in Cincinnati, Ohio, and Philadelphia, Pennsylvania, drinking water at 0.1 ppb; but was not detected in 7 other drinking waters surveyed (EPA 1980d).

In a four-city study (Cincinnati, Ohio; St. Louis, Missouri; Atlanta, Georgia; Hartford, Connecticut) to determine the major source type of priority pollutants in tap water and POTW influents, it was found that 43, 38, and 28% of commercial sources, industrial sources, and POTW influents, respectively, contained trans- 1 ,2dichloroethene (EPA 198 lc). The average concentrations from the industrial sources were between 10 and 100 ppb while the others were <10 ppb. Industrial effluent monitoring data from Shackelford et al. (1983) was obtained from a database of a comprehensive EPA survey of 4,000 effluent samples from industries and POTWs. This survey was conducted in response to the consent decree between the National Resources Defense Council and the EPA on June 7, 1976. Data from this study are presented in Table 5-3.

Over the last decade, the Safe Drinking Water Act has focussed attention on improved controls over VOC contamination (including 1,2-dichloroethene) of community drinking water systems. Based on available national statistics, 1,2-dichloroethene has been found in detectable concentrations at less than 5% of the community systems using surface water sources. The figures jumped to 21%, however, for community systems relying on groundwater (Coniglio et al. 1980). No comparable figures are available for noncommunity systems, such as truck stops or highway convenience stores in rural areas, or for domestic groundwater wells.

5.4.3 Sediment and Soil

Available data on 1,2-dichloroethene in soil are limited to those obtained through hazardous waste site monitoring (Aldis et al. 1983; EPA 1986c, 1987a; Pennington 1983; VIAR 1987). Soil gas pollutants

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in a shallow, unconfined aquifer receiving waste water from metal-plating operations at Picattinny Arsenal in Morris County, New Jersey, were found to have a maximum cis-1,2-dichloroethene concentration of 33 ppb in the vadose zone (Smith 1988). 1,2-Dichloroethene has been detected, but not quantified, in sediment samples at Love Canal, New York (HSDB 1995).

Recent summaries related to data on 1,2dichloroethene in sediments have not been located. In the early 1980s 1,2-dichloroethene was found at a concentration of >5 ppb (wet weight) in sediment at 4% of 361 stations reported in EPA's STORET database (Staples et al. 1985). No further summary information was located on the occurrence of 1,2-dichloroethene in sediments. EPA is in the process of consolidating all available information on toxics in sediments to comply with provisions of the Water Resources Development Act of 1992. This will lead to the creation of a National Sediment Inventory, which should eventually facilitate custom data retrievals and encourage research studies to analyze available sediment monitoring results (EPA 1993).

5.4.4 Other Environmental Media

Trans-1,2dichloroethene concentrations ranging from 22 to 55 g/L have been detected in municipal sludge from various treatment plants throughout the United States (Feiler et al. 1980; Naylor and Loehr 1982).

Few reports exist of 1,2-dichloroethene in biota from U.S. waters. This is because 1,2-dichloroethene is not a typical biota contaminant (Staples et al. 1985). Nicola et al. (1987) reported mean and maximum 1,2dichloroethene levels of 0.04 and 0.05 ppm, respectively, in fish tissue from Commencement Bay in Tacoma, Washington. No fish obtained at the 95 stations in EPA's STORET database contained detectable levels of 1,2-dichloroethene (Staples et al. 1985). A BCF of 6 was estimated for fathead minnows (ASTER 1995) using the method of Veith and Kosian (1983). Using a log octanol/water partition coefficient of 2.06 for trans-1,2-dichloroethene and a recommended regression equation (Lyman et al. 1982), a BCF of 22 has been estimated (HSDB 1995). Based on these estimated BCFs, 1,2-dichloroethene is not expected to bioaccumulate to any appreciable extent.

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The general population is exposed to 1,2-dichloroethene in urban air and drinking water, with higher possibilities of exposure in community systems relying on groundwater supplies. Contaminated tap water can cause exposure via ingestion, inhalation, and dermal contact during showering and bathing. Inhalation is the most probable route of exposure. 1,2-Dichloroethene has been detected in urban air at average concentrations of 0.013-0.076 ppb (0.052-0.30 $\mu g/m^3$) (EPA 1983a). These exposure levels correspond to an average daily intake of l-6 μg 1,2-dichloroethene, assuming an average daily intake of 20 m^3 of air. Risks from inhalation exposures may be of more concern to populations in regions such as Gulf Coast states that have substantial production facilities for chlorinated polymers (Hall et al. 1989). An average daily intake of 0.5-5.4 μg from water is calculated assuming a concentration of 0.23-2.7 ppb (HSDB 1995). Data are insufficient for estimating 1,2-dichloroethene intake via other routes of exposure.

Ashley et a1.(1994) determined the internal dose of 32 volatile organic compounds in 600 or more people in the United States who participated in the Third National Health and Nutrition Survey (NHANES III). Detectable concentrations of cis- and tram-1,2-dichloroethene were found in fewer than 10% of the samples examined. Their detection limits were 0.013 and 0.014 ppb, respectively.

According to a National Occupational Exposure Survey (NOES) conducted by NIOSH between 1981 and 1983, an estimated 215 workers in the United States are potentially exposed to 1,2-dichloroethene (mixture of cis and trans isomers); an estimated 61 workers in the United States are potentially exposed to cis-1,2-dichloroethene (NIOSH 1988). These tentative estimates will be updated as additional information on trade name compounds containing 1 ,2dichloroethene becomes available. There was no NOES estimate for the trans isomer. Occupational exposure is by dermal contact with the vapor and liquid or by inhalation (HSDB 1995). Common operations in which there is potential industrial exposure to 1,2-dichloroethene include: use as a low-temperature solvent for heat-sensitive substances in extraction of caffeine, perfume oils, and fats from animal flesh; in rubber and dye industries in extraction and application; as a direct solvent in gums, waxes, etc.; in solvent mixtures for ester and ether derivatives, lacquers, resins, thermoplastics, and artificial fibers; in organic synthesis for polymers and telomeres; and in miscellaneous applications as a liquid dry cleaning agent, cleaning agent for printed circuit boards, food packaging adhesive, and germicidal fumigant (NIOSWOSHA 1978). The extent of continuing use of 1,2-dichloroethene in these operations is unknown.

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Firefighters and workers at landfill sites may also be exposed to 1,2dichloroethene (Michal 1976; NIOSWOSHA 1978; Vogt and Walsh 1985). No information was located on exposure levels in other occupational settings.

5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Other than individuals who are occupationally exposed, populations with potentially high exposure include those living near production and processing facilities, hazardous waste sites, municipal waste water treatment plants, and municipal landfills. Near production and processing facilities, certain hazardous waste sites, and municipal landfills, potential exists for exposure to elevated levels of dichloroethene in air downwind of the sites and in contaminated drinking water from groundwater downgradient of the sites. Potential exposure levels cannot be estimated with the data available.

5.7 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of 1,2-dichloroethene is available. Where adequate information is not available, ATSDR, in conjunction with the NTP, is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of 1,2-dichloroethene.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that if met would reduce the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

5.7.1 Identification of Data Needs

Physical and Chemical Properties. The physical and chemical properties of both cis- and trans-1,2-dichloroethene are well characterized (see Table 3-2) and allow prediction of the transport

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and transformation of the chemicals in the environment. Therefore, no data needs have been identified at this time.

Current production and import/export volumes and usage data are presently unavailable in the literature. Much of the information regarding 1,2dichloroethene may be difficult to obtain because many manufacturing companies maintain confidentiality. In 1977, the estimated production of cis-1,2-dichloroethene was 500 metric tons. No information was available for the trans isomer or for the mixture (HSDB 1995). Also, information about future domestic production, and past, present and future imports and exports is lacking. Furthermore, determining the percentage of 1,2dichloroethene that is used as a captive intermediate (i.e., the 1,2dichloroethene consumed in closed processes in which the compound is not isolated), as opposed to its use as a solvent, is critical to estimating the amount released to the environment. Differences in toxicity and environmental fate also suggest that isomer-specific information on use and consumption is important. Determination of the levels of 1,2-dichloroethene in consumer products is essential for estimating the exposure of the general population.

With up-to-date and accurate production, import/export, and use data, the extent of release into the environment and the potential for human exposure could be more realistically determined. Disposal methods have been described and appear to be satisfactory.

Because the EPA identified trans-1,2-dichloroethene as a hazardous waste, its disposal is regulated under the Resource Conservation and Recovery Act (RCRA). Specific information on federal regulations concerning hazardous waste disposal by land treatment, landfilling, incineration, thermal treatment, chemical/physical/biological treatment, underground injection, and deep sea injection appears in the Code of Federal Regulations (40 CFR 190 to 399). Release of trans-1 ,2dichloroethene in waste water is regulated under the Clean Water Act by the National Pollutant Discharge Elimination System (NPDES). Information regarding effluent guidelines and standards for trans-1,2-dichloroethene can be found in 40 CFR 122, 40 CFR 125, 40 CFR 413.02(i), 40 CFR 414, and 40 CFR433.1l(e).

Environmental Fate. 1,2Dichloroethene released to the environment partitions mainly to the atmosphere (Eisenreich et al. 1981; Swann et al. 1983; Thomas 1982). It is primarily found in the atmosphere and groundwater (HSDB 1995; TR193 1995). Important sources of 1,2dichloroethene include industrial releases and degradation products from other solvents such as trichloroethene,

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tetrachlorethene, and vinyl chloride (Parsons et al. 1984; Shen 1982b; Smith and Dragun 1984; Vogel et al. 1987). 1,2Dichloroethene isomers have predicted atmospheric half-lives of 12 days (cis) and 5 days (trans) (Goodman et al. 1986). Both isomers react with hydroxyl radicals in the atmosphere, forming for-my1 chloride, but atmospheric ozone, nitrate radicals and singlet oxygen have little environmental effect (Atkinson and Carter 1984). In surface waters, the isomers of 1,2dichloroethene are rapidly volatized; half-lives of 5-6.2 hours are estimated for water 1 m deep (Dilling 1977). The compound is not significantly bound to soils or sediments (Barber et al. 1988). Soil-groundwater degradation processes are anaerobic and may involve multiple pathways. Additional information about the long-term atmospheric fate would be useful, because of the importance of this pathway and the uncertainty of atmospheric degradation processes.

Bioavailability from Environmental Media. No specific information is available regarding human inhalation, oral, or dermal absorption of 1,2-dichloroethene from air, water, food, or soil. Exposure via contaminated drinking water is particularly relevant to humans. Since 1,2-dichloroethene is a neutral lipophilic chemical with a low molecular weight, it probably is readily absorbed through the lungs and gastrointestinal tract. The few available toxicity studies of animals exposed to 1,2-dichloroethene support this contention (Filser and Bolt 1979; Gargas et al. 1988, 1989). No information about human exposure to 1,2-dichloroethene in the environment and the resulting concentrations in human tissue was located. Studies of absorption of 1,2dichloroethene from air, water, food, and soil in contaminated environments near hazardous waste sites would allow for determination of the rate and extent of absorption from each of these media and for comparison of the potential hazards posed by 1,2-dichloroethene within these media.

Food Chain Bioaccumulation. Few data are available describing the food chain bioaccumulation of 1,2dichloroethene. Experimental data are unavailable; therefore, it is not known if the bioconcentration potential is consistent with estimated values obtained from regression equations. The estimated BCF of 6 for fathead minnows (ASTER 1995; Veith and Kosian 1983) suggests that the potential for 1,2dichloroethene to bioconcentrate is low for aquatic organisms. Therefore, further studies on bioaccumulation are not recommended. However, biomagnification studies would enable scientists to assess the dangers of human exposure to 1,2dichloroethene from fish and seafood.

Data describing exposure levels in air, surface water, drinking water, groundwater, and soil are limited. 1,2-Dichloroethene has been detected in urban and rural air, air near hazardous waste sites, and indoor

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air (Grimsrud and Rasmussen 1975; Lipsky and Jacot 1985; Shah and Singh 1988; Vogt and Walsh 1985). Where it is used as a dry cleaning agent and in the manufacture of other chemicals, indoor air concentrations of 1,2-dichloroethene are likely to be greater than concentrations in outdoor air. Information concerning the number of persons potentially exposed to 1,2-dichloroethene near waste sites, manufacturing and production facilities, and use facilities, however, is not available. In these areas and in areas of widespread use, the potential for human exposure is high. Monitoring data that showed the existence of 1,2-dichloroethene in food could not be located. 1,2-Dichloroethene has been detected infrequently in drinking water supplies. Reliable estimates of human intake of 1,2-dichloroethene via air, water, and food are not available. Therefore, it is recommended that further studies on human intake of 1,2-dichloroethene from air, water, and food, particularly around hazardous waste sites, be undertaken.

Exposure Levels in Humans. 1,2-Dichloroethene is not a naturally occurring substance. Monitoring data pertaining to the presence of 1,2-dichloroethene in human urine, breast milk, blood, or adipose tissue were not located in the available literature. Information on biological media monitoring of the general populations, particularly populations near waste sites, is necessary for assessing the need to conduct health studies on these populations.

Exposure Registries. No exposure registries for 1,2-dichloroethene were located. This substance is not currently one of the compounds for which a subregistry has been established in the National Exposure Registry. The substance will be considered in the future when chemical selection is made for subregistries to be established. The information that is amassed in the National Exposure Registry facilitates the epidemiological research needed to assess adverse health outcomes that may be related to exposure to this substance.

Production, Import/Export, Use, Release, and Disposal. According to the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. Section 11023, industries are required to submit substance release and off-site transfer information to the EPA. The Toxics Release Inventory (TRI), which contains this information for 1993, became available in 1995. This database will be updated yearly and should provide a list of industrial production facilities and emissions.

Exposure Levels in Environmental Media. Reliable monitoring data for the levels of 1,2dichloroethene in contaminated media at hazardous waste sites are needed so that the information

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obtained on levels of 1,2-dichloroethene in the environment can be used in combination with the known body burden of 1,2-dichloroethene to assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

5.7.2 Ongoing Studies

As part of the Third National Health and Nutrition Evaluation Survey (NHANES III), the Environmental Health Laboratory Sciences Division of the National Center for Environmental Health, Centers for Disease Control and Prevention, will be analyzing human blood samples for 1,2-dichloro-ethene and other volatile organic compounds. These data will give an indication of the frequency of occurrence and background levels of these compounds in the general population.

No studies on the environmental fate of 1,2dichloroethene are in progress. NIOSH is now updating its occupational exposure estimates with additional information about exposure to trade name compounds. No other ongoing studies that would address data needs on general population and worker exposure to 1,2-dichloroethene were found.