

5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

The primary sources of 1,1-dichloroethene in the environment are related to the synthesis, fabrication, and transport of 1,1-dichloroethene and the fabrication of its polymer products. Because of the volatile nature of the chemical, releases to the atmosphere are the greatest source of ambient 1,1-dichloroethene. Smaller amounts of the chemical are released to surface water and soil, primarily as a result of waste disposal. 1,1-dichloroethene in waste water should partition to the atmosphere as a result of volatilization during treatment processes. Most of the 1,1-dichloroethene released to the environment partitions to air or water, including groundwater (Table 5-1).

1,1-dichloroethene has been identified in at least 492 of the 1,350 hazardous waste sites on the EPA National Priorities List (NPL) (HAZDAT 1992). However, the number of sites evaluated for 1,1-dichloroethene is not known. The frequency of these sites can be seen in Figure 5-1. Of these sites, 1 is located in the Commonwealth of Puerto Rico (not shown).

1,1-Dichloroethene is rapidly transformed in the troposphere, where oxidation by hydroxyl radicals is the dominant transformation process. Biotransformation is believed to be the dominant transformation process for 1,1-dichloroethene in groundwater, although this process is probably not important in aerobic surface waters. Biotransformation in soil has not been studied extensively, but it has been shown to occur by methanogenic organisms. Biotransformation will be more important in subsurface soils, because 1,1-dichloroethene in surface soils will volatilize to the atmosphere. 1,1-dichloroethene has been detected in air, surface water, groundwater, and soil, with the frequency of detection and the concentrations greatest near source areas (e.g., industrial areas, landfills, hazardous wastes sites).

The potential for human exposure to 1,1-dichloroethene is greatest for those at its point of production, formulation, or transport. Occupational exposure to 1,1-dichloroethene may occur by inhalation or dermal contact. Members of the general public may be exposed by inhalation or by ingesting contaminated drinking water. Those who live near hazardous waste sites contaminated

TABLE 5-1. Releases to the Environment from Facilities that Manufacture or Process 1,1-Dichloroethene^a

Facility	Location ^b	Reported amounts released in pounds						Off-site waste transfer
		Air	Underground injection	Water	Land	Total environment ^c	POTW transfer	
3M	DECATUR, AL	1,750	0	1	0	1,751	0	0
MONSANTO CO. CHEMICAL GROUP	DECATUR, AL	2,170	0	0	0	2,170	0	0
EASTMAN KODAK CO. KODAK COLORADO DIV.	WINDSOR, CO	85	0	19	0	104	0	0
DOW CHEMICAL DALTON SITE	DALTON, GA	2,910	0	0	1	2,911	0	53,100
MORTON INTERNATIONAL INC.	RINGWOOD, IL	11,100	0	0	0	11,100	0	0
BF GOODRICH CO.	LOUISVILLE, KY	920	0	0	0	920	0	0
W. R. GRACE & CO.	OWENSBORO, KY	127,700	0	31	14	127,745	0	0
MARINE SHALE PROCESSORS INC.	AMELIA, LA	120	0	0	0	120	0	0
VULCAN MATERIALS CO.	GEISMAR, LA	163	0	2	0	165	0	0
DOW CHEMICAL CO. LOUISIANA DIV.	PLAQUEMINE, LA	43	0	38	0	81	0	0
PPG INDUSTRIES INC.	WESTLAKE, LA	92,434	0	389	0	92,823	0	158
DOW CHEMICAL USA MIDLAND	MIDLAND, MI	25,762	0	150	0	25,912	0	0
RHONE-POULENC INC. WALSH DIVISION	GASTONIA, NC	146	0	0	0	146	0	0
ALLIED-SIGNAL INC.	ELIZABETH, NJ	500	0	0	0	500	0	8
DU PONT PARLIN PLANT IMAGING SYSTEMS DEPT.	PARLIN, NJ	15	0	0	0	15	14	248
ALLIED-SIGNAL INC.	BUFFALO, NY	108	0	0	0	108	0	0
EASTMAN KODAK CO.	ROCHESTER, NY	879	0	200	0	1,079	0	7
GENCORP POLYMER PRODUCTS	MOGADORE, OH	540	0	0	0	540	49	1
OCCIDENTAL CHEMICAL CORP. VCM PLANT	DEER PARK, TX	0	0	0	0	0	0	5
DOW CHEMICAL CO.	FREEPORT, TX	15,300	0	2	0	15,302	0	0
OCCIDENTAL CHEMICAL CORP. CORPUS CHRISTI PLANT	GREGORY, TX	5	0	0	0	5	0	0
HERCULES INC.	COVINGTON, VA	1,189	0	0	0	1,189	0	0
ARCO CHEMICAL CO.	SOUTH CHARLEST, WV	1,351	0	0	0	1,351	31	21,000
Totals		285,190	0	832	15	286,037	94	74,527

^aDerived from TRI91 (1993)^bPost office state abbreviations used^cThe sum of all released of the chemical to air, land, water, and underground injection wells by a given facility.

POTW = publicly owned treatment works

5. POTENTIAL FOR HUMAN EXPOSURE

with 1,1-dichloroethene, especially those who receive their drinking water from underground sources, may potentially be exposed to 1,1-dichloroethene, the levels of which cannot be established at present. Quantitative data that address levels of human exposure to 1,1-dichloroethene are limited.

5.2 RELEASES TO THE ENVIRONMENT

5.2.1 Air

Air releases are the largest source of 1,1-dichloroethene releases to the environment, and emissions from polymer synthesis and fabrication industries contribute most to overall atmospheric loading. Singh et al. (1981) have estimated that air emissions of 1,1-dichloroethene from polymer synthesis in the United States range between 2% and 5% of the annual production. EPA (1985a) estimated total annual air emissions of 1,1-dichloroethene of ≈ 650 tons/year, which was 0.8% of the production volume for that year. Over one-half of that total (355 tons) was from the polymer production/fabrication industries. The remaining emissions were from monomer synthesis (223 tons/year; 34%) and monomer storage, handling, and transportation (73 tons/year; 11%). Small amounts of 1,1-dichloroethene (not quantified) were estimated to be released during the incineration (disposal) of polymer products containing the 1,1-dichloroethene monomer, 1,1,1-trichloroethane, and other chlorinated solvents (Oki et al. 1990; Yasuhaka and Morita 1988). Crume (1991) reported that 1,1-dichloroethene can be released to the atmosphere by air stripping contaminated groundwater. This process transfers groundwater contaminants into the gaseous phase and subsequently releases them into the atmosphere with no further treatment (the releases were not quantified). However, more recent data indicate that both the number of emission point sources and the total amount of 1,1-dichloroethene released to the atmosphere are much less than EPA's earlier estimates. This decrease is the result of shifts away from the use of the compound by processors and improvements in control technology. For example, survey data submitted by the Chemical Manufacturers Association to EPA indicate that ≈ 103.4 tons of 1,1-dichloroethene per year are released from manufacturing and processing facilities (CMA 1989).

According to the TRI91 (1993), an estimated total of 285,190 pounds (129.3 metric tons) of 1,1-dichloroethene, amounting to 99.7% of the total environmental release, was discharged to the

5. POTENTIAL FOR HUMAN EXPOSURE

air from manufacturing and processing facilities in the United States in 1991. The data listed in TRI should be used with caution since only certain types of facilities are required to report. This is not an exhaustive list.

Hazardous waste sites and landfills where 1,1-dichloroethene have been improperly disposed of are additional potential sources of release of the chemical to the atmosphere because of volatilization (see Section 5.4.1).

5.2.2 Water

Industrial releases of 1,1-dichloroethene to surface water contribute to the overall environmental loading of the chemical but to a much lesser extent than atmospheric emissions. Liquid effluents produced during polymerization operations are estimated to contribute ≈ 2 tons of waste 1,1-dichloroethene each year (Neufeld et al. 1977). Other potential industrial sources of waste 1, 1-dichloroethene in surface water are metal finishing and nonferrous metals manufacturing industries, soap and detergent manufacturers, electric coil coating and battery manufacturers, coal mines, laundries, and industries involving paint and ink formulation. 1,1-dichloroethene has been measured in raw waste water from these industries at mean concentrations of 3-760 $\mu\text{g} / \text{L}$ (EPA 1981).

According to TRI91 (1993), an estimated total of 832 pounds (0.4 metric tons) of 1,1-dichloroethene, amounting to 0.29% of the total environmental release, was discharged to water from manufacturing and processing facilities in the United States in 1991 (TRI91 1993). An estimated total of 94 pounds (0.043 metric tons), amounting to 0.03% of the total environmental release, was discharged to publicly owned treatment works. The TRI data should be used with caution since only certain types of facilities are required to report.

Hazardous waste sites where 1,1-dichloroethene has been improperly disposed are additional potential sources of the chemical, although there are no quantitative data available to address how much 1,1-dichloroethene enters the environment from this source. In addition, surface water or groundwater contaminated with 1,1,1-trichloroethane, tetrachloroethylene, 1,1,2-trichloroethylene, and 1,2-dichloroethane can be an additional source of 1,1-dichloroethene through biotic or abiotic elimination or dehydrochlorination transformations (Baek et al. 1990; Cline and

5. POTENTIAL FOR HUMAN EXPOSURE

Viste 1985; Lesage et al. 1990; McCarty et al. 1986). Hydrolysis of 1,1,1-trichloroethane in water or water/sediment systems will result in the formation of 1,1-dichloroethene by elimination, although it is a very slow process, with a half-life of -1 year (Haag and Mill 1988). Total releases of 1,1-dichloroethene from these sources have not been quantified or estimated.

5.2.3 Soil

Limited information is available on the releases of 1,1-dichloroethene to soil. An estimated total of 180 pounds/year of 1,1-dichloroethene are disposed of in municipal landfills as residual monomer in some consumer products on a national basis (Neufeld et al. 1977).

According to TRI91 (1993), an estimated total of 15 pounds (0.007 metric tons) of 1,1-dichloroethene, amounting to 0.005% of the total environmental release, was discharged to soil from manufacturing and processing facilities in the United States in 1991 (TRW1 1993). The TRI data should be used with caution since only certain types of facilities are required to report.

5.3 ENVIRONMENTAL FATE

5.3.1 Transport and Partitioning

The tendency of a chemical to partition between soil, water, sediment, air, and biota can be inferred from its physical/chemical properties. Based on a vapor pressure of 592 mmHg (Verschuere 1983), most of the 1,1-dichloroethene released into the environment will ultimately partition into the atmospheric compartment as shown by the vapor partitioning model of Mackay and Paterson (1981) although other factors such as water solubility may affect the rate at which the partitioning will occur. In localized situations, intervening processes such as biotransformation, may alter this outcome.

As the magnitude of the Henry's law constant for 1,1-dichloroethene, 0.19 atmospheres m³/mole (Pankow and Rosen 1988), indicates, 1,1-dichloroethene is likely to partition readily into the atmosphere from water. Because of this, 1,1-dichloroethene is generally not found in surface water in high concentrations. Studies on atmospheric removal processes indicate that once in the

5. POTENTIAL FOR HUMAN EXPOSURE

atmosphere, 1,1-dichloroethene is unlikely to be removed by physical processes such as wet deposition (e.g., rain) or by adsorption to atmospheric particulates (EPA 1980d).

1, 1-Dichloroethene spilled onto surface soil will also tend to partition to the atmosphere, while some of the chemical may percolate into the subsurface soil. Once in the subsurface soil, 1,1-Dichloroethene will partition between soil and water. 1,1-dichloroethene has high water solubility and a small log soil organic carbon sorption coefficient (K_{oc}) value of 1.81 (EPA 1982) indicating that 1, 1-dichloroethene will migrate through soil without significant retardation by adsorption to organic carbon. Similarly, 1,1-dichloroethene will migrate relatively freely within groundwater.

1,1- Dichloroethene in surface water is unlikely to partition significantly into aquatic organisms. Although measured bioconcentration factors were not located in the available literature, partitioning of 1,1-dichloroethene from water into aquatic organisms can be predicted in part by the magnitude of the octanol/water partition coefficient (K_{ow}) value. The chemicals with a log K_{ow} of <4.0 are unlikely to bioaccumulate to hazardous levels in human food chains (Veith et al. 1985). The log K_{ow} is 2.13 (Veith et al. 1985) and based upon this calculation, bioaccumulation in the human food chain is not expected to be significant for this compound.

5.3.2 Transformation and Degradation

Transformations of 1,1-dichloroethene can occur from the reaction with radical species in the atmosphere and from biodegradation under anaerobic conditions in soil or water.

5.3.2.1 Air

Atmospheric degradation of 1,1-dichloroethene is expected to be dominated by gas-phase oxidation with photochemically produced hydroxyl radicals. An experimental rate constant for this process of 8.11×10^{-12} cm³/molecule-second at 25°C has been determined (Tuazon et al. 1988) and has been recommended as the best value in an extensive review of the reaction of hydroxyl radicals with organic compounds (Atkinson 1989). Using an average atmospheric hydroxyl radical concentration of 5×10^5 molecule/cm³, a half-life of 2-3 days can be calculated for this process (EPA 1980d; Tuazon et al. 1988). A higher atmospheric concentration of hydroxyl radicals

5. POTENTIAL FOR HUMAN EXPOSURE

(10^6 molecules/cm³) will reduce the half-life of 1,1-dichloroethene to 4-20 hours (Grosjean 1990). The products from this reaction are phosgene, formaldehyde, and chloroacetyl chloride (Tuazon et al. 1988).

Atmospheric degradation of 1,1-dichloroethene may also occur by a gas-phase reaction with other atmospheric oxidants, namely ozone and nitrate radicals, although these processes are too slow to successfully compete with the reaction of 1,1-dichloroethene with hydroxyl radicals (Grosjean 1990). An experimental rate constant for the gas-phase reaction of ozone with 1,1-dichloroethene of 3.7×10^{11} cm³/molecule-second at 25°C (Atkinson and Carter 1984) translates to an atmospheric half-life of more than 10 years for this process using an average atmospheric ozone concentration of 7×10^{11} molecule/cm³. Nitrate radicals are destroyed by sunlight, and the oxidation of organic compounds by this oxidant is only important at night. The rate constant for the oxidation of 1,1-dichloroethene by nitrate radicals, 1.78×10^{-15} cm³/molecule-second at 25°C (Sabljić and Gusten 1990), translates to a half-life of 19 days in a moderately polluted atmosphere, although at nitrate concentrations of 50 ppt the half-life may be reduced to 6 days (Grosjean 1990). Reaction products of 1,1-dichloroethene with hydroxyl radicals and nitrates in air include chloroacetyl chloride, phosgene, formaldehyde, carbon monoxide, and nitric acid (EPA 1983a).

Another process for release of organic compounds in the atmosphere is by direct photolytic degradation; however, because chloroethenes do not adsorb radiation at wavelengths <300 nm to any significant extent (EPA 1980d; Tuazon et al. 1988), this process is not an important degradation pathway for 1,1-dichloroethene.

5.3.2.2 Water

Biotransformation under anaerobic conditions is believed to be the dominant transformation process for 1,1-dichloroethene in groundwater. However, Ensign et al. 1992 observed that 1,1-dichloroethene was not degraded efficiently by propylene-grown *Xanthobacter*-cells (strain Py2) under anaerobic conditions. The environmental media was not reported. The importance of this process under aerobic conditions, such as those normally found in ambient surface water, has not been determined. Conflicting results have been obtained for the aerobic degradation of 1,1-dichloroethene. Several investigations (Bouwer et al. 1981; McCarty et al. 1986; Pearson and McConnel 1975) have uncovered no evidence for biotransformation of chlorinated ethenes such

5. POTENTIAL FOR HUMAN EXPOSURE

as 1,1-dichloroethene under aerobic conditions. In contrast, Tabak et al. (1981) reported transformation of 54% of 5 mg/L and 30% of 10 mg/L test concentrations of 1,1-dichloroethene under aerobic conditions within 1 week after incubation with a domestic waste water seed; these removal figures were adjusted to account for volatilization losses from control flasks of 24% for the 5 mg/L and 15% for the 10 mg/L test concentrations.

Under anaerobic conditions (such as those that occur in groundwater), the importance of biotransformation is more clearly defined. McCarty et al. (1986) found that 1,1-dichloroethene was nearly quantitatively reduced to vinyl chloride under methanogenic conditions after 108 days. In another study, vinyl chloride was produced from the reductive dechlorination of 1,1-dichloroethene by microorganisms in anoxic microcosms after 1-2 weeks of incubation (Barrio-Lage et al. 1986). Wilson et al. (1986) studied the behavior of 1,1-dichloroethene in authentic aquifer material known to support methanogenesis. The disappearance of this compound was observed with an initial long lag time, and vinyl chloride, a daughter product of degradation, was found in trace amounts. Baek et al. (1990) also observed the formation of vinyl chloride under anaerobic conditions when 1,1-dichloroethene was incubated with digested sludge under both fermentive and methanogenic conditions. Vinyl chloride has been classified as a possible human carcinogen by EPA (EPA 1985a); ATSDR has produced a toxicological profile on this compound (ATSDR 1990).

Photolysis and hydrolysis of 1,1-dichloroethene in natural aquatic media are not significant processes (EPA 1982). The estimated half-life for hydrolysis of 1,1-dichloroethene at 25°C under neutral (or slightly basic) conditions is 1.2×10^8 years (Jeffers et al. 1989). Similarly, oxidation is not a significant transformation mechanism for 1,1-dichloroethene in aqueous environments. Degradation rates due to reactions with singlet oxygen and the peroxy radical are not estimated to be environmentally significant in aquatic systems (EPA 1980e).

5.3.2.3 Sediment and Soil

A methane-utilizing culture isolated from lake sediment was able to degrade 600 ng/mL 1,1-dichloroethene to 200 ng/mL under aerobic conditions within 2 days. The end products were nonvolatile and did not include vinyl chloride which is known to be formed under anaerobic conditions (Fogel et al. 1986).

5. POTENTIAL FOR HUMAN EXPOSURE

5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

5.4.1 Air

The National Ambient Volatile Organic Compound Database, updated in 1988 to include ambient and indoor volatile organic compounds (VOCs) concentrations in urban, rural, remote, source-dominated and indoor environments, reports an ambient daily average concentration for 1,1-dichloroethene of 4.6 ppb (Shah and Heyerdahl 1988). The ambient average concentration represents contributions from rural, suburban, urban, and source-dominated sites. In a survey of the indoor air of 26 homes and apartments near Research Triangle Park, North Carolina, 1,1-dichloroethene was found in 4 of 15 summer samples at a mean concentration of 47.3 ppb and 4 of 16 winter samples at a mean concentration of 7.1 ppb (EPA 1985). The EPA TEAM (Total Exposure Assessment Measurement) studies measured 1,1-dichloroethene concentrations in 1,085 personal air samples collected from 350 New Jersey residents (discrepancy in the actual number of residents sampled) over three seasons. Only 77 (7%) of the samples had measurable concentrations of 1,1-dichloroethene, and 107 (10%) of the samples had trace levels. The detection limit ranged from 3 to 14 $\mu\text{g}/\text{m}^3$ (Wallace 1991).

The results of an on-site field data collection program based on short-term studies conducted in seven U.S. cities indicated that 1,1-dichloroethene was present in air at an average concentration range of 0.005-0.03 ppb in various cities (Singh et al. 1981, 1982). 1,1-Dichloroethene was detected in 24 of 79 ambient air samples (collected from 1986 to 1987 in the Kanawha Valley, West Virginia; Los Angeles, California; and Houston, Texas) at a mean concentration of 0.84 ppb (Pleil et al. 1988). It was also found in 33 of 35 ambient air samples (collected in Newark, New Jersey, July-August 1981) at a geometric mean concentration of 0.38 ppb (Harkov et al. 1987). Corresponding values for Elizabeth and Camden, New Jersey, were 33 of 34 samples at a mean concentration of 0.35 ppb and 28 of 30 samples with a mean concentration of 0.36 ppb, respectively (Harkov et al. 1987).

1,1-Dichloroethene has been measured in air in the vicinity of five of six hazardous waste sites as well as a sanitary landfill in New Jersey (1983-1984), with arithmetic mean concentrations ranging from 0.39 to 38.9 ppb measured at waste sites, and an arithmetic mean concentration of 2.6 ppb measured at the sanitary landfill. The highest concentration measured at these six sites was

5. POTENTIAL FOR HUMAN EXPOSURE

97 ppb (Harkov et al. 1985; LaRegina et al. 1986). Although quantitative information on the air concentrations of 1,1-dichloroethene at hazardous waste sites on the NPL is not available, 1,1-dichloroethene is probably present in air at those NPL sites where it has been measured in either the soil, surface water, or groundwater.

5.4.2 Water

1,1-dichloroethene concentrations >5 mg/L have been measured in raw waste water from the metal finishing and nonferrous metals manufacturing industries (EPA 1981). Lower concentrations (<1 mg/L) have been measured in raw waste water from industries involving paint and ink formulation, soap and detergent manufacturing, coil coating, battery manufacturing, coal mining and laundries (EPA 1981). Treated waste waters from all these industries ranged from <1 to 4 mg/L (EPA 1981). According to the STORET database maintained by the EPA, 1,1-dichloroethene has been detected in 3.3% of 1,350 effluent samples monitored nationwide (Staples et al. 1985).

1,1-dichloroethene has been detected in surface waters sampled near industrial sites at concentrations ranging from less than 1 to 550 $\mu\text{g/L}$ (Going and Spigarelli 1977). According to the STORET database maintained by the EPA, 1,1-dichloroethene has been detected in 6% of 8,714 surface water samples monitored nationwide (Staples et al. 1985). However, no 1,1-dichloroethene was detected in raw surface water during a 105-city survey of U.S. cities (Coniglio and Miller 1980). 1,1-dichloroethene has been detected infrequently at low concentrations in urban runoff that will contribute to surface water concentrations. The Nationwide Urban Runoff Program (NURP), initiated to evaluate the significance of priority pollutants in urban storm water runoff, report a detection frequency of only 3%, with a concentration range of 1.5-4 $\mu\text{g/L}$ (Cole et al. 1984).

About 3% of the drinking water supplies in the United States have been found to contain 1,1-dichloroethene at 0.2-0.5 $\mu\text{g/L}$ (estimated mean 0.3 $\mu\text{g/L}$) concentration in an EPA survey (EPA 1985a). 1,1-dichloroethene was also detected (quantification limit of 0.2 ppb) in 2.3% of the 945 samples of finished drinking water taken from community-based groundwater sources in a nationwide survey (Rajagopal and Li 1991, Westrick et al. 1984). The maximum concentration of 1, 1-dichloroethene detected in the positive samples was 6.3 $\mu\text{g/L}$ (subset median values were

5. POTENTIAL FOR HUMAN EXPOSURE

0.28-1.2 µg/L). 1,1-dichloroethene was detected in 9 of 466 U.S. drinking water wells sampled in the 1982 Ground Water Supply Survey at a median concentration of 0.3 µg/L (Cotruvo 1985).

1,1-dichloroethene has been detected in 25.2% of 178 contaminated sites monitored under the Comprehensive Emergency Response, Compensation, and Liability Act (CERCLA) making it the fifth most frequently detected organic contaminant at these sites (Plumb 1987). Contamination of groundwater at an industrial site in Waite Park, MN, resulting from the mishandling of waste product, paint, and solvent led to a maximum 1,1-dichloroethene concentration of 88 µg/L in deep monitoring wells and 22 µg/L in shallow wells (ATSDR 1990). This aquifer contamination led to a maximum 1,1-dichloroethene concentration of 94 µg/L in Waite Park municipal wells resulting in this city's water supply being listed as an NPL site. The disposal of organic chemicals in trenches at a waste disposal site near Ottawa, Canada, resulted in 1,1-dichloroethene groundwater concentrations ranging from 0.9 to 60 µg/L in 43% of samples taken from a 37-well monitoring network in 1988 (Lesage et al. 1990). Leachate originating from the Orange County and Alachua Municipal Landfills in north central Florida resulted in groundwater contamination near the landfills. The average concentration of 1,1-dichloroethene in wells sampled near the Orange County Landfill and the Alachua Municipal Landfill was 0.12 and < 1.0 µg/L, respectively (Hallbourg et al. 1992). 1,1-dichloroethene has also been detected in groundwater sampling surveys conducted in New Jersey (Cain et al. 1989; Fusillo et al. 1985).

The concentration of 1,1-dichloroethene in leachate from the Moyer Landfill in Collegeville, Pennsylvania, classified as an NPL site by the EPA in 1982, ranged from 1 to 2 ppb (Varma 1985). In a 1987-1988 survey of groundwater contamination at 19 municipal and 6 industrial landfills in Wisconsin, 1,1-dichloroethene was detected at 1 site at an average concentration of 3.4 µg/L (Battista and Connelly 1988).

5.4.3 Sediment and Soil

No information is available on ambient concentrations of 1,1-dichloroethene in soil, although this chemical is often found at hazardous waste sites. Because of the tendency of 1,1-dichloroethene to partition into the atmosphere, with remaining material having the potential to percolate into groundwater, ambient concentrations in surface soil are expected to be low. No information is available on the concentration of 1,1-dichloroethene in sediment.

5. POTENTIAL FOR HUMAN EXPOSURE

5.4.4 Other Environmental Media

1,1-dichloroethene copolymers are used in the manufacture of films used in food packaging. Residual 1,1-dichloroethene monomer has been detected at concentrations of <0.02-1.26 ppm in retail food packaging films containing polyvinylidene chloride; residues in a variety of foodstuffs wrapped with the films were in the range of ≤ 0.005 -0.01 ppm (Gilbert et al. 1980).

Concentrations of residual 1,1-dichloroethene in household films used to package food were reported by Birkel et al. (1977) to be 6.5-10.4 ppm (average 8.8 ppm). At one time, some films contained as much as 30 ppm 1,1-dichloroethene (Birkel et al. 1977). No information on the levels of 1,1-dichloroethene in humans was located.

1,1-dichloroethene was detected in a composite sample of Rigolets clams obtained from Lake Pontchartrain, Louisiana, in 1980 at a concentration of 4.4 ppb wet weight (Ferrario et al. 1985).

5.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

Information on exposure of the general population to 1,1-dichloroethene is limited. An EPA TEAM study conducted from 1980 to 1987, reported that the average exposure of the general population to 1,1-dichloroethene is $6.5 \mu\text{g} / \text{m}^3$ based on personal air samples from 350 homes in New Jersey (Wallace 1991).

The National Occupational Hazard Survey (NOHS), conducted by the National Institute for Occupational Safety and Health (NIOSH), estimated that 56,857 workers in 3,853 plants were potentially exposed to 1,1-dichloroethene in the workplace in 1970 (NIOSH 1976). These estimates were derived from observation of the actual use of 1,1-dichloroethene (1%), the use of trade-name products known to contain 1,1-dichloroethene (19%), and the use of generic products suspected of containing the compound (80%). The largest numbers of exposed workers were special trade contractors or in the fabricated metal products industry or wholesale trade industry. The occupational groups of exposed workers consisted of carpenters, warehousemen (not otherwise classified), and miscellaneous machine operators.

Data from a second workplace survey, the National Occupational Exposure Survey (NOES), conducted by NIOSH from 1980 to 1983, indicated that 2,679 workers, including 291 women, in

5. POTENTIAL FOR HUMAN EXPOSURE

97 plants were potentially exposed to 1,1-dichloroethene in the workplace in 1980 (NIOSH 1984). The greatest number of exposed workers were chemical technicians. All estimates were derived from observations of the actual use of the compound.

Neither the NOHS nor the NOES databases contain information on the frequency, concentration, or duration of exposure of workers to any of the chemicals listed therein. Rather, they only provide estimates of workers potentially exposed to the chemicals.

Varying occupational exposure levels can be found in the literature. Reported ranges of concentrations associated with the monomer and polymer plants are \approx 23-25 ppb and 6-12 ppb, respectively (Walling 1984). Exposure concentrations \leq 1,900 ppm have been reported in a copolymer monofilament fiber production plant (Ott et al. 1976). However, in polymer manufacturing plants, worker exposure has been reported as $<$ 5 ppm (Jaeger 1975). Wallace (1991) reported an exposure concentration of 120 ppm for a cabinet maker; however, the concentration decreased to 14 ppm when measured during a different season (the seasons were not reported).

1,1-dichloroethene was produced in significant amounts that under certain conditions may approach 100%, from the thermal degradation of methyl chloroform (Glisson et al. 1986). This implies that inadvertent exposure to 1,1-dichloroethene may occur in many industrial situations when methyl chloroform is used in the vicinity of operations involving heat, such as welding or soldering and metal cleaning. 1,1-dichloroethene has also been detected as a pyrolysis product of the pesticide endosulfan in tobacco smoke (Chopra et al. 1978).

The Occupational Safety and Health Administration (OSHA) recently reduced the 8-hour timeweighted-average (TWA) permissible exposure level (PEL) to 1 ppm (OSHA 1989), which should limit future workplace exposures to low levels of this compound.

5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Human exposure to 1,1-dichloroethene is potentially highest in workplace settings and among populations residing in the vicinity of hazardous waste sites where the compound may contaminate environmental media.

5. POTENTIAL FOR HUMAN EXPOSURE

The presence of residual monomeric 1,1-dichloroethene in polymeric food wraps and other consumer products is another potential source of human exposure. Exposure from these sources is difficult to estimate. However, there is no evidence in the literature to implicate consumer products as major sources of 1,1-dichloroethene exposure (EPA 1985a).

In addition to releases from hazardous waste sites, ambient air and water may be contaminated with 1,1 -dichloroethene by releases from industrial production and polymerization processes (EPA 1977, 1985a; Wang et al. 1985a, 1985b). Levels are significantly higher in areas surrounding production sites (EPA 1977, 1985a).

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 1,1-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 1,1-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. Available data adequately characterize the physical and chemical properties of 1,1-dichloroethene (HSDB 1992; Merck 1983) (see Chapter 3).

Production, Import/Export, Use, and Disposal. 1,1-dichloroethene is produced commercially. The estimated production of the compound in 1989 totalled 230 million pounds, up from an

5. POTENTIAL FOR HUMAN EXPOSURE

estimated production capacity of 178 million pounds/year in 1985. 1,1-dichloroethene is used as an intermediate in the synthesis of other organic chemicals and polymers, including flexible films for food packaging. Monomeric 1,1-dichloroethene has been detected in many food packaging materials and foodstuffs. 1,1-dichloroethene is released mainly to the atmosphere. EPA requires compliance with RCRA regulations when producing, treating, storing, or disposing of 1,1-dichloroethene. Current disposal regulations require dissolving the compound in combustible solvents and scatter spraying the solvent into a furnace with an afterburner and alkaline scrubber. Additional information on the current criteria for land treatment and burial and on the amounts of 1,1-dichloroethene disposed of by incineration versus landfilling would be helpful.

According to the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. Section 11023, industries are required to submit chemical release and off-site transfer information to the EPA. The Toxics Release Inventory (TRI), which contains this information for 1990, became available in May of 1992. This database will be updated yearly and should provide a list of industrial production facilities and emissions.

Environmental Fate. The available data suggest that 1,1-dichloroethene can undergo transformation due to the reaction with radical species in the atmosphere and biodegradation under anaerobic conditions in water and under aerobic conditions in soil (Ensign et al. 1992; Foget et al. 1986; Grosjean 1990; Tabak et al. 1981; Tuazon et al. 1988). The atmospheric half-life of 1,1-dichloroethene in air following hydroxyl radical reaction is estimated to be 4-20 hours, and the products of this reaction are phosgene, formaldehyde, and chloroacetyl chloride (Tuazon et al. 1988). The estimated half-life for hydrolysis of 1,1-dichloroethene at 25°C under neutral conditions is 1.2×10^8 years (Jeffers et al. 1989). 1,1-dichloroethene is reduced to vinyl chloride under methanogenic conditions (McCarty et al. 1986). In a methane-utilizing culture from lake sediment, 1,1-dichloroethene was degraded under aerobic conditions within 2 days; the end products, although unspecified, did not include vinyl chloride. More information is needed to define these processes and to quantify degradation rates. Such information would be helpful in understanding the fate of nonvolatilized 1,1-dichloroethene in these media.

Bioavailability from Environmental Media. The monitoring data available indicate that 1,1-dichloroethene is present in some samples of air, water, soil, and foodstuffs (EPA 1981, IW5a; Gilbert et al. 1980; Shah and Heyerdahl 1988; Singh et al. 1981; Verma 1985). Animal studies

5. POTENTIAL FOR HUMAN EXPOSURE

indicate that 1,1 -dichloroethene is absorbed following inhalation and oral exposure. 1,1 -dichloroethene and its metabolites can be measured in the breath, blood, urine, and adipose tissue of humans. Thus, it can be concluded that 1,1-dichloroethene is bioavailable from the environment. Good quantitative data that correlate varying levels in the environment with levels in the body and health effects and data on the extent to which 1,1-dichloroethene can be absorbed from various media (i.e., soil) are lacking. This information may be difficult to obtain since environmental levels can fluctuate widely and exposure may be sporadic.

Food Chain Bioaccumulation. No information was found regarding the bioconcentration of 1,1-dichloroethene in plants, aquatic organisms, or animals. On the basis of the log octanol/water partition coefficient value of 2.13 (EPA 1982), bioconcentration of the compound to significant levels by terrestrial or aquatic organisms is not expected. No data were located regarding the biomagnification of 1,1-dichloroethene in terrestrial or aquatic food chains. Given the expected limited bioconcentration (Barrio-Lage et al. 1986; Wilson et al. 1986) of the compound in the tissues of terrestrial and aquatic organisms, and the extent to which 1,1-dichloroethene undergoes biotransformation, biomagnification in terrestrial and aquatic food chains is not expected. Additional experimental data to confirm this predicted limited food chain bioaccumulation of 1,1-dichloroethene would be helpful in evaluating the relative significance of this route of exposure.

Exposure Levels in Environmental Media. Data on the concentrations of 1,1-dichloroethene in surface water, soil, and food, are limited (EPA 1981, 1985a; Gilbert et al. 1980; Shah and Heyerdahl 1988; Singh et al. 1981; Verma 1985). More data are needed to provide a more complete characterization of human exposure. The concentration of 1,1-dichloroethene in the air above hazardous waste sites and in groundwater near them is not well documented. The available data indicate that human exposure may occur because of 1,1-dichloroethene's presence in these environmental media. Additional monitoring data will better address the degree to which it occurs.

Reliable monitoring data for the levels of 1,1-dichloroethene in contaminated media at hazardous waste sites are needed so that the information obtained on levels of 1,1-dichloroethene in the environment can be used in combination with the known body burden of 1,1-dichloroethene to

5. POTENTIAL FOR HUMAN EXPOSURE

assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

Exposure Levels in Humans. Although an analytical method is available to detect 1,1-dichloroethene in human tissue, no studies were found that measured its levels in human tissues. Most of the data on exposure levels of 1,1-dichloroethene are based on occupational studies conducted under controlled environmental conditions (Walling 1984), and these data are not current. More current information on the potential exposure resulting from residence in the vicinity of hazardous waste sites would provide a more accurate characterization of human exposure in the United States.

This information is useful for assessing the need to conduct health studies on these populations.

Exposure Registries. No exposure registries for 1,1-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.

5.7.2 On-going Studies

One on-going study on the environmental fate, including the accumulation and biodegradation of 1,1-dichloroethene was located. The study is being conducted by the EPA, and further details are not available (EXICHEM 1993). Remedial investigations and feasibility studies at NPL sites known to have 1,1-dichloroethene contamination (NPLTD 1988) should be completed in the near future and may add to the current knowledge regarding the transport and degradation of 1,1-dichloroethene in the environment.

Environmental monitoring conducted in conjunction with remedial investigation/feasibility studies at hazardous waste sites on the NPL should add to the current database on environmental levels of 1,1-dichloroethene.

5. POTENTIAL FOR HUMAN EXPOSURE

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 and Injury Control, Centers for Disease Control, will be analyzing human blood samples for 1,1-dichloroethene and other volatile organic compounds.

Studies being conducted at the University of California, Riverside, will use *cis*- and *trans*-1,2-dichloroethene as surface probes to evaluate interactive mechanisms with individual soil constituents (CRIS USDA 1993). These data will give an indication of the frequency of occurrence and background levels of these compounds in the general population.