

6. POTENTIAL FOR HUMAN EXPOSURE

6.1 OVERVIEW

The majority of dichloropropene data pertaining to environmental releases, environmental fate and partitioning, monitoring in environmental media, and the potential for human exposure have been provided for the 1,3- isomer only. This is most likely because 1,3-dichloropropene is produced in much larger quantities than the other isomers and it is released directly into the environment as a pesticide. Therefore, the focus of this chapter is on 1,3-dichloropropene. Relevant data regarding 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene are included whenever available.

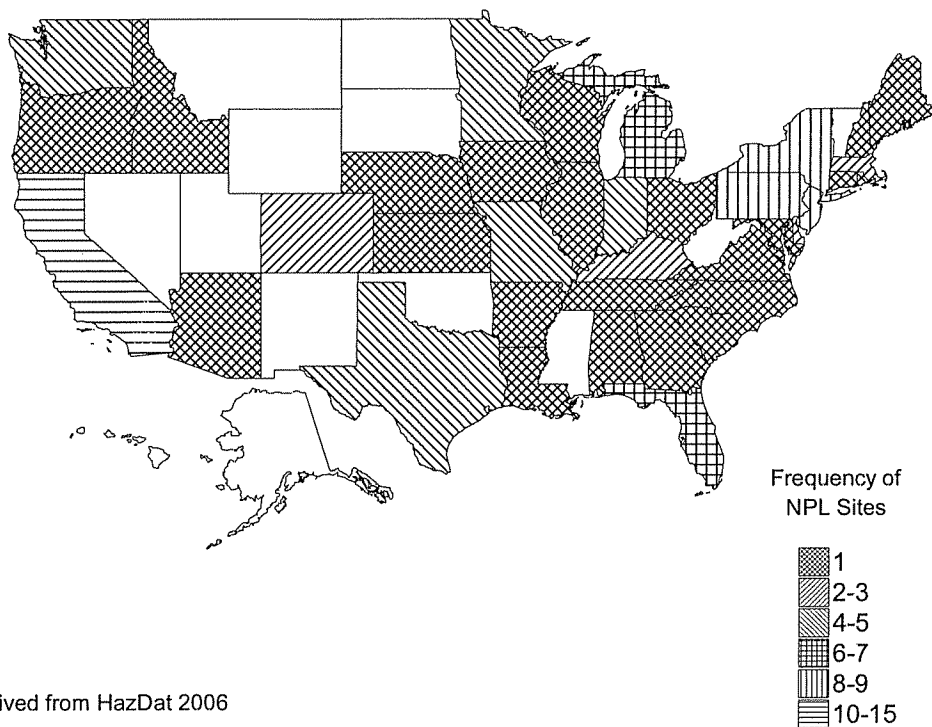
1,2-, 1,3-, and 2,3-Dichloropropene have been identified in at least 5, 112, and 3 of the 1,678 hazardous waste sites, respectively, that have been proposed for inclusion on the EPA National Priorities List (NPL) (HazDat 2006). However, the number of sites evaluated for 1,2-, 1,3-, and 2,3-dichloropropene is not known. The frequency of sites where 1,3-dichloropropene has been identified can be seen in Figure 6-1, while those where 1,2- and 2,3-dichloropropene have been identified can be seen in Figures 6-2 and 6-3, respectively. 1,1- and 3,3-Dichloropropene were not identified in any of the 1,678 hazardous waste sites that have been proposed for inclusion on the EPA NPL.

1,3-Dichloropropene is not a naturally occurring compound (IARC 1986). It is produced synthetically and may be released to the atmosphere in fugitive or accidental emissions during its manufacture, storage, and transport. 1,3-Dichloropropene's use as a soil fumigant for the control of nematodes in various crops will result in its direct release to the environment (EPA 1978a; Lao et al. 1982). 1,3-Dichloropropene is typically applied to soils prior to planting by underground injection at a depth of 12–18 inches (EPA 1998b). Due to its volatile nature, it may migrate to the soil surface where it volatilizes to air. In order to reduce potential emissions to air and increase the effectiveness of 1,3-dichloropropene as a fumigant, soil sealing techniques such as immediate irrigation, soil compacting, and covering the treated fields with tarps are common agricultural practices when using 1,3-dichloropropene and other fumigants (EPA 1998b).

1,3-Dichloropropene may leach into groundwater and soil from landfills and hazardous waste sites (Hauser and Bromberg 1982; Sabel and Clark 1984). The most common release of 1,3-dichloropropene to soil occurs during the application of the chemical to agricultural fields when used as a soil fumigant

6. POTENTIAL FOR HUMAN EXPOSURE

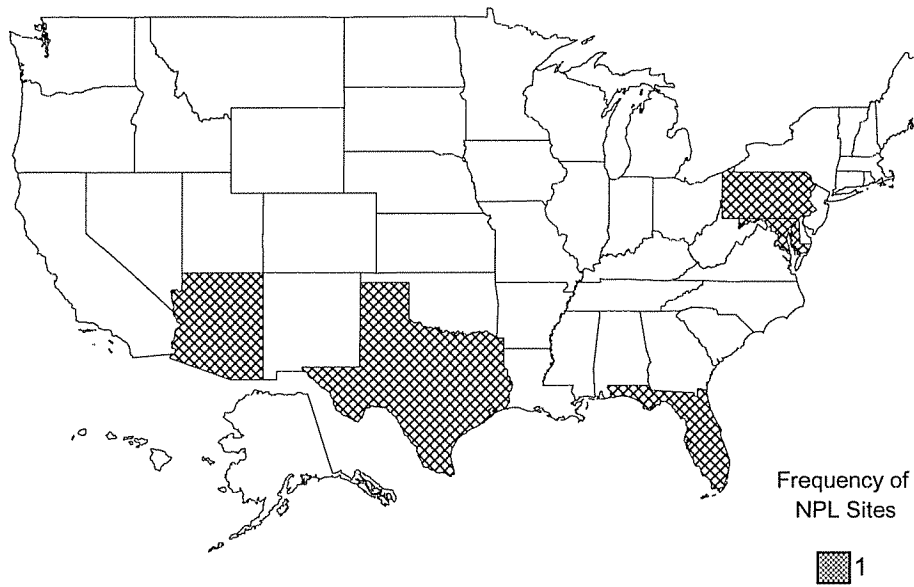
Figure 6-1. Frequency of NPL Sites with 1,3-Dichloropropene Contamination



Derived from HazDat 2006

6. POTENTIAL FOR HUMAN EXPOSURE

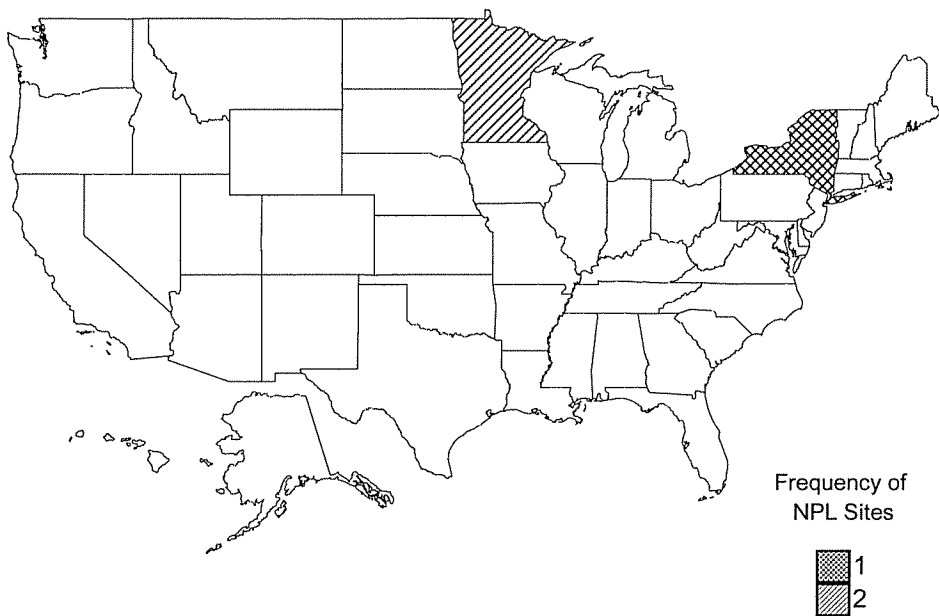
Figure 6-2. Frequency of NPL Sites with 1,2-Dichloropropene Contamination



Derived from HazDat 2006

6. POTENTIAL FOR HUMAN EXPOSURE

Figure 6-3. Frequency of NPL Sites with 2,3-Dichloropropene Contamination



Derived from HazDat 2006

6. POTENTIAL FOR HUMAN EXPOSURE

(CEPA 1982; Cohen 1986; Krijgsheld and Van der Gen 1986; Maddy et al. 1982). Accidental spills may also release 1,3-dichloropropene to the environment (Markovitz and Crosby 1984; Sterrett et al. 1986). Releases of 1,1-, 1,2-, and 3,3-dichloropropene into the environment are expected to be low since these substances are not produced or used on a large scale for commercial or industrial purposes. 2,3-Dichloropropene may be released from facilities where it is produced or used.

Limited monitoring data are available for 1,3-dichloropropene in surface water, drinking water, and soil; however, the existing data indicate that this substance is not widely detected in these media (Dowty et al. 1975a, 1975b; EPA 2006j; Krijgsheld and Van der Gen 1986; Otson 1987; Rogers et al. 1987). 1,3-Dichloropropene has not been detected in table-ready foods (EPA 1998b; FDA 2005b). 1,3-Dichloropropene was positively detected in air in generally <5% of urban air samples collected across the United States. Mean concentrations among the positive samples from both urban and rural locations across the United States ranged from 0.088 to 0.33 ppb. 1,3-Dichloropropene air concentrations as high as 35.2 ppb have been measured at high-use locations. A few nationwide surveys have been conducted in which 1,3-dichloropropene was analyzed for in water; however, only the STORET database lists positive detections of this substance (EPA 2006j; Kolpin et al. 2000; Moran et al. 2004). 1,3-Dichloropropene was detected in approximately 40% of 12,673 water samples listed in STORET (EPA 2006j). However, only 6% of the samples contained 1,3-dichloropropene above the quantitation limit (unspecified). The range, mean, and median of quantifiable 1,3-dichloropropene concentrations were 0.002–25, 0.5, and 0.5 ppb, respectively. 1,3-Dichloropropene was detected in only 0.1% of 70,631 public water system samples collected in the United States between 1993 and 1997 (EPA 2001c).

1,1-, 1,2-, 2,3-, and 3,3-Dichloropropene are not commonly found at measurable concentrations in air, surface water, drinking water, groundwater, soil, or food. 1,1-Dichloropropene has been detected in 64% of 5,348 water samples listed in STORET, but only 1% of the samples contained 1,1-dichloropropene above the quantifiable limit. The range of quantifiable concentrations in water was 0.001–5 ppb, with a mean of 0.4 ppb (EPA 2006j). 1,1-Dichloropropene was detected in only 0.01% of 97,698 public water system samples collected in the United States between 1993 and 1997 (EPA 2001c).

Possible routes of human exposure to 1,3-dichloropropene include inhalation, ingestion of contaminated drinking waters, and dermal contact. 1,3-Dichloropropene is rarely detected in foods due to its relatively short environmental persistence; therefore, exposure to the general population through the consumption of food is considered to be low. High levels of exposure to 1,3-dichloropropene are most likely to occur in occupational settings where 1,3-dichloropropene is either produced or used as a soil fumigant (Albrecht

6. POTENTIAL FOR HUMAN EXPOSURE

1987b; Albrecht et al. 1986; Markovitz and Crosby 1984; Nater and Gooskens 1976; Osterloh et al. 1984, 1989a, 1989b; van Joost and de Jong 1988; Wang 1984). Intake by inhalation or dermal contact is the most probable route of workplace exposure to 1,3-dichloropropene. 1,3-Dichloropropene is a volatile compound and, after soil application as a fumigant, a fraction of the compound will volatilize and escape into the atmosphere (Krijgsheld and Van der Gen 1986). Inhalation and dermal contact are probably the major sources of exposure to individuals who work in fields where 1,3-dichloropropene is applied.

The potential for human exposure to 1,1-, 1,2-, and 3,3-dichloropropene is expected to be low because they are not produced or used in high amounts. Since 2,3-dichloropropene may be released from facilities where this substance is produced or used, individuals who work or live near these facilities may be exposed to this substance; however, exposure of the general population to 2,3-dichloropropene is not expected to be important.

6.2 RELEASES TO THE ENVIRONMENT

The Toxics Release Inventory (TRI) data should be used with caution because only certain types of facilities are required to report (EPA 2005a). This is not an exhaustive list. Manufacturing and processing facilities are required to report information to the TRI only if they employ 10 or more full-time employees; if their facility is included in Standard Industrial Classification (SIC) Codes 10 (except 1011, 1081, and 1094), 12 (except 1241), 20–39, 4911 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4931 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4939 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4953 (limited to facilities regulated under RCRA Subtitle C, 42 U.S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited to facilities primarily engaged in solvents recovery services on a contract or fee basis); and if their facility produces, imports, or processes $\geq 25,000$ pounds of any TRI chemical or otherwise uses $>10,000$ pounds of a TRI chemical in a calendar year (EPA 2005a).

6.2.1 Air

Estimated releases of 4,129 pounds (1.9 metric tons) of 1,3-dichloropropene to the atmosphere from 15 domestic manufacturing and processing facilities in 2003, accounted for about 92% of the estimated total environmental releases from facilities required to report to the TRI (TRI04 2006). Estimated

6. POTENTIAL FOR HUMAN EXPOSURE

releases of 5,391 pounds (2.4 metric tons) of 2,3-dichloropropene to the atmosphere from five domestic manufacturing and processing facilities in 2004, accounted for about 99% of the estimated total environmental releases from facilities required to report to the TRI (TRI04 2006). These releases of 1,3- and 2,3-dichloropropene are summarized in Tables 6-1 and 6-2, respectively. 1,1-, 1,2-, and 3,3-Dichloropropene were not listed in the TRI.

1,3-Dichloropropene is produced synthetically and may be released to the atmosphere as fugitive or accidental emissions during its manufacture (Leiber and Berk 1984; van Joost and de Jong 1988), transport (Markovitz and Crosby 1984; Sterrett et al. 1986), and storage (Albrecht et al. 1986). For example, on April 8, 1984, a rail accident that occurred about 45 miles southeast of Tucson, Arizona resulted in a spill of 15,000 gallons of 1,3-dichloropropene. During the clean-up, which took place between August 1984 and March 1985, approximately 19,000 pounds of 1,3-dichloropropene were released to ambient air by an aeration process (Sterrett et al. 1986).

A major anthropogenic release of 1,3-dichloropropene to the atmosphere occurs during its application as a soil fumigant (Albrecht 1987a; Markovitz and Crosby 1984; Osterloh et al. 1984, 1989a, 1989b). Current application methods involve injecting the fumigant at least 12 inches below the soil surface (EPA 1998b). Off-gassing of 1,3-dichloropropene in chisel trace left behind during application occurs for several days after application. Current methods used to minimize volatilization of 1,3-dichloropropene after application include soil compaction, irrigation, and covering with a tarp (EPA 1998b). Modification of current application methods and the use of organic and fertilizer amendments are being explored as ways to further minimize air emissions of 1,3-dichloropropene from treated fields (Gan et al. 1998a, 1998b; Kim et al. 2003b; Wang et al. 2001a, 2001b).

1,3-Dichloropropene was detected in atmospheric samples of three sites located in Washington state, Arizona, and North Carolina following its application (NCFR 1997). 1,3-Dichloropropene was broadcast applied to a 20-acre loamy sand field at an application rate of 252 lbs a.i./A at the Washington state site. It was row applied to a 20-acre sandy loam located in Arizona at a rate of 121.2 lbs a.i./A, and was broadcast applied at a rate of 164 lbs a.i. to a 12-acre sandy loam plot in North Carolina used to grow tobacco. Atmospheric samples were monitored over a 15-day period at each site and at distances of up to 1,600 meters from the site. These data are summarized in Table 6-3.

6. POTENTIAL FOR HUMAN EXPOSURE

Table 6-1. Releases to the Environment from Facilities that Produce, Process, or Use 1,3-Dichloropropene^a

State ^c	RF ^d	Reported amounts released in pounds per year ^b							
		Air ^e	Water ^f	UI ^g	Land ^h	Other ⁱ	Total release		
							On-site ^j	Off-site ^k	On- and off-site
AR	1	0	0	0	0	0	0	0	0
CA	2	25	0	0	0	0	25	0	25
DE	1	34	0	0	0	0	34	0	34
FL	1	1,215	0	0	0	0	1,215	0	1,215
GA	2	618	0	0	0	0	618	0	618
LA	2	525	0	0	0	0	525	0	525
NC	1	500	0	0	0	0	500	0	500
OH	1	5	0	0	250	0	5	250	255
TX	3	1,057	0	0	92	0	1,149	0	1,149
WA	1	150	0	0	0	0	150	0	150
Total	15	4,129	0	0	342	0	4,221	250	4,471

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

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

^cPost office state abbreviations are used.

^dNumber of reporting facilities.

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

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

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

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

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

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

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

RF = reporting facilities; UI = underground injection

Source: TRI04 2006 (Data are from 2004)

6. POTENTIAL FOR HUMAN EXPOSURE

Table 6-2. Releases to the Environment from Facilities that Produce, Process, or Use 2,3-Dichloropropene^a

State ^c	RF ^d	Reported amounts released in pounds per year ^b						Total release		
		Air ^e	Water ^f	UI ^g	Land ^h	Other ⁱ	On-site ^j	Off-site ^k	On- and off-site	
IA	1	4,768	No data	0	0	0	4,768	0	4,768	
LA	2	541	No data	0	0	0	541	0	541	
TX	2	82	2	0	9	0	93	0	93	
Total	5	5,391	2	0	9	0	5,402	0	5,402	

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

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

^cPost office state abbreviations are used.

^dNumber of reporting facilities.

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

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

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

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

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

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

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

RF = reporting facilities; UI = underground injection

Source: TRI04 2006 (Data are from 2004)

6. POTENTIAL FOR HUMAN EXPOSURE

Table 6-3. Maximum Concentrations (24-Hour Time-Weighted Average) of 1,3-Dichloropropene in Air at Varying Distances from Treated Fields

Distance from treated field (meters) ^a	Location	Maximum 4-hour concentration (ppb)	Maximum 24-hour TWA concentration (ppb)	Mean 7-day concentration (ppb)	Mean 15-day concentration (ppb)
1,600	Arizona	20.0	5.1	0.7	0.5
1,200	Arizona	34.7	10.1	1.2	0.8
800	Arizona	47.5	13.8	2.1	1.4
800	Washington	37.8	17.5	4.6	3.2
800	North Carolina	13.9	2.4	0.3	0.3
500	Arizona	106.1	30.9	4.1	2.6
500	Washington	40.3	20.2	5.3	3.8
500	North Carolina	20.3	3.5	0.5	0.3
125	Arizona	376.1	127.4	20.2	12.2
125	Washington	114.7	61.2	12.1	8.8
125	North Carolina	61.8	12.8	2.3	1.3
25	Arizona	786.6	397.5	43.1	24.7
25	Washington	68.6	46.7	16.5	13.7
25	North Carolina	86.7	49.0	5.8	3.3
5	Arizona	350.4	281.2	40.7	23.0
5	Washington	77.2	51.8	20.2	16.2
5	North Carolina	147.7	75.6	8.4	4.8
Onsite	Arizona	509.6	234.7	69.4	37.6
Onsite	Washington	77.2	58.6	33.3	25.4
Onsite	North Carolina	74.8	57.6	16.6	8.9

^aAll samples were obtained at a height of approximately 5 feet above ground.

Source: NCFA 1997

6. POTENTIAL FOR HUMAN EXPOSURE

The monitoring data indicated that 1,3-dichloropropene air concentrations peaked during the first 3 days following treatment and then declined over a period of 14 days following treatment, which was the duration of the air monitoring study.

Telone II[®] was applied at approximately 12.8 gallons per acre (121 lbs a.i./acre) to a fallow plot in Nevada and 1,3-dichloropropene levels were monitored for 7 days directly above the field and at locations up to one-half mile away (EPA 1998b). The average concentration of 1,3-dichloropropene at a 6-inch height above the field during 7 days was 465.31 $\mu\text{g}/\text{m}^3$; at a 5-foot height at the edge of the field, it was 94.81 $\mu\text{g}/\text{m}^3$; at a 5-foot height 100 feet away from the field, it was 39.39 $\mu\text{g}/\text{m}^3$; at a 5-foot height 0.25 miles from the field, it was 5.17 $\mu\text{g}/\text{m}^3$; and at a 5-foot height one-half mile from the field, it was 3.88 $\mu\text{g}/\text{m}^3$. Wind velocity was determined to be the major factor in the dispersion of 1,3-dichloropropene.

1,3-Dichloropropene has been identified in air samples collected at 6 of the 1,678 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2006). 1,1-, 1,2-, 2,3-, and 3,3-Dichloropropene were not identified in air samples collected at any of the 1,678 NPL hazardous waste sites.

6.2.2 Water

Estimated releases of 2 pounds (0.001 metric tons) of 2,3-dichloropropene to surface water from five domestic manufacturing and processing facilities in 2003, accounted for <1% of the estimated total environmental releases from facilities required to report to the TRI (TRI04 2006). These releases are summarized in Table 6-2. According to TRI estimates, there were no releases of 1,3-dichloropropene to surface water from 15 domestic manufacturing and processing facilities in 2004 (TRI04 2006). TRI data for 1,3--dichloropropene are summarized in Table 6-1. 1,1-, 1,2-, and 3,3-Dichloropropene were not listed in the TRI.

Very little information regarding the release of 1,3-dichloropropene to water was found in the available literature. It has been suggested that chlorination of organic substances during treatment in water systems can result in the formation of low levels of 1,3-dichloropropene (Dowty et al. 1975a, 1975b; Krijgsheld and Van der Gen 1986; Otson 1987; Rogers et al. 1987). Trace quantities of 1,3-dichloropropene are formed during the chlorination of cooling water, which prevents biofouling at electricity-generating power facilities (Bean et al. 1985). Very little information is available regarding the presence of 1,3-dichloropropene in drinking water. A survey of sewage treatment facilities demonstrated that 1,3-dichloro-

6. POTENTIAL FOR HUMAN EXPOSURE

propene may be released to surface waters via primary and secondary effluents (EPA 1978a; Lao et al. 1982). Waste water effluents from petroleum refineries may also release 1,3-dichloropropene to surface waters (Snider and Manning 1982). Waste water from 1,3-dichloropropene production sites can also release 1,3-dichloropropene to surface waters (EPA 1981a).

Due to its high mobility in soils and the fact that 1,3-dichloropropene is injected underground to a depth of 12–18 inches when used as a fumigant, migration to groundwater is possible (Cohen 1986; Krijgsheld and Van der Gen 1986; Maddy et al. 1982). 1,3-Dichloropropene may also be released to groundwater via landfills and hazardous waste sites (Hauser and Bromberg 1982; Sabel and Clark 1984).

2,3-Dichloropropene has been qualitatively identified in groundwater collected from the Ville Mercier hazardous waste site located in southern Quebec, Canada (Pakdel et al. 1994).

1,2- 1,3-, and 3,3-Dichloropropene have been identified in groundwater samples collected at 1, 70, and 3 of the 1,678 NPL hazardous waste sites, respectively, where it was detected in some environmental media (HazDat 2006). 1,1- and 3,3-Dichloropropene were not identified in groundwater samples collected at any of the 1,678 NPL hazardous waste sites. 1,3-Dichloropropene has been identified in surface water samples collected at 10 of the 1,678 NPL hazardous waste sites, respectively, where it was detected in some environmental media (HazDat 2006). 1,1-, 1,2-, 2,3-, and 3,3-Dichloropropene were not identified in surface water samples collected at any of the 1,678 NPL hazardous waste sites.

6.2.3 Soil

Estimated releases of 342 pounds (0.2 metric tons) of 1,3-dichloropropene to soils from 15 domestic manufacturing and processing facilities in 2004, accounted for about 8% of the estimated total environmental releases from facilities required to report to the TRI (TRI04 2006). Estimated releases of 9 pounds (0.004 metric tons) of 2,3-dichloropropene to soils from five domestic manufacturing and processing facilities in 2004, accounted for <1% of the estimated total environmental releases from facilities required to report to the TRI (TRI04 2006). These releases of 1,3- and 2,3-dichloropropene are summarized in Tables 6-1 and 6-2, respectively. 1,1-, 1,2-, and 3,3-Dichloropropene were not listed in the TRI.

The most common release of 1,3-dichloropropene to soil occurs in agricultural fields where it is applied as a soil fumigant (CEPA 1982; Cohen 1986; Krijgsheld and Van der Gen 1986). Accidental spills may

6. POTENTIAL FOR HUMAN EXPOSURE

also release 1,3-dichloropropene to soil (Markovitz and Crosby 1984; Sterrett et al. 1986). For example, on April 8, 1984, a rail accident that occurred about 45 miles southeast of Tucson, Arizona resulted in a spill of 15,000 gallons of 1,3-dichloropropene (Sterrett et al. 1986).

According to the National Pesticide Use Database updated by the National Center for Food and Agricultural Policy, a total of approximately 34.7 million pounds (15,700 metric tons) of 1,3-dichloropropene was used in the United States in 1997 (NCFA 1997). The estimated amounts applied, crops grown, total acres treated in each state are provided in Table 6-4.

1,3-Dichloropropene has been identified in soil and sediment samples collected at 28 and 6 of the 1,678 NPL hazardous waste sites, respectively, where it was detected in some environmental media (HazDat 2006). 1,1-, 1,2-, 2,3-, and 3,3-Dichloropropene were not identified in soil or sediment samples collected at any of the 1,678 NPL hazardous waste sites.

6.3 ENVIRONMENTAL FATE

6.3.1 Transport and Partitioning

The transport and partitioning of an organic compound in the environment is a function of the physical and chemical properties of that compound and the site-specific characteristics of the environment (e.g., percent soil organic matter). Based upon similarities in their physical and chemical properties, 1,1-, 1,2-, cis- and trans-1,3-, 2,3-, and 3,3-dichloropropene should behave similarly in regards to transport and partitioning within the environment.

In the atmosphere, measured vapor pressures of the dichloropropene isomers ranging from 22 to 91 mm Hg at 20 °C (EPA 1981c) suggest that these compounds will exist predominantly in the vapor phase (Eisenreich et al. 1981). Water solubility values ranging from 2,000 to 2,700 mg/L (measured at 20–25 °C) (Dilling 1977; Gunther et al. 1968; Mackay and Shiu 1981; Tomlin 2003), indicate that wet deposition may remove these compounds from the atmosphere. This is confirmed by the detection of 1,3-dichloropropene in rainwater (Section 6.4.2).

In surface waters, volatilization of dichloropropenes should be an important fate process that will compete with the transformation processes of biodegradation and hydrolysis (Section 6.3.2.2). Based on experimentally measured Henry's law constants for cis- and trans-1,3-dichloropropene of 2.71×10^{-3} and

6. POTENTIAL FOR HUMAN EXPOSURE

Table 6-4. Estimated Annual Use of 1,3-Dichloropropene in the United States

State	Acres treated	Pounds applied	Crops grown in treated soil
Alabama	10,478	422,120	Cotton, peanuts
Arizona	18,974	971,942	Cantaloupes, carrots, cotton, melons, watermelons
California	13,296	1,509,058	Beets, Brussels sprouts, cantaloupes, carrots, hot peppers, melons, parsley, potatoes, sweet potatoes
Colorado	3,668	246,759	Carrots, sugarbeets
Florida	29,115	1,826,311	Cotton, peanuts, potatoes, tobacco
Georgia	83,361	2,994,402	Cotton, peanuts, tobacco
Idaho	19,692	1,668,071	Onions, potatoes, sugarbeets
Maryland	321	36,492	Cucumbers
Michigan	Not available	Not available	Strawberries
Montana	2,374	113,943	Sugarbeets
Nebraska	2,418	116,024	Sugarbeets
New Mexico	22,222	1,066,983	Cotton, hot peppers
New York	2,436	640,202	Onions, strawberries
North Carolina	128,557	10,846,670	Cucumbers, peanuts, sweet peppers, sweet potatoes, tobacco
Oklahoma	Not available	Not available	Peanuts
Oregon	35,185	5,831,260	Asparagus, blueberries, carrots, onions, potatoes, strawberries
South Carolina	42,348	2,548,082	Cotton, cucumbers, peanuts, sweet potatoes, tobacco
Tennessee	191	9,159	Sweet potatoes
Texas	2,268	153,721	Cantaloupes, carrots, celery, melons, onions, peanuts, sweet peppers, sweet potatoes, watermelons
Utah	223	60,634	Onions
Washington	24,814	3,640,768	Carrots, onions, potatoes, strawberries, strawberries
Wisconsin	51	14,660	Strawberries
Wyoming	Not available	Not available	Sugarbeets

Source: data are from the National Pesticide Use Database updated in 1997 by the National Center for Food and Agricultural Policy (NCFA 1997).

6. POTENTIAL FOR HUMAN EXPOSURE

8.71×10^{-4} atm-m³/mol at 20 °C, respectively (Leistra 1970), these chemicals are expected to volatilize from environmental waters (Thomas 1982). Using the method of Thomas (1982), the estimated volatilization half-lives of cis- and trans-1,3-dichloropropene from a model river 1 meter deep, flowing at a velocity of 1 m/sec with a wind velocity of 3 m/sec are 3.8 and 4.2 hours, respectively. Experimental K_{oc} values for cis- and trans-1,3-dichloropropene in aqueous solutions are reportedly 23 and 26, respectively (Kenaga 1980). Based on these K_{oc} values, 1,3-dichloropropene is not expected to adsorb to suspended solids and sediment in the water column. Based on similarities in structure, vapor pressure, and water solubility, volatilization of 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene from water surfaces and adsorption of these substances to sediment is expected to be similar to that of 1,3-dichloropropene.

In soil, 1,3-dichloropropene can exist as a gas or dissolved in water. The adsorption characteristics for each form are different. Experimental K_{oc} values for 1,3-dichloropropene in Arlington sandy loam, Chualar clay loam, Mocho silty clay loam, and Pahokee muck ranged from 18 to 60 (Kim et al. 2003b). K_{oc} values measured in soils of 3.19, 10.4, and 55.1% organic carbon were 25.7, 26.3, and 27.6, respectively, for cis-1,3-dichloropropene and 27.8, 27.2, and 27.5, respectively, for trans-1,3-dichloropropene (Hamaker and Thompson 1972). These K_{oc} values indicate a high mobility in soil (Swann et al. 1983) and a potential for leaching. Although movement in saturated soils is possible, concurrent hydrolysis and biodegradation should attenuate the amounts of 1,3-dichloropropene that may actually leach to groundwater. Furthermore, extensive groundwater monitoring programs, conducted in California, have not demonstrated that 1,3-dichloropropene is contaminating well waters in areas of continued field applications of the pesticide (Cohen 1986; Maddy et al. 1982). Measured K_{oc} values were not located for 1,1-, 1,2-, 2,3-, or 3,3-dichloropropene; however, the mobility of these substances in soils is expected to be similar to that of 1,3-dichloropropene.

1,3-Dichloropropene is more likely to adsorb to soil when it is in the vapor phase than when it is dissolved in water (Munnecke and Vangundy 1979). Adsorption for the vapor phase depends partly upon the soil's temperature and organic content (Leistra 1970). Soil adsorption isotherms show a positive correlation between adsorption of 1,3-dichloropropene and the percentage of organic matter in soil. It was also observed that adsorption of vapor-phase 1,3-dichloropropene is approximately 3 times greater at 2 °C than it is at 20 °C. Adsorption isotherms measured for humus sand, peaty sand, and peat indicate vapor-phase K_{oc} values for 1,3-dichloropropene ranging from about 450 to 750. These K_{oc} values suggest medium to low soil mobility for 1,3-dichloropropene in the vapor phase in soil (Swann et al. 1983).

6. POTENTIAL FOR HUMAN EXPOSURE

The factors influencing the volatility of 1,3-dichloropropene from a field following its application are soil organic matter, wind speed, soil moisture content, depth of incorporation-injection, soil temperature and soil porosity. 1,3-Dichloropropene was soil injected to a depth of 12–14 inches at an application rate of 346 lb. a.i. per acre into a sandy loam field, loamy sand field, and muck soil. At 6–12 hours posttreatment, 1,3-dichloropropene reached a maximum concentration of 0.4–20.3 $\mu\text{g}/\text{m}^3$ at a height of 6 inches above the soil surface (EPA 1998b). 1,3-Dichloropropene concentrations decreased to $\leq 0.14 \mu\text{g}/\text{m}^3$ in all air samples from all locations by seven days posttreatment. It was not detected above the loamy sand and sandy loam soils by 14 days or above the muck soil by 21 days. Volatilization rates appeared to be inversely proportional to the amount of soil organic matter and proportional to soil porosity.

Field management practices such as covering the treated fields with tarps, compacting the treated soils, and irrigating the treated soil post injection are commonly used practices to reduce volatilization losses of soil fumigants such as 1,3-dichloropropene. Following application of 1,3-dichloropropene at 98 kg/ha (87.5 lbs/A), volatilization losses from uncovered soil columns (12.5 cm inside diameter) were 62, 47, and 36% at injection depths of 20, 30, and 40 cm, respectively, after 20 days (Gan et al. 1998b). The total volatilization loss for 1,3-dichloropropene injected to a depth of 20 cm and then covered with a high density polyethylene (HDPE) tarp was 53% after 20 days. It was determined that the high permeability of HDPE reduced its ability to act as an effective barrier for 1,3-dichloropropene. However, volatilization losses were reduced substantially if the soil was immediately irrigated post injection. Only 34% of the nominally applied 1,3-dichloropropene was volatilized after injection at a depth of 20 cm, followed by irrigation with 184 mL of water applied to the soil surface at a rate of 2 mL/minute. The authors observed that the volatilization rate of the cis isomer was consistently greater than the trans isomer in each experiment. This observation is consistent with the fact that the cis isomer possesses a lower boiling point, higher vapor pressure, and larger Henry's law constant than the trans isomer.

As discussed in Section 6.3.2.3, dichloropropenes can be removed from soils via hydrolysis, microbial degradation, and volatilization. Since the rate of these processes can vary significantly with soil conditions, the wide range of reported persistence half-lives for 1,3-dichloropropene is not surprising and demonstrates that the persistence of this substance in soil depends upon specific local conditions.

Measured bioconcentration factor (BCF) values for the dichloropropene isomers were not found in the literature. Using a measured $\log K_{ow}$ of 2.0 and a regression derived equation, a BCF of 19.5 can be estimated for 1,3-dichloropropene (Meylan et al. 1999; Tomlin 2003). According to a classification

6. POTENTIAL FOR HUMAN EXPOSURE

scheme developed by Franke et al. (1994), this BCF value suggests that the potential for bioconcentration of 1,3-dichloropropene in aquatic organisms is low. Based on their structural similarities to 1,3-dichloropropene, bioconcentration of 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene in aquatic organisms is also expected to be low.

6.3.2 Transformation and Degradation

6.3.2.1 Air

The important environmental fate process for the degradation of 1,3-dichloropropene in ambient air is the vapor-phase reaction with photochemically produced hydroxyl radicals. The rate constants for the reactions of cis- and trans-1,3-dichloropropene with hydroxyl radicals have been experimentally determined to be 7.7×10^{-12} and 1.3×10^{-11} cm³/molecule-sec at 22 °C, respectively (Tuazon et al. 1984). 1,3-Dichloropropene will also be removed from air via reaction with ozone; however, this reaction is expected to be secondary to photooxidation with hydroxyl radicals. The rate constants for the reactions of cis- and trans-1,3-dichloropropene with ozone molecules have been experimentally determined to be 1.5×10^{-19} and 6.7×10^{-19} cm³/molecule-sec at 22 °C, respectively (Tuazon et al. 1984).

Assuming that the average yearly troposphere hydroxyl radical and ozone molecule concentrations are 5.0×10^5 and 7.0×10^{11} molecules/cm³, respectively (Atkinson et al. 1979), the corresponding half-lives for cis-1,3-dichloropropene in air are about 2.1 days (50 hours) and 76 days. The corresponding half-lives for trans-1,3-dichloropropene in air would be about 1.2 days (30 hours) and 17 days. Tuazon et al. (1984) calculated the respective half-lives of 52 and 12 days for cis- and trans-1,3-dichloropropene reactions with ozone based on an average background tropospheric concentration for ozone of 1.0×10^{12} molecules/cm³. For the cis and trans isomers, the authors also calculated respective half-lives of 12 and 7 hours for the reactions with photochemically generated hydroxyl radicals present at an average concentration of 2.0×10^6 molecules/cm³ (Tuazon et al. 1984).

The estimates of average hydroxyl radical and ozone concentrations in air used by Tuazon et al. (1984) are more indicative of urban atmospheres. In general, the hydroxyl radical and ozone concentrations in polluted air may increase by an order of magnitude over those estimates used by Atkinson et al. (1979). Therefore, the half-life of 1,3-dichloropropene in ambient air may range between 7 and 50 hours, depending on the concentrations of cis- and trans-isomers and hydroxyl radicals in the troposphere.

6. POTENTIAL FOR HUMAN EXPOSURE

Formyl chloride and chloroacetaldehyde have been identified as reaction products of 1,3-dichloropropene with both hydroxyl radicals and ozone. Reaction with ozone also yields chloroacetic acid, formic acid, hydrogen chloride, carbon dioxide, and carbon monoxide (Tuazon et al. 1984).

1,3-Dichloropropene is also susceptible to photolysis in air. However, direct photodegradation of 1,3-dichloropropene should not be an important fate process, compared to its reaction with hydroxyl radicals (EPA 1981b). Nevertheless, some evidence that the photodecomposition of 1,3-dichloropropene may be enhanced by the presence of atmospheric particulates exists (Tuazon et al. 1984).

Data regarding the degradation of 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene in air are not available. Based on the physical and chemical properties of these isomers, photooxidation is expected to be similar to that of 1,3-dichloropropene. As is expected for 1,3-dichloropropene, ozonolysis and direct photolysis may occur for 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene; however, photooxidation is expected to be the dominant removal mechanism for dichloropropenes in the atmosphere.

6.3.2.2 Water

River die-away test data pertaining to the biodegradation of 1,3-dichloropropene in natural waters were not available in the literature. Several aerobic biological screening studies, which used settled domestic waste water for inocula, demonstrated that 1,3-dichloropropene is biodegradable (Tabak et al. 1981a, 1981b). Within 7 days, the original cultures, added to synthetic media that contained 5 mg yeast extract/L, were able to degrade about 50% of the 1,3-dichloropropene at an initial concentration of 10 ppm (Tabak et al. 1981a, 1981b). Acclimation to a series of subcultures was also demonstrated. The third subculture, with identical concentrations and under identical conditions, showed an approximate 85% removal of 1,3-dichloropropene within the same period of time (Tabak et al. 1981a, 1981b). Nevertheless, the rate of biodegradation for 1,3-dichloropropene in natural waters cannot be inferred from screening study data.

Yon et al. (1991) studied the dissipation of ¹⁴C-labeled 1,3-dichloropropene at 5 µg/mL in a sediment/water system made from ditch bottom sediments and aerobic ditch water. Although 49–58% of the 1,3-dichloropropene volatilized after 7 days, degradation was also observed based on the presence of the radiolabeled metabolite 3-chloropropenic acid and other unspecified polar products. The authors reported this degradation as aerobic aquatic metabolism; however, the possible role of hydrolysis was not addressed.

6. POTENTIAL FOR HUMAN EXPOSURE

In addition to losses via biodegradation, 1,3-dichloropropene may undergo hydrolysis in natural waters. Hydrolysis half-lives measured in buffered solutions at pH 5, 7, and 9 were 13.5 days at 20 °C (EPA 1998b). Hydrolysis half-lives measured at pH 5.5 and 7.5 were 2 days at 29 °C, 11–13 days at 15 °C, and 90–100 days at 2 °C (EPA 1998b). McCall (1987) reported similar hydrolysis half-lives of 3.1, 11.3, and 51 days measured at 30, 20, and 10 °C, respectively, in sterile, buffered water and stated that this process was independent of pH. However, Guo et al. (2004) measured half-lives of 8.7, 7.2, and 2.8 days at pH 4, 7, and 10, respectively, in buffer solutions at 20 °C during a more extensive examination of the effect of pH on hydrolysis. In contrast to McCall (1987), these authors concluded that the rate of hydrolysis of 1,3-dichloropropene increases with increasing pH. The primary hydrolysis product of 1,3-dichloropropene is 3-chloroallyl alcohol, which is broken down further to 3-chloroacrylic acid and eventually to CO₂ (Guo et al. 2004).

Aquatic biodegradation and hydrolysis data were not available for 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene. Based on structural similarities, these isomers are expected to biodegrade similarly to 1,3-dichloropropene. Hydrolysis of 2,3- and 3,3-dichloropropene will also be similar to that of 1,3-dichloropropene; however, hydrolysis of 1,1- and 1,2-dichloropropene is expected to be much slower due to the inhibiting effect of the two vinylic chlorine atoms (Smith and March 2001).

6.3.2.3 Sediment and Soil

1,3-Dichloropropene reportedly biodegrades in soil (Castro and Belser 1966, 1968; Roberts and Stoydin 1976; Tu 1988, van der Pas and Liestra 1987). Belser and Castro (1971) reported that the microbial degradative pathway for both the cis and trans isomers followed a similar sequence. The initial step of the reaction involves allylic dechlorination of 1,3-dichloropropene and hydroxyl substitution to form the corresponding chloroallyl alcohol (Castro and Belser 1966; Roberts and Stoydin 1976). Again, both cis- and trans-chloroallyl alcohols undergo oxidation, resulting in the formation of the corresponding chloroacrylic acids (Castro and Belser 1968; Roberts and Stoydin 1976). Next, vinylic chlorines are removed and subsequently, propanoic acid 3-aldehyde is oxidized to carbon dioxide (Belser and Castro 1971).

1,3-Dichloropropene is degraded more rapidly in soil that has a history of treatment with this pesticide than in previously untreated soil (Chung et al. 1999; Ou 1989, 1998; Ou et al. 1995; Verhagen et al. 1996). Furthermore, while the degradation rates of the cis- and trans- isomers are similar in untreated

6. POTENTIAL FOR HUMAN EXPOSURE

soil, degradation in previously treated soil has been shown to be more rapid for trans-1,3-dichloropropene than for cis-1,3-dichloropropene. For example, cis- and trans-1,3-dichloropropene applied to previously untreated soil plots (16 µg/g) were degraded by approximately 68 and 72%, respectively, after 28 days (Ou 1998). In a soil plot that had been previously treated with this pesticide 6 times over the past 12 years, cis-1,3-dichloropropene (16 µg/g) was degraded by approximately 100% after 28 days while trans-1,3-dichloropropene was degraded by approximately 99% after 14 days. Chung et al. (1999) observed the enhanced degradation of trans-1,3-dichloropropene over cis-1,3-dichloropropene in soils increasing with increasing numbers of field applications; approximately 100% of cis- and trans-1,3-dichloropropene in these soils (16 µg/g) were degraded after 5–10 and 7–14 days, respectively. However, the degradation rates of cis- and trans-1,3-dichloropropene were again similar to each other in soil that had been left untreated for 2 years and resembled degradation rates in previously untreated control soils; approximately 75–100% of cis- and trans-1,3-dichloropropene were degraded after 28 days.

1,3-Dichloropropene may also hydrolyze in moist soils. In laboratory studies, hydrolysis rates have been measured in soil slurries and buffer solutions. For soil-water slurries with a concentration of 10^{-2} M, 1,3-dichloropropene hydrolyzed at a rate of 3.4% per day (Castro and Belser 1966). In general, soils possess a relative humidity of >98%. Under dry conditions, the relative humidity of soil may fall below 90% (U.S. Army 1985). Therefore, 1,3-dichloropropene is likely to hydrolyze in moist soils. Once again, corresponding chloroallyl alcohols were reported as the products of hydrolysis for cis- and trans-1,3-dichloropropene (Castro and Belser 1966). Greater than 60% of 1,3-dichloropropene applied at <61 g/kg to both sterile and nonsterile Arlington sandy loam with a 10% moisture content hydrolyzed within 30 days (Guo et al. 2004). Initially, there was no difference between the degradation in sterile and nonsterile soils; however, degradation in the nonsterile soil began to exceed degradation in the sterile soil after 10 days of incubation as soil microorganisms adapted to the pesticide.

Batzer et al. (1996) studied the fate of 1,3-dichloropropene in sealed aerobic soil incubation flasks. The degradation half-lives of ^{14}C -labeled-1,3-dichloropropene measured in Wahiawa silty clay, Catlin silt loam, and Fuquay loamy sand were 1.8, 12.3, and 61 days, respectively (Batzer et al. 1996; EPA 1998b). These authors stated that the rapid degradation in the Wahiawa silty clay may have been a result of the combination of biodegradation and abiotic hydrolysis. Major metabolites formed during the biodegradation of 1,3-dichloropropene identified during this study were 3-chloroallyl alcohol and 3-chloroacrylic acid. Minor metabolites identified (<0.4% applied ^{14}C) were acetic acid, adipic acid, butyric acid, chloroacetic acid, 4-chlorobutyric acid, fumaric acid, glycolic acid, hexanoic acid, lactic acid, malonic acid, 2-methylmalonic acid, oxalic acid, propionic acid, and succinic acid.

6. POTENTIAL FOR HUMAN EXPOSURE

Anaerobic metabolism half-lives measured for 1,3-dichloropropene at 15 and 25 °C were 9.1 and 2.4 days, respectively, in a silty clay loam soil and 7.7 and 2.4 days, respectively, in a sandy loam soil (EPA 1998b). The metabolites identified included chloroacrylic acid and propionic acid.

The persistence of 1,3-dichloropropene in soil has been measured by a number of investigators. van der Pas and Leistra (1987) reported half-lives of 3–4 days in fields used for planting flower bulbs. Only very small amounts of 1,3-dichloropropene remained after periods up to 49 days. Leistra (1970) reported a much slower degradation rate of 0.035/day for a loam soil, which corresponds to a half-life of 19.8 days. A degradation rate of 0.01/day, which corresponds to a half-life of 69 days, was reported for sandy and peat soils (Leistra 1970). Albrecht (1987a) has reported half-lives of 3–25 days at 20 °C for 1,3-dichloropropene. Radiolabeled cis- and trans-1,3-dichloropropene was applied to soils and stored in sealed jars for 12 weeks. In a sandy loam soil, 19% of the cis isomer and 18% of the trans isomer remained, while 10% of the cis isomer and 22% of the trans isomer persisted in a medium loam soil (Roberts and Stoydin 1976). The half-lives of 1,3-dichloropropene measured in water-saturated sandy subsoils (24 g/m³) ranged from 16 to 64 days (Boesten et al. 1991). Smelt et al. (1989) reported that 1,3-dichloropropene at initial concentrations of 62–80 mg/kg in moist loamy soils was quickly degraded (100% after 5–8 days) following a 3–6-day lag phase. The initial and second half-lives of cis- and trans-1,3-dichloropropene applied at 345 lb a.i./A to bare loamy sand soil were 1 and 7 days, respectively, in the 24-inch surface layer (EPA 1998b). 1,3-Dichloropropene, applied at 342 lb a.i./A to a sand soil field plot, declined from a maximum concentration of 130,000 ppb in the 0.3–0.45 m layer of soil immediately following application to below the detection limit (10 ppb) in any soil layer after 71 days (1998b).

Biodegradation and hydrolysis data for 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene in soil or sediment were not available. Based on structural similarities, these isomers are expected to biodegrade similarly to 1,3-dichloropropene. Hydrolysis of 2,3- and 3,3-dichloropropene in soil will also be similar to that of 1,3-dichloropropene; however, hydrolysis of 1,1- and 1,2-dichloropropene is expected to be much slower due to the inhibiting effect of the two vinylic chlorine atoms (Smith and March 2001).

6.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to 1,3-dichloropropene depends in part on the reliability of supporting analytical data from environmental samples and biological specimens. Concentrations of 1,3-dichloropropene in unpolluted atmospheres and in pristine surface waters are often

6. POTENTIAL FOR HUMAN EXPOSURE

so low as to be near the limits of current analytical methods. In reviewing data on 1,3-dichloropropene levels monitored or estimated in the environment, it should also be noted that the amount of chemical identified analytically is not necessarily equivalent to the amount that is bioavailable. The analytical methods available for monitoring 1,3-dichloropropene in a variety of environmental media are detailed in Chapter 7.

The majority of the available dichloropropene monitoring data are for the 1,3- isomer. Therefore, the data reported in Section 6.4 refer primarily to 1,3-dichloropropene. When available, monitoring data for the other dichloropropene isomers are included.

6.4.1 Air

1,3-Dichloropropene is not a widely occurring atmospheric pollutant. According to the National Ambient Volatile Organic Compounds (VOCs) Database, a compilation of published and unpublished air monitoring data from 1970 to 1987, the median urban atmospheric concentration of cis-1,3-dichloropropene is 23.9 ppbV (parts per billion by volume) for 148 samples collected from representative locations (EPA 1988). Information regarding the occurrence of cis-1,3-dichloropropene in suburban, rural, remote, source-dominated (air surrounding a facility or known release of the chemical in question), workplace, and indoor and personal atmospheres was not included by the VOC database. Also, no data were reported for trans-1,3-dichloropropene (EPA 1988).

cis- and trans-1,3-Dichloropropene were detected in 15 (4.3%) and 10 (2.9%) out of 349 air samples, respectively, collected from Camden, New Jersey; Washington, DC; Orlando, Florida; Pensacola, Florida; Chicago, Illinois; Sauget, Illinois; Toledo, Ohio; Houston, Texas; Baton Rouge, Louisiana; Port Neches, Texas; and Wichita, Kansas during the 1990 Urban Air Toxics Program conducted by EPA (1991). The range, mean, and median of concentrations in positive samples were 0.04–0.59, 0.23, and 0.22 ppbV, respectively, for cis-1,3-dichloropropene and 0.01–2.62, 0.70, and 0.17 ppbV, respectively, for trans-1,3-dichloropropene. cis- and trans-1,3-Dichloropropene concentrations were <1 ppbV in urban air samples from 13 sites located in Louisiana, Texas, Vermont, and New Jersey collected from September 1996 to August 1997 (Mohamed et al. 2002). cis- and trans-1,3-Dichloropropene were each detected in only 3 out of 267 air samples from 13 semi-rural to urban locations in Maine, Massachusetts, New Jersey, Pennsylvania, Ohio, Illinois, Louisiana, and California collected from 1997 to 1999 (Pankow et al. 2003). Positive concentrations were 0.013–0.018 ppbV for cis-1,3-dichloropropene and 0.007–0.008 ppbV for trans-1,3-dichloropropene; limits of detection were not specified. cis- and trans-1,3-Di-

6. POTENTIAL FOR HUMAN EXPOSURE

chloropropene were detected in 0 and 3% of air samples, respectively, collected from six locations in the Columbus, Ohio area; concentrations and detection limits were not specified (Spicer et al. 1996). Out of 2,507 air samples collected from 25 sites across the state of Minnesota over a period of 8 years (1991–1998), cis-1,3-dichloropropene was detected above $0.14 \mu\text{g}/\text{m}^3$ (0.031 ppb) in 43 air samples and trans-1,3-dichloropropene was detected above $0.21 \mu\text{g}/\text{m}^3$ (0.046 ppb) in 82 air samples (Pratt et al. 2000). The mean and maximum concentrations were 0.02 and $0.99 \mu\text{g}/\text{m}^3$ (0.004 and 0.22 ppb), respectively, for cis-1,3-dichloropropene and 0.03 and $1.48 \mu\text{g}/\text{m}^3$ (0.007 and 0.326 ppb), respectively, for trans-1,3-dichloropropene.

During a study conducted by the California Air Resources Board in July 1995, 1,3-dichloropropene was detected in 100% of samples collected from four sites in California representative of high use areas with mean and maximum concentrations of 24 and $160 \mu\text{g}/\text{m}^3$ (5.3 and 35.2 ppb), respectively (Baker et al. 1996). During measurements of airborne pesticide concentrations in an urban area of California, 1,3-dichloropropene was detected in 8 out of 8 samples in 1990, 16 out of 21 samples in 1996, and 14 out of 53 samples in 2000 (Lee et al. 2002). Mean 1,3-dichloropropene concentrations in these samples were 0.9, 0.57, and $0.40 \mu\text{g}/\text{m}^3$ (0.20, 0.13, and 0.088 ppb), respectively. In air from rural California communities, 1,3-dichloropropene was detected in 32 out of 32 samples in 1990, 64 out of 84 samples in 1996, and 77 out of 267 samples in 2000. Mean 1,3-dichloropropene concentrations in these samples were 24, 1.4, and $1.5 \mu\text{g}/\text{m}^3$ (5.3, 0.31, and 0.33 ppb), respectively.

The concentrations of dichloropropene (unspecified isomers) in air samples collected from Deer Park, Texas; Freeport, Texas; Plaquemine, Louisiana; and Baton Rouge, Louisiana during the 1970s ranged from 7 to 570 ppt where it was detected (Brodzinsky and Singh 1982; EPA 1979). Dichloropropene (unspecified isomers) was qualitatively identified in 1 out of 10 ambient air samples collected in the Kanawha Valley, West Virginia during 1977 (EPA 1978b).

6.4.2 Water

According to 1999–2006 nationwide U.S monitoring data from the STORET database, 1,3-dichloropropene was detected in 5,465 out of 12,673 water samples; however, only 771 of these detections were above the quantitation limit (unspecified). The mean, median, and range of quantifiable concentrations were 0.5, 0.5, and $0.002\text{--}25 \mu\text{g}/\text{L}$ (ppb), respectively (EPA 2006j). 1,1-Dichloropropene was detected in 3,443 out of 5,348 water samples; however, only 70 of these detections were above the quantitation limit (unspecified). The mean, median, and range of quantifiable concentrations were 0.4, 0.5, and 0.001--

6. POTENTIAL FOR HUMAN EXPOSURE

5 µg/L (ppb), respectively (EPA 2006j). The source of 1,1-dichloropropene in these water samples is unknown. 1,1-Dichloropropene does not appear to be produced or used based on available data; therefore, direct release of this substance into the environment is not expected. 1,1-Dichloropropene may be formed as a metabolite during the anaerobic degradation of higher chlorinated propenes. Data for 1,2-, 2,3-, and 3,3-dichloropropene were not listed in STORET.

1,3-Dichloropropene was detected in groundwater contaminated by leachates from municipal landfills in New York, Minnesota, and Wisconsin at concentrations up to 18 µg/L (ppb) (Sabel and Clark 1984). In California, 1,3-dichloropropene was detected in groundwater at unspecified concentrations as a result of pesticide applications (Cohen 1986). An extensive groundwater monitoring program for agricultural chemicals in California detected cis-1,3-dichloropropene in only two groundwater samples, and trans-1,3-dichloropropene in only one groundwater sample (Cohen 1986). By comparison, dibromochloropropane, another soil fumigant, was detected in 2,522 groundwater samples. In 54 municipal wells of varying depths of 65–1,200 feet in areas of California where Telone[®] or DD[®] had been applied for over 15 years, 1,3-dichloropropene was not detected in any sample at or above the quantification limit of 0.1 ppb (Maddy et al. 1982).

cis- and trans-1,3-Dichloropropene were not detected (detection limit 0.20 µg/L) in groundwater samples from 1,831 sites located in 20 of the U.S. major hydrologic basins (Kolpin et al. 2000). During the U.S. Geological Survey's (USGS) National Water-Quality Assessment (NWQA) Program conducted from 1986 to 1999, concentrations of cis- and trans-1,3-dichloropropene were below the detection limit of 0.2 µg/L (ppb) in untreated groundwater from 1,685 and 1,592 rural private wells, respectively (Moran et al. 2004). Concentrations of cis- and trans-1,3-dichloropropene were below the detection limit of 0.09 µg/L (ppb) in 30 randomly distributed monitoring wells located in Wichita, Kansas during the High Plains Regional Ground-Water Study conducted in 2000 as part of the USGS NWQA Program (USGS 2002). The concentrations of cis- and trans-1,3-dichloropropene measured in 34 wells (including 5 public use wells) in Cook Inlet Basin, Alaska during 1999 were below 0.09 and 0.13 µg/L (ppb), respectively (USGS 2001).

During the registration of Telone II[®], Dow AgroSciences conducted a small-scale prospective groundwater monitoring study at a site in Wisconsin to satisfy EPA requirements (EPA 1998b). In September 1997, Telone II[®] was applied to a sugar beet field at 28 gallons per acre (266 pounds per acre). Depth to the groundwater of an aquifer used for drinking water ranged from 15 to 22 feet. Over a period of 11 months, the mean and maximum concentrations of 1,3-dichloropropene were 134 and 579 ppb,

6. POTENTIAL FOR HUMAN EXPOSURE

respectively, in on-site wells and 26.6 and 173 ppb, respectively, in an off-site well located 65 feet downgradient.

Dow AgroSciences performed a similar groundwater study in southern Florida (EPA 1998b). In December 1995, Telone C-17[®] was applied to a pepper field at 22.5 gallons per acre (214 pounds per acre). The concentration of 1,3-dichloropropene in eight shallow (1–2 feet deep) on-site wells peaked at 833 ppb and then dropped to 0.19 ppb by 110 days after application. The concentration in five off-site wells ranged from trace levels to 0.23 ppb. The mean and range of 1,3-dichloropropene concentrations were 0.30 and 0.05–21.6 ppb, respectively, in eight on-site wells at a depth of 10 feet and 0.04 and 0.05–1.03 ppb, respectively, in the on-site wells that tapped the Lower Tamiami Aquifer, a possible drinking water source, at a depth of 70 feet. The mean concentration of 1,3-dichloropropene plus its degradates was 1.15 ppb in the 10 feet deep on-site wells, 0.17 ppb in the 70 feet deep on-site wells, and 0.074 ppb in the off-site wells. 1,3-Dichloropropene was not detected in an off-site deep well. 1,3- and 2,3-Dichloropropene were detected above 0.1 ppb in 5 and 3 out of 42 piezometers and domestic wells, respectively, in the area of the Abbotsford aquifer in southwestern British Columbia, Canada (Zebarth et al. 1998). Maximum concentrations ranged from 0.15 to 0.76 ppb for 1,3-dichloropropene and from 0.10 to 0.67 ppb for 2,3-dichloropropene.

According to Round 2 data (1993–1997) reported under the EPA Unregulated Contaminant Monitoring Program (UCM), 1,3-dichloropropene was detected in 81 out of 70,631 samples collected from public water systems across the United States with a mean concentration of 1.282 ppb and a range of 0.20–39.00 ppb (EPA 2001c). 1,1-Dichloropropene was detected in 18 out of 97,698 public water system samples with a mean concentration of 8.944 ppb and a range of 0.10–153.00 ppb. 1,2-, 2,3-, and 3,3-Dichloropropene were not included in the UCM data; these chemicals are not listed as drinking water contaminant candidates by EPA (EPA 2001c).

1,3-Dichloropropene was qualitatively identified in New Orleans, Louisiana, drinking water collected in August 1974 (Dowty et al. 1975a, 1975b). Unspecified isomers of dichloropropene were qualitatively identified in drinking water samples collected in Philadelphia, Pennsylvania in 1995 and 1996 (Suffet et al. 1980). An analysis of 15 drinking water samples from Denver collected between October 1, 1985, and March 31, 1986, did not detect cis- or trans-1,3-dichloropropene at or above detection limits of 0.13 ppb (Rogers et al. 1987). At quantities above the detection limit of 0.1 ppb, 1,3-dichloropropene was not detected in 42 raw and 42 finished drinking water samples collected between July 1982 and May 1983 from nine municipalities along the Great Lakes (Otson 1987).

6. POTENTIAL FOR HUMAN EXPOSURE

The concentrations of cis- and trans-1,3-dichloropropene/L detected in rainwater collected in Portland, Oregon, in 1982 were 10 and 2 ng/L (ppt), respectively (Mazurek and Simoneit 1986).

6.4.3 Sediment and Soil

According to 1999–2006 nationwide U.S monitoring data from the STORET database, 1,3-dichloropropene was detected in only 2 out of 613 soil samples (EPA 2006j). 1,3-Dichloropropene concentrations in these two samples were 0.04 and 0.005 mg/kg. According to the STORET data, 1,3-dichloropropene was detected in 139 out of 324 sediment samples; however, none of these detections were above the quantitation limit (unspecified) (EPA 2006j). 1,1-Dichloropropene was not detected above the quantitation limit (unspecified) in 74 soil samples and 37 sediment samples. Data for 1,2-, 2,3-, and 3,3-dichloropropene were not listed in STORET. No other information regarding the levels of dichloropropenes found in soil or sediment was located in the available literature.

6.4.4 Other Environmental Media

1,1-, cis-1,3-, and trans-1,3-Dichloropropene were analyzed for but not detected in approximately 90 foods during the U.S. Food and Drug Administration's Total Diet Study (TDS) (FDA 2005b).

According to the National Pesticide Use Database updated by the National Center for Food and Agricultural Policy in 1997, 1,3-dichloropropene is applied to fields used to grow the following crops in the United States each year: asparagus, beets, blueberries, Brussels sprouts, cantaloupes, carrots, celery, cotton, cucumbers, hot peppers, melons, onions, parsley, peanuts, potatoes, strawberries, sugarbeets, sweet peppers, sweet potatoes, tobacco, and watermelons. However, 1,3-dichloropropene residues have not been found in crops grown in soils treated with this pesticide (EPA 1998b; Roby and Melichar 1997). This is most likely because 1,3-dichloropropene is a preplant fumigant that breaks down quickly in the soil and is therefore not expected to be available for plant uptake (EPA 1998b).

Neither 1,3-dichloropropene nor its metabolites were detected in carrot, lettuce, radish, tomato, and wheat grown in soil treated with this ¹⁴C-labeled 1,3-dichloropropene; however, natural incorporation of the ¹⁴C-label was observed (Barnekow et al. 1996). Similarly, soybean plants grown in ¹⁴C-labeled 1,3-dichloropropene at 380 L/ha did not contain the pesticide or its metabolites (Barnekow et al. 1995). The

6. POTENTIAL FOR HUMAN EXPOSURE

¹⁴C-label residue was detected in the fatty acids, protein, pigments, organic acids, sucrose and other carbohydrates, and lignin of the soybean plants.

During a study of organic compounds in tobacco smoke, the concentrations of 1,3-dichloropropene in ultra low tar, full flavor low tar, and full flavor cigarette brands were 11.4, 11.7, and 14.4 µg/cigarette, respectively (Bi et al. 2005).

6.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

Possible routes of human exposure to 1,3-dichloropropene include the inhalation of vapors, ingestion of drinking water, and dermal contact.

Monitoring data regarding the presence of 1,3-dichloropropene in foods were not located (see Section 6.4.4). This may be the result of rapid degradation of 1,3-dichloropropene taking place before the pesticide can be taken up by the crop plants. It has been suggested that chlorination of water can lead to the formation of 1,3-dichloropropene, and that the detection of 1,3-dichloropropene in various treated water samples confirm this (Krijgsheld and Van der Gen 1986). However, information pertaining to the occurrence of 1,3-dichloropropene in drinking water is also very limited, and 1,3-dichloropropene is not expected to occur at levels which are a concern to human health. 1,1-Dichloropropene was detected in only 0.01% of public water system samples collected nationwide; therefore, exposure to this substance via drinking water is expected to be very low (EPA 2001c).

Occupational exposures to 1,3-dichloropropene, occurring mainly during handling and application as a soil fumigant, have been documented (Albrecht 1987a; Albrecht et al. 1986; Markovitz and Crosby 1984; Nater and Gooskens 1976; Osterloh et al. 1984, 1989a, 1989b; Schenker and McCurdy 1986; van Joost and de Jong 1988; Wang 1984). According to the NOES conducted by NIOSH between 1981 and 1983, it has been estimated that 2,162 workers were potentially exposed to 1,3-dichloropropene (NIOSH 2006). The NOES database does not contain information on the frequency, concentration, or duration of workers' exposure to any of the chemicals listed therein. The survey provides only estimates on the number of workers potentially exposed to chemicals in the workplace. The most probable routes of occupational exposure are inhalation and dermal contact at places where 1,3-dichloropropene- and/or 1,3-dichloropropene-containing compounds are produced or used as a soil fumigant. Albrecht (1987a) studied the inhalation exposure of 1,3-dichloropropene to workers involved in applying Telone II[®] to pineapple fields in Hawaii. Exposures were predominantly below 1 ppm. According to Osterloh et al. (1989a),

6. POTENTIAL FOR HUMAN EXPOSURE

15 individuals applying 1,3-dichloropropene were exposed at a mean air concentration of 2.56 mg/m³ over a period of 2–7 hours. The mean concentration of the metabolite, N-acetyl-S-[cis-3-chloro-prop-2-enyl]-cysteine, in the urine of these individuals was 1.37 µg/mg creatinine following exposure.

Exposure monitoring studies were conducted for workers using 1,3-dichloropropene as a fumigant on treated fields in North Carolina, Washington, and Arizona (EPA 1998b). Employee exposure was estimated by monitoring personal air samples for product loaders, applicators, and re-entry workers over 4-hour periods or during short job specific tasks. The 4-hour samples provided time-weighted average air concentrations over a major portion of an actual work day, while the task-specific samples measured the air concentrations associated only with high-contact activities. For product loaders, these activities were the actual loading events. The 4-hour loader samples included the loading events, and the time spent on site between loading events. 1,3-Dichloropropene was broadcast applied to a sandy loam used to grow potatoes at an application rate of 252 lbs a.i./A at the Washington state site. It was row applied in Arizona to a loamy sand used to grown cotton at a rate of 121.2 lbs a.i./A, and was row applied at a rate of 82 lbs a.i. to a field in North Carolina used to grow tobacco. The exposure levels of the employees categorized by job function are summarized in Table 6-5.

The Monsanto Agricultural Products Company conducted research to ensure that workers in the workplace were not being exposed to unacceptable levels of 1,3-dichloropropene in the air during its manufacture. Under laboratory conditions simulating the workplace environment, atmospheric levels of 1,3-dichloropropene ranged from 0.4 to 4.0 ppm (Leiber and Berk 1984). These levels can be compared to the NIOSH recommended 8 and 10 hour time weighed average (TWA) of 1 ppm for 1,3-dichloropropene (NIOSH 2005).

The primary metabolites for cis- and trans-1,3-dichloropropene in the body are the corresponding mercapturic acids, metabolite N-acetyl-S-(cis- and trans-3-chloro-2-propenyl)-L-cysteine (abbreviated cis- and trans-DCP-MA) (Brouwer et al. 2000; He 1993; Van Welie et al. 1991a; Verberk et al. 1990). Exposure to 1,3-dichloropropene can be tested by analyzing for these metabolites in urine samples. The geometric mean and range of cis-DCP-MA concentrations in urine samples collected from 14 application workers in the Netherlands on 114 application days were 9.33 and 0.04–55.1 mg/g creatinine, respectively (Brouwer et al. 2000). The corresponding geometric mean and range of calculated 8-hour time-weighted average exposure concentrations were 2.7 and 0.1–9.5 mg/m³, respectively. Twelve individuals applying cis- and trans-1,3-dichloropropene to Dutch flower bulb fields were exposed to an 8-hour time-weighted average air concentrations of 0.34–10.78 mg/m³ for the cis isomer and 0.11–8.07 mg/m³ for the trans

6. POTENTIAL FOR HUMAN EXPOSURE

Table 6-5. Exposure Levels of Employees to 1,3-Dichloropropene Measured During Loading and Application

Job activity	Site	Exposure duration ^a	Range (ppb)	Mean concentration (ppb)	Median concentration (ppb)
Loading	Washington, Arizona	4 hours	38.9–1,305	359	137
Loading	Washington, Arizona	Task only	116–7,148	2,383	1,069
Loading	North Carolina	Task only	11–260	102	97.2
Application	Washington, Arizona, North Carolina	4 hours and task	9.5–1,448	299	253

^aTask-specific operations lasted 4–46 minutes

6. POTENTIAL FOR HUMAN EXPOSURE

isomer (Brouwer et al. 1991a; van Welie et al. 1991a). At comparable respiratory exposures, cis-1,3-dichloropropene yielded approximately 3 times more mercapturic acid in urine samples than the trans isomer, which was attributed to differences in metabolism. Approximate cumulative urinary excretions of cis- and trans-DCP-MA at the maximum respiratory exposures were 50 mg (at 10.7 mg/m³) and 15 mg (at 8 mg/m³), respectively. A related study reported that the proportion between respiratory exposure to 1,3-dichloropropene and urinary mercapturic acid excretion for field bystanders was similar to that of applicators (van Welie et al. 1991b). Kezic et al. (1996) compared dermal 1,3-dichloropropene exposure to respiratory exposure. The estimated mean total uptake of cis-1,3-dichloropropene in five adults dermally exposed on the forearm and hand to 86 mg/m³ of the pesticide vapor for 45 minutes was 67 µg. The average total cis-DCP-MA excreted in urine over a 24-hour period was 48 µg. The authors concluded that when whole-body dermal exposure is compared with inhalation, dermal uptake amounts to only 2–5% of absorption through inhalation.

Populations that live near hazardous waste sites may be exposed to 1,3-dichloropropene via inhalation, drinking contaminated groundwater, or dermal contact with contaminated soil. Individuals who shower or bathe in groundwater contaminated with 1,3-dichloropropene may be exposed through inhalation and dermal contact. 1,3-Dichloropropene has been identified in at least 108 of the 1,678 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (HazDat 2006).

Pertinent monitoring data regarding the dermal exposure of 1,3-dichloropropene were not located in the available literature. Dermal exposure is possible for workers involved in fumigant applications of 1,3-dichloropropene.

Data regarding human exposure to 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene were not located in the available literature. Exposure of the general population to these substances is expected to be low since they are not produced or used in large quantities (IUR). 1,1-Dichloropropene has been detected in drinking water. However, it was found in only 0.01% of 97,698 public water system samples collected nationwide; therefore, exposure to this substance via drinking water is expected to be very low. Occupational exposure may occur through inhalation and dermal contact at facilities where the dichloropropene isomers are produced or used. People who live near these facilities may also be exposed if these substances are released into the surrounding areas. According to the National Occupational Exposure Survey (NOES) conducted by NIOSH between 1981 and 1983, it has been estimated that 302 workers (3 female workers) were potentially exposed to 2,3-dichloropropene (NIOSH 2006).

6. POTENTIAL FOR HUMAN EXPOSURE

6.6 EXPOSURES OF CHILDREN

This section focuses on exposures from conception to maturity at 18 years in humans. Differences from adults in susceptibility to hazardous substances are discussed in Section 3.7, Children's Susceptibility.

Children are not small adults. A child's exposure may differ from an adult's exposure in many ways. Children drink more fluids, eat more food, breathe more air per kilogram of body weight, and have a larger skin surface in proportion to their body volume. A child's diet often differs from that of adults. The developing human's source of nutrition changes with age: from placental nourishment to breast milk or formula to the diet of older children who eat more of certain types of foods than adults. A child's behavior and lifestyle also influence exposure. Children crawl on the floor, put things in their mouths, sometimes eat inappropriate things (such as dirt or paint chips), and spend more time outdoors. Children also are closer to the ground, and they do not use the judgment of adults to avoid hazards (NRC 1993).

Dichloropropene (unspecified isomers) was qualitatively identified in 1 out of 12 samples of breast milk collected from Bayonne, New Jersey; Jersey City, New Jersey; Bridgeville, Pennsylvania; and Baton Rouge, Louisiana during the late 1970s (EPA 1980; Pellizzari et al. 1982).

Current data regarding the exposure of children to dichloropropenes (including body burden data, detection in breast milk, dietary exposure data, pathways of exposure, differences in intake compared to adults, and secondary exposure data) are not available. Individuals with the greatest potential for exposure to 1,3-dichloropropene include bystanders and residents located near fields treated with this fumigant who may inhale 1,3-dichloropropene that has volatilized into the air (EPA 1998b). Therefore, children who live or play near fields where 1,3-dichloropropene is applied may be exposed to this substance through inhalation.

6.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

High levels of exposure to 1,3-dichloropropene are most likely to occur in occupational settings where 1,3-dichloropropene is either produced or used as a soil fumigant. Intake by inhalation or dermal contact is the most probable route of high exposure to 1,3-dichloropropene. 1,3-Dichloropropene is a volatile compound and, after soil application as a fumigant, a fraction of the compound will volatilize and escape into the atmosphere (Krijgsheld and Van der Gen 1986). Potentially high exposures to 2,3-dichloro-

6. POTENTIAL FOR HUMAN EXPOSURE

propene should be limited to individuals who work at facilities where these substances are produced or used.

6.8 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 dichloropropenes is available. Where adequate information is not available, ATSDR, in conjunction with 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 dichloropropenes.

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.

6.8.1 Identification of Data Needs

Although the following discussion covers 1,1-, 1,2-, 1,3-, and 2,3-dichloropropene, testing to fill data gaps for 1,3-dichloropropene should take priority, since it is the only isomer currently in production at a significant volume.

Physical and Chemical Properties. The physical and chemical properties of both cis- and trans-1,3-dichloropropene have been described and are readily available in the literature (Dilling 1977; EPA 1981a; Kenaga 1980; Leistra 1970; Lewis 2001; Lide 2005; O'Neil et al. 2001; Verschueren 2001). Some of these physical properties were required for assessing the fate and transport of 1,3-dichloropropene in the environment because experimental data were not available. The literature values were sufficient for performing the necessary estimates. No data needs regarding the physical and chemical properties of 1,3-dichloropropene are identified at this time. Measured vapor pressure values are available for 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene. Measured log octanol/water partition coefficients, Henry's law constants, soil/water partitioning coefficients, and bioconcentration factors are lacking for these isomers.

6. POTENTIAL FOR HUMAN EXPOSURE

In addition, measured water solubility data are lacking for 1,1- and 3,3-dichloropropene. Measured values for these end points would be helpful in predicting the fate and transport of these isomers where experimental data are lacking.

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 TRI, which contains this information for 2003, became available in May of 2005. This database is updated yearly and should provide a list of industrial production facilities and emissions.

Current dichloropropene production and import/export volumes are unavailable in the literature. Much of the information regarding 1,3-dichloropropene has been included in combination with other chemicals. For example, USITC (1989) data for 1,3-dichloropropene are grouped with other soil fumigants. Historical production volumes are well documented (Yang 1986), but information regarding future domestic production, and past, present, and future imports and exports are lacking in the literature

Literature pertaining to the use of 1,3-dichloropropene as an agricultural soil fumigant is readily available (Krijgsheld and Van der Gen 1986). Information on the uses of 1,1-, 1,2-, and 3,3-dichloropropene and more detailed use information for 2,3-dichloropropene would be helpful. Disposal methods for 1,3-dichloropropene have been described and appear to be satisfactory; however, methods that describe the disposal of 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene are not available.

Environmental Fate. Information concerning the partitioning of 1,3-dichloropropene in the environment is available (Cohen 1986; Dilling 1977; EPA 1986; Kenaga 1980; Leistra 1970; Munnecke and Vangundy 1979; Roberts and Stoydin 1976; Thomas and McKenry 1974; van der Pas and Leistra 1987). Information on the transport and degradation of 1,3-dichloropropene in environmental media is also available (Cohen 1986; Dilling 1977; EPA 1986; Leistra 1970; Munnecke and Vangundy 1979; Roberts and Stoydin 1976; Swann et al. 1983; Thomas 1982; van der Pas and Leistra 1987). No data needs are identified regarding the environmental fate of 1,3-dichloropropene. Data regarding the environmental fate of 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene were not located in the literature. Although the environmental fate of these substances is expected to be similar to that of 1,3-dichloropropene, there may be some differences especially pertaining to the rates of hydrolysis and ozonolysis. Measured data for these isomers would provide a much better understanding of their environmental fate and partitioning.

6. POTENTIAL FOR HUMAN EXPOSURE

Bioavailability from Environmental Media. Case reports of people who have experienced 1,3-dichloropropene poisoning following oral, dermal, and inhalation exposure indicate that 1,3-dichloropropene can be absorbed by these routes (Albrecht 1987a; Markovitz and Crosby 1984; Osterloh et al. 1984, 1989a, 1989b). However, information regarding oral or dermal absorption of 1,3-dichloropropene in water, soil, or plant material have not been found. Studies of absorption of 1,3-dichloropropene from air, water, soil, and plant material would allow determination of the rate and extent of absorption from each of these media, and allow comparison of the potential hazard posed by 1,3-dichloropropene contained in each. A data need exists regarding the bioavailability of 1,3-dichloropropene from these media. Bioavailability data for 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene were not located in the literature. Although the bioavailability of these substances is expected to be low, additional information would be helpful in verifying this.

Food Chain Bioaccumulation. Few data are available describing the food chain bioaccumulation of dichloropropenes. Experimental data are unavailable; therefore, we do not know if the bioconcentration potential is consistent with estimated values obtained from regression equations (Lyman 1982). Information concerning the potential for food chain biomagnification has not been described. Knowledge in this area would enable scientists to assess the dangers of human exposure to dichloropropenes via food such as fish and seafoods.

Exposure Levels in Environmental Media. Reliable monitoring data for the levels of dichloropropenes in contaminated media at hazardous waste sites are needed so that the information obtained on levels of dichloropropenes in the environment can be used in combination with the known body burden of the dichloropropenes to assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

Air and groundwater monitoring data are available for 1,3-dichloropropene. However, more information on the levels of 1,3-dichloropropene in surface water, drinking water, soil, and sediment would be helpful since data related to these media are lacking. Monitoring data indicate that 1,3-dichloropropene is generally not detected in table-ready foods. 1,3-Dichloropropene is not expected to be present in crops grown in soil treated with this pesticide; however, additional monitoring for 1,3-dichloropropene in these types of foods would be helpful in confirming this. Environmental monitoring data for 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene are very limited. Although concentrations of these substances in the environment are expected to be low, additional information would be helpful in verifying this.

6. POTENTIAL FOR HUMAN EXPOSURE

Exposure Levels in Humans. 1,3-Dichloropropene is not a naturally occurring substance (IARC 1986). Available information shows that N-acetyl cysteine is present in the urine of people who were occupationally exposed to 1,3-dichloropropene (Osterloh et al. 1984, 1989a, 1989b). Additional information regarding the utility of this biomarker as an indicator of general population exposure to the compound may be useful in monitoring the frequency of human exposure to 1,3-dichloropropene. Information concerning the numbers of persons potentially exposed to 1,3-dichloropropene near waste sites and manufacturing, production, and use facilities is also not available. In these areas and those of widespread use, the potential for human exposure is high. Human exposure data for 1,1-, 1,2-, 2,3-, or 3,3-dichloropropene were not located in the literature. Although human exposure to these substances is not expected to be important, information would be helpful in verifying this.

Exposures of Children. Data regarding the exposure of children to dichloropropenes (including body burden data, detection in breast milk, dietary exposure data, pathways of exposure, differences in intake compared to adults, and secondary exposure data) are not available. Exposure data for children who live or play near fields where 1,3-dichloropropene is applied would be particularly helpful.

Child health data needs relating to susceptibility are discussed in Section 3.12.2, Identification of Data Needs: Children's Susceptibility.

Exposure Registries. No exposure registries for the dichloropropenes were located. These substances are not currently among the compounds for which sub-registries have been established in the National Exposure Registry. These substances will be considered in the future when chemical selection is made for sub-registries 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 these substances.

6.8.2 Ongoing Studies

The Federal Research in Progress (FEDRIP 2006) database provides additional information obtainable from a few ongoing studies that may fill in some of the data needs identified in Section 6.8.1.

D.O. Chellemi and J.W. Noling of the University of Florida, Institute of Food and Agriculture, Gainesville, Florida are being funded by the U.S. Department of Agriculture (USDA) to conduct field-scale demonstration/validation studies of alternatives for methyl bromide using new developments in

6. POTENTIAL FOR HUMAN EXPOSURE

application technology and methods. S.R. Yates and S.K. Papiernik, S.K. of Agricultural Research Service, Riverside, California are being funded by the USDA to study the fate and transport of alternative fumigants and methyl bromide. L.T. Ou and A.V. Ogram of the University of Florida, Soil and Water Science, Gainesville, Florida are being funded by the USDA to study the mechanisms and mitigation of agrochemical impacts on human and environmental health. This will include characterization of biotic and abiotic processes, degradation rates, and determination of degradation products.

Ongoing studies regarding the environmental fate and partitioning, environmental monitoring, or the potential for human exposure of 1,1-, 1,2-, 2,3-, and 3,3-dichloropropene were not identified in the Federal Research in Progress database (FEDRIP 2006).