

## 5. POTENTIAL FOR HUMAN EXPOSURE

### 5.1 OVERVIEW

Isophorone is released to the air mainly in urban centers, as a result of evaporation of solvents containing this chemical. Isophorone can enter surface waters from industrial effluent discharges or from runoff from soils at hazardous waste or other contaminated sites. Isophorone disappears rapidly in air by hydroxyl radical reaction (half-life <5 hours), but may persist in natural waters from several days to about a month. Volatilization and sorption are not expected to be significant removal mechanisms from water. In soils, isophorone is expected to degrade microbially, but no rate data are available. Isophorone has been monitored in effluents (range <5-1380 ppb), ambient water (range <0.6'-100 ppb), drinking water (from contaminated surface water) (range 0.02-9.5 ppb), and soils at hazardous waste sites (range 0.16-6500 ppm). At this time, isophorone has been found in at least 9 out of 1177 National Priority List (NPL) hazardous waste sites in the United States (VIEW database 1989). Occupational exposures occur mainly by inhalation and dermal contact and are documented most frequently in the printing trades. Air concentrations in screen printing facilities range from <0.47-25.7 ppm. A 1988 estimate by the National Institute for Occupational Safety and Health reported that 37,469 workers (9211 of whom were female) were exposed to isophorone in both trade name products and chemical named products.

### 5.2 RELEASES TO THE ENVIRONMENT

#### 5.2.1 Air

Since isophorone is used mainly as a solvent (see Subsection 4.3) that is evaporated during or after use, the vast majority of environmental releases are to the air. Use patterns indicate that most air releases are in urban centers, with a smaller percentage of release in rural areas. Nonetheless, very little ambient air monitoring data exist to confirm this, probably because of its short atmospheric lifetime (half-life <5 hours). Apparently, a major source of isophorone in the environment is the printing industry, since these operations usually do not use emission control technologies to reduce emitted isophorone concentrations (Bierbaum and Parnes 1974; Kominsky 1981; Lee and Frederick 1981; Samimi 1982). Other industries e.g. metal coating that use similar ventilation methods (NIOSH 1978a) are major sources of atmospheric isophorone. Coal-fired power plants may also emit isophorone to the air, since isophorone has been detected in the fly ash of one such plant (Harrison et al. 1985). Volatilization from surface waters is not expected to be a significant source of isophorone in the atmosphere, since this is anticipated to be a slow process (based on the Henry's Law Constant of 4.55~10<sup>-4</sup> atm m<sup>3</sup> mol<sup>-1</sup>). Wastewater treatment plants may, however, emit some isophorone from influent

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water to the air, particularly if gas stripping methods are used (Hawthorne and Sievers 1984, Hawthorne et al. 1985). Drinking water plants that practice aeration of influent water may also emit small amounts of isophorone to air.

### 5.2.2 Water

Little data are available to estimate releases of isophorone to water. During isophorone manufacture, process water may contact the isophorone and carry some of it to wastewater streams. During use of isophorone, paint spray booths that use water curtains, wash water, and process water all may contain isophorone. Isophorone has been detected in the United States in industrial effluent discharges (Burse and Pellizzari 1982; Hawthorne and Sievers 1984; Hawthorne et al. 1985; Jungclaus et al. 1976), hazardous waste landfill leachate and runoff (Ghassemi et al. 1984; Hauser and Bromberg 1982; Stonebraker and Smith 1980), and urban runoff (Cole et al. 1984). Specific industrial categories that produce wastewaters containing isophorone include timber products, petroleum refining, paint and ink, pulp and paper, automobile and other laundries, pharmaceuticals, foundries, transportation equipment, and publicly-owned treatment works (Burse and Pellizzari 1982). It is likely that treated waters from these industries that are often discharged to surface waters will contain isophorone (Burse and Pellizzari, 1982).

### 5.2.3 Soil

The only direct measurements of isophorone in soil were found for samples taken from hazardous waste sites. Ghassemi et al. (1984) found isophorone in leachates from hazardous waste landfills, and Hauser and Bromberg (1982) detected the presence of isophorone in the "sediment/soil/water" of Love Canal. These studies suggest that isophorone also was present in the soil. The Contract Laboratory Program Statistical Data Base (queried April 13, 1987) reported that isophorone has been detected at 4 of 357 hazardous waste sites at a concentration range of 1.68-6500 ppm.

## 5.3 ENVIRONMENTAL FATE

### 5.3.1 Transport and Partitioning

Isophorone has a water solubility of 12,000 ppm, a log octanol/water partition coefficient of 1.67, a Henry's Law constant of  $4.55 \times 10^{-6}$  atm m<sup>3</sup> mol<sup>-1</sup>, a vapor pressure of 0.3 mm Hg at 20°C, a log sediment sorption coefficient of approximately 1.46, and a log bioconcentration factor (BCF) of 0.85. Isophorone is released to air and water from its manufacturing and use. Based on its water solubility, some isophorone may wash out of the atmosphere; however, only limited amounts will be washed out because of the short atmospheric half-life of isophorone. Particularly during the day,

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when hydroxyl radical (HO·) concentrations are highest, very little atmospheric transport will occur due to its fast reaction with HO·.

In water, neither volatilization nor sorption to sediments is expected to be an important transport mechanism. The results of two EXAMS model runs and the value of the Henry's Law constant (calculated from the solubility' and the vapor pressure) suggest that volatilization will not be important in shallow ponds or in lakes. EXAMS is an environmental model that predicts the behavior of a chemical in surface waters (EPA 1985a). Using the code test data for a pond developed by the Athens Environmental Research Laboratory of EPA, the half-life for volatilization was calculated to be 104 days, while for a lake, the half-life was calculated to be 288 days. Input data included molecular weight, vapor pressure, Henry's Law constant, octanol/water partition coefficient, sediment sorption coefficient, and water solubility. Equations correlating solubility or octanol/water partition coefficients with sorption partition coefficients ( $K_{oc}$ ) were not developed using structures similar to isophorone, however, and the  $K_{oc}$  value entered into the EXAMS model thus should be viewed as tentative. The volatilization rates predicted by the EXAMS model appear to be consistent with the observation of Hawthorne and Sievers (1984), who reported that isophorone could be analyzed in wastewater by purge and trap methods but was not found in the air above the wastewater in a closed system without a purge.

McFall et al. (1985) reported isophorone concentrations in sediments of Lake Pontchartrain, LA, an estuary located in the Mississippi River delta. Sediments containing isophorone were detected in the Inner Harbor Navigation Canal (IHNC), the Rigolets, and the Chef Menteur Pass. Concentrations in the overlying waters were not reported. Therefore, the sorption partition coefficient in these sediments could not be derived from these experimental data.

The bioconcentration of isophorone in bluegill sunfish has been reported by Barrows et al. (1978, 1980) and Veith et al. (1980) (all reports used the same BCF value). These researchers reported a bioconcentration factor of 7 ( $\log BCF = 0.85$ ) as determined in a continuous dilution flow-through system using  $^{14}C$ -labeled isophorone. This value suggests that concentrations of isophorone in fish living in isophorone contaminated waters will not be more than an order of magnitude higher than concentrations in the water. Nonetheless, concentrations of isophorone have been found in fish in Lake Michigan tributaries and embayments (Camanzo et al. 1987) (see section 5.4) at concentrations ranging from below the detection limit ( $\cong 0.02$  mg/kg) to 3.61 mg/kg wet weight. McFall et al. (1985) also analyzed oysters from the IHNC and clams from the Rigolets and the Chef Menteur Pass in Lake Pontchartrain for isophorone. Oysters from the IHNC had detectable levels of isophorone (38 ppb dry weight), but clams did not; the detection limits were not specified and no BCF can be calculated with the data supplied. These data indicate, however, that isophorone can be found in aquatic organisms at mg/kg levels, although no

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correlation was found between the concentration of isophorone and lipid content in the organism (Camanzo et al. 1987).

### 5.3.2 Transformation and Degradation

#### 5.3.2.1 Air

No studies were located regarding the rates or products of reaction of isophorone in the atmosphere. Isophorone does not significantly absorb light above wavelengths of 290 nm (Sadtler Index 1966 [UV #44]); hence, it is not expected to undergo direct photolysis. However isophorone can react with photochemically produced  $\text{NO}_x$  in the atmosphere (usually formed at higher concentrations in photochemical smogs) producing moderate eye irritation,  $\text{NO}_2$ , other oxidants (including ozone, various peroxy compounds, and free radicals), and formaldehyde as indicated in smog chamber studies (Altshuller and Bufalini 1971; Farley 1977; Levy 1973). Probably, the most significant reaction of isophorone in the atmosphere is its reaction with  $\text{HO}\cdot$ . Addition of  $\text{HO}\cdot$  will occur at the double bond of the compound and may be followed by multiple reaction pathways (Atkinson 1985). Recently, Atkinson (1987) developed a method to estimate the  $\text{HO}\cdot$  reaction rate based on structure. Using this method, an overall reaction rate of  $81.5 \times 10^{-12} \text{ cm}^3 \text{ molecule}^{-1} \text{ set}^{-1}$  was calculated. This reaction rate yields a half-life of 4.7 hours for an atmospheric 24-hour average  $\text{HO}\cdot$  concentration of  $0.5 \times 10^6 \text{ molecules cm}^{-3}$  (Atkinson 1985). In indoor air,  $\text{HO}\cdot$  concentrations probably are significantly lower (Atkinson 1985); therefore, reaction half-lives of  $\text{HO}\cdot$  with isophorone in indoor air probably will be much longer than in outdoor air. Thus, isophorone is expected to persist much longer in indoor air than in outdoor air unless the indoor/outdoor air exchange rate is high.

#### 5.3.2.2 Water

The aerobic biodegradation of isophorone has been studied using sludge and wastewater inocula as well as combined biological and physical treatment methods. Isophorone appears to biodegrade under most conditions simulating those in sewage treatment plants. No studies regarding biodegradation or abiotic reactions involving photolysis or oxidation of isophorone in surface and groundwater were located in the literature.

Aerobic biodegradation of isophorone appears to be possible in sewage sludge or settled domestic wastewater. The exact conditions, however, appear to be important. For example, Tabak et al. (1981a,b) reported 100% degradation of isophorone in 7 days using settled domestic wastewater amended with 5 ppm of yeast extract. Price et al. (1974) reported that the equivalent of 42% theoretical oxygen demand for the compound was consumed in 20 days with a domestic wastewater seed without the yeast extract, and Kawasaki (1980) reported that isophorone was resistant to biodegradation in a test developed by the Japanese Ministry of International Trade and Industry (MITI). The MITI test is essentially a BOD test conducted over 14 days with a seed obtained from soil and sludge samples taken throughout

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Japan. The results are reported as a pass if 30% or more of the theoretical BOD is consumed and as a fail if less than 30% is consumed. During the operation of two model sewage treatment plants, Hannah et al. (1986) and McShane et al. (1987) reported that virtually all of the isophorone added to the influent water was removed during the activated sludge portion of the treatment process. The hydraulic detention times for both systems were on the order of several hours. None of the test concentrations were near the activated sludge EC50 of 100 ppm (Yoshioka et al. 1986). Some of the removal may have been due to adsorption to the sludge as Hannah et al. (1986) reported that the sludge from their process contained isophorone at concentrations that exceeded the influent water concentrations.

While the evidence presented in the literature cited above suggests that isophorone can be virtually completely removed under sewage treatment plant conditions, monitoring data presented in Section 5.4 indicate that isophorone is still present in treated wastewater and in ambient water. This, in turn, suggests that the exact conditions under which isophorone is rapidly biodegraded or removed are not well understood. The presence of this compound in treated wastewater is indicative that the proper removal conditions were not employed for these systems, or that the input concentrations into sewage treatment plants were high enough that the capacity of the treatment plants were exceeded.

### 5.3.2.3 Soil

No studies were located regarding the transformation of isophorone in soils. Based on the information presented above and the lack of any monitoring data that report isophorone in groundwater or soils (except for hazardous waste sites), it appears that isophorone may not be discharged to soils in large amounts, and the small amounts that are deposited may degrade rapidly in soil. Another explanation, however, is that there is a lack of studies determining isophorone content in soil.

## 5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

### 5.4.1 Air

No ambient air monitoring for isophorone was located in the literature. The estimated atmospheric half-life of isophorone is <5 hours may account for the lack of monitoring data, since concentrations will decrease rapidly with distance from the source. Another explanation, however, is that no studies have been conducted that analyzed for isophorone in air.

### 5.4.2 Water

Isophorone has been detected in surface waters, sediments, drinking water, industrial effluents, urban runoff, and in runoff waters from hazardous waste sites. Table 5-1 summarizes the available data.

TABLE 5-1. Detection of Isophorone in Water

Media Type	Location	Sampling Dates	# of Samples	Sample Type	Analytical Method	Concentration		% Occurrence	Reference
						Range	(ppb) Mean		
<u>Surface Water</u>									
	Delaware River	8/77-3/78	NS	grab/ composite	GC/MS	<0.6-3	NS	NS	Hites 1979
	Delaware River	winter '76-'77	18	grab	GC/MS	trace	NS	NS	Sheldon and Hites 1978
	Delaware River	summer '76	18	grab	GC/MS	ND	ND	NA	Sheldon and Hites 1978
	Olentangy River, OH	NS	NS	grab	GC/FID	<5	ND	0	Shafer 1982
	Potomac River by Quantico	1986	NS	grab	GC/MS	<2	ND	0	Hall et al. 1987
<u>Sediments</u>									
	Lake Pontchartrain	5/80-6/80	10	grab	GC/MS	0.9 <sup>a</sup> -12	2.9	NS	McFall et al. 1985
<u>Drinking Water</u>									
	Cincinnati, OH	NS	NS	NS	NS	0.02	NS	NS	EPA 1975
	New Orleans, LA	8/74-9/74	NS	continuous adsorption	GC/MS	1.5-9.5	NS	NS	EPA 1974 Keith et al. 1976
	Philadelphia, PA	2/75-1/77	12	grab	GC/MS	NS	NS	17	Suffet et al. 1980
<u>Effluents</u>									
	Shale oil sites	7/81-12/82	NS	grab	GC/MS	0.34-5.8 <sup>b</sup>	NS	100	Nawthorne and Sievers 1984
	Tire manufacturing plant	NS	NS	grab	GC/MS	40	NS	100	Jungclaus et al. 1976
	Unspecified effluent	NS	NS	NS	GC/MS	NS	NS	NS	Perry et al. 1979
	Philadelphia sewage treatment plnt influent	8/77-3/78	NS	grab/ composite	GC/MS	100	NS	NS	Hites 1979
	Philadelphia sewage treatment plnt effluent	8/77-3/78	NS	grab/ composite	GC/MS	10	NS	NS	Hites 1979
	Plastics effluents	NS	NS	grab	GC/FID	40.5	NS	100	Shafer 1982
	Ship holding tank	NS	NS	grab	GC/FID	<50	NS	0	Shafer 1982
	Secondary sewage effluent	NS	NS	grab	GC/FID	120	NS	100	Shafer 1982
	Chemical industry final effluent	NS	NS	grab	GC/FID	<5	NS	0	Shafer 1982
	Chemical manufacturing plant final effluent	NS	NS	grab	GC/FID	< 20	NS	0	Shafer 1982
	Timber products	NS	2 <sup>c</sup>	NS	GC/MS	55-111	83	NS	Bursey and Pellizzari 1982
	Petroleum refining	NS	1 <sup>c</sup>	NS	GC/MS	1380	NS	NS	Bursey and Pellizzari 1982
	Paint and ink	NS	5 <sup>c</sup>	NS	GC/MS	24-946	185	NS	Bursey and Pellizzari 1982
	Pulp and paper	NS	1 <sup>c</sup>	NS	GC/MS	753	NS	NS	Bursey and Pellizzari 1982
	Auto & other laundries	NS	2 <sup>c</sup>	NS	GC/MS	43-44	43	NS	Bursey and Pellizzari 1982

TABLE 5-1 (continued)

Media Type	Location	Sampling Dates	# of Samples	Sample Type	Analytical Method	Concentration		% Occurrence	Reference
						Range	(ppb) Mean		
Pharmaceuticals		NS	1 <sup>c</sup>	NS	GC/MS	237	NS	NS	Bursey and Pellizzari 1982
Foundries		NS	1 <sup>c</sup>	NS	GC/MS	136	NS	NS	Bursey and Pellizzari 1982
Transportation Equip.		NS	2 <sup>c</sup>	NS	GC/MS	28-318	173	NS	Bursey and Pellizzari 1982
PTOWs <sup>d</sup>		NS	15 <sup>c</sup>	NS	GC/MS	4.2-114	11.5	NS	Bursey and Pellizzari 1982
<u>Urban Runoff</u>									
	Washington, DC	NS-7/82	86	grab	NS	10	NS	4	Cole et al. 1984
<u>Hazardous Waste Sites</u>									
Love Canal		8/80-10/80	NS	grab	GC/MS	NS <sup>f</sup>	NS	NS	Hauser and Bromberg 1982
Valley of the Drums		1979	2 <sup>c</sup>	grab	NS	15-37 <sup>g</sup>	26	NS	Stonebraker and Smith 1980
11 Disposal Sites		NS	8	grab/ composite	NS	29 <sup>h</sup>	NS	12.5	Ghessemi et al. 1984
Cooper Road site, NJ		NS	NS	NS	NS	NS <sup>i</sup>	NS	NS	VIEW database 1988
Sheridan Disposal Services, TX		NS	NS	NS	NS	2500 <sup>e</sup>	NS	NS	VIEW database 1988
Summit National site, OH		NS	NS	NS	NS	NS <sup>g</sup>	NS	NS	VIEW database 1988
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	78	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	91	NS	CLSD8 1987
Unspecified site		NS	2	NS	NS	NS <sup>g</sup>	315	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	1	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	360	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	538	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	48	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	12	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	20	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	48	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	137	NS	CLSD8 1987
Unspecified site		NS	1	NS	NS	NS <sup>g</sup>	11	NS	CLSD8 1987
Unspecified site		NS	2	NS	NS	NS <sup>g</sup>	57.6	NS	CLSD8 1987

<sup>a</sup> Average of 8 samples

<sup>b</sup> µg in air per mL wastewater from purge and trap analysis

<sup>c</sup> number of positive samples

<sup>d</sup> Publicly owned treatment works

<sup>e</sup> detected in groundwater

ND not detected

NA not applicable

NS not specified

GC/MS gas chromatography/mass spectroscopy

GC/FID gas chromatography/flame ionization detector

<sup>f</sup> detected in sediment, soil, or water

<sup>g</sup> detected in water

<sup>h</sup> detected in leachate

<sup>i</sup> detected in groundwater

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In general, isophorone is found in urban centers and appears to result from industrial activities. For example, its presence in the Delaware River near Philadelphia is the result of industrial effluents that are discharged into the sewer system (Hites 1979). The sewage is treated in Philadelphia's Northeast Sewage Treatment plant, which discharges its effluent into the Delaware River. Isophorone was detected in the Delaware River in the winter only; in the summer, biodegradation or other processes (e.g., sorption) may have removed it from the water column. Isophorone has been detected in the sediments of Lake Pontchartrain, which is located in the delta plain of the Mississippi River. Its presence probably is due to the many industries that are situated along the Mississippi River and use the river water as process water. Levels of isophorone in surface waters range from a trace to 100 ppb; however, this range represents only a few determinations.

The presence of isophorone in drinking water is probably the result of using contaminated surface water as a source of drinking water. Of the three cities for which drinking water data are listed, Philadelphia receives its drinking water from the Delaware River, Cincinnati from the Ohio River, and New Orleans from the Mississippi River. These rivers receive numerous industrial effluents.

As listed in Table 5-1, isophorone has been detected in the effluents of a variety of industries. Levels in industrial effluents range from 4.2-1380 ppb. Five reports of positive identifications were found in the open literature: a shale oil site; a tire manufacturing plant; sewer pump sample receiving wastes from phenolic resins manufacturing or processing, vinyl acetate, and polyvinylchloride process areas; final effluent from a sewage treatment system receiving wastes from plants producing plasticizers, butyl rubber, and olefin; and an unspecified effluent. The remaining samples listed in Table 5-1 are from an EPA data base of over 4000 analyses of organic pollutants in industrial wastewater made during the survey conducted in response to the consent decree between the Natural Resources Defense Council and EPA, June 7, 1976 (Bursey and Pellizzari 1982).

Isophorone also has been detected in urban runoff from Washington, DC (Cole et al. 1984). It has been detected in water (unspecified type) at 13 of 357 hazardous waste sites as shown in the contract laboratory statistical data base (1-538 ppb).

### 5.4.3 Soil

Isophorone has been identified in soil only at hazardous waste sites. The contract laboratory program statistical data base reports that isophorone has been detected at 1.68-6500 ppm in 4 of 357 hazardous waste sites.



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### 5.4.4 Other Media

Isophorone has been detected in oysters (but not in clams) in Lake Pontchartrain, LA; the mean of eight samples of oysters from the Inner Harbor Navigation Canal section of the lake contained 38 ppb dry weight of, isophorone. Hall et al. (1987) and De Vault (1985) did not detect isophorone in the fish in the Potomac River and Great Lakes Harbors and tributaries, respectively; in these cases, isophorone was not detected in the water either. Camanzo et al. (1987) reported finding isophorone in nearshore fish from 14 Lake Michigan tributaries and embayments; their results are presented in Table 5-2. Sampling was performed in 1983. Isophorone was detected in fish samples from all but 2 of the sites; the mean of the samples that had detectable levels of the compound was 1.17 mg/kg wet weight. In addition to isophorone, the authors also reported the lipid content of the composite fish samples. No correlation could be found between isophorone concentration and lipid content.

Johansson and Ryhage (1976) reported that isophorone was present in one of three samples of the pharmaceutical clofibrate [ethyl 2-(4-chlorophenoxy)-2-methylpropionate], which lowers elevated serum lipids. The analysis was performed on samples available from Sweden, but clofibrate is also available in the United States. The concentration of isophorone present in samples of the drug available in the United States was not reported.

### 5.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

No ambient air monitoring data are available for isophorone; consequently, no potential inhalation exposures from ambient air can be estimated. Inhalation of isophorone from showering with contaminated water cannot be estimated from the available data (no measurements have been made).

Isophorone concentrations in surface waters and drinking waters are expected to vary considerably with season and with fluctuations in industrial discharges. Considering the dates of most of the positive identifications in surface and drinking water (middle to late 1970s), the effect of more stringent discharge limits in some industries since that time, and the probable seasonal, spatial, and temporal variations in concentrations, it is not possible to make an accurate estimate of ingestion intake of isophorone from drinking water without significant uncertainty. From the available data, it appears that long-term ingestion of isophorone from drinking water will be limited to those systems that receive their water from contaminated surface water sources and the seasonally averaged concentration in these waters probably will be <1 ppb.

Anjou and von Sydow (1967) reported that 0.2% of the essential oil of the American cranberry, Vaccinium macrocarpon, consisted of isophorone; they did not report the percentage of isophorone or the percentage of essential

TABLE 5-2. Detection of Isophorone in Fish near Lake Michigan

Location	Fish	Sampling Dates	# of Samples <sup>a</sup>	Mean Concentration <sup>b</sup>	% Lipid
<u>St. Joseph River</u>	Common Carp	1983	5	ND <sup>c</sup>	23.1
	Smallmouth Bass	1983	7	0.74	3.7
<u>Kalamazoo River</u>	Common Carp	1983	4	0.12	5.9
	Largemouth Bass	1983	4	0.72	3.1
<u>Grand River</u>	Common Carp	1983	3	ND	4.0
	Channel Catfish	1983	6	ND	13.5
<u>Muskegon River</u>	Common Carp	1983	4	0.94	17.9
	Pumpkinseed	1983	3	0.40	2.4
<u>White Lake</u>	Common Carp	1983	4	0.66	15.4
	Bowfin	1983	5	ND	12.1
<u>Pere Marquette River</u>	Common Carp	1983	6	3.13	11.0
	Bowfin	1983	8	ND	13.5
<u>Manistee River</u>	Common Carp	1983	4	ND	10.5
	Bowfin	1983	4	0.76	11.5
<u>Platte River</u>	Common Carp	1983	3	2.32	14.7
	Northern Pike	1983	6	ND	3.5
<u>Boardman River</u>	Smallmouth Bass	1983	6	3.61	5.4
	Rock Bass	1983	3	1.44	3.5
<u>Grand Traverse Bay</u>	Common Carp	1983	3	0.47	16.2
	Lake Trout	1983	4	2.33	18.8

TABLE 5-2 (continued)

Location	Fish	Sampling Dates	# of Samples <sup>a</sup>	Mean% Concentration	% Lipid
<u>Manistique River</u>	Smallmouth Bass	1983	5	1.03	4.5
	Northern Pike	1983	3	ND	2.1
<u>Whitefish River</u>	Common Carp	1983	11	0.88	16.4
	Rock Bass	1983	7	0.69	3.0
<u>Escanaba River</u>	Common Carp	1983	5	0.41	12.9
	Northern Pike	1983	6	0.48	2.9
<u>Ford River</u>	Northern Pike	1983	6	ND	3.0
	Rock Bass	1983	5	ND	3.1

<sup>a</sup> All samples are composites of the stated number of fish and were analyzed by gas chromatography/mass spectroscopy.

<sup>b</sup> mg/kg wet weight

<sup>c</sup> Not Detected

Source: Camanzo et al. 1987

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oil in whole cranberries. Without this information it is not possible to estimate the concentration of isophorone in whole cranberries and compare the concentration to other sources. However, frequent consumption of cranberry containing products is unlikely to represent significant intake of isophorone. Ingestion of isophorone from consumption of fish and shellfish cannot validly be estimated from the available data (see Table 5-2).

Potential dermal exposure levels also are difficult to estimate from the available data. Dermal exposure from bathing in contaminated waters cannot be estimated without significant uncertainty. Other potential dermal exposures cannot be estimated with the available data.

Occupational exposures have been documented most frequently in the screen printing trade and are summarized in Table 5-3. During screen printing operations, both dermal and inhalation exposures can occur. Breathing zone concentrations during screen printing range from <1 to 25.7 ppm, while general area concentrations range from <1 to 16 ppm. The exposure level varies significantly with the ventilation present in the work area. While exposure estimate for a specific screen printing operation is possible, no reasonable estimates can be made for other operations that may use isophorone because of lack of data.

The relative contributions of the exposure routes and sources are as follows. For persons exposed to isophorone in the workplace, total doses will probably be substantially higher than those exposed only to ambient air and drinking water, and their inhalation and dermal exposures for the occupationally exposed can be assumed to result exclusively from the workplace exposures. Inhalation and dermal exposure for persons not exposed to isophorone in the workplace will most likely result from showering or bathing, but only in locations that receive their drinking water from contaminated surface water sources. These exposures are expected to be very small. In locations that do not have the potential for isophorone in the drinking water, any ingestion, inhalation, or dermal exposure is unlikely.

### 5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURE

Populations with potentially high exposure include those occupationally exposed to isophorone (e.g., screen print workers, some adhesives formulators and users, some coatings manufacturing and use workers). Individuals living near hazardous waste sites may be exposed to isophorone dermally, but probably not by inhalation. These individuals also may be exposed to isophorone by ingestion if they drink water from contaminated wells located down gradient from the site.

### 5.7 ADEQUACY OF THE DATABASE

Section 104 (i) (5) of CERCLA, 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

TABLE 5-3. Occupational Monitoring of Isophorone

Company	Process	Sample Type	Concentration (ppm)		Number of Samples	% Positive	Reference
			Range	Mean <sup>a</sup>			
Pre-Finish Metals	Wire Coating	Area	<1 - 3.37	1.13	24	33	NIOSH 1978a
Pre-Finish Metals	Wire Coating	Personal	<1 - 3.37	1.13	19	42	NIOSH 1978a
Joel and Aronoff	Screen Printing	Personal	<0.5 - 14	7.35	14	14	Lee and Fredrick 1981
Unspecified	Screen Printing	Area	3.5 - 16	10.2	46	100	Samimi 1982
Unspecified	Screen Printing	Personal	8.3 - 23	14.7	78	100	Samimi 1982
Electrocal	Screen Printing	Area	0.70 - 1.22	0.957	6	100	Bierbaum and Parnes 1974
Electrocal	Screen Printing	Personal	0.84 - 1.39	1.10	3	100	Bierbaum and Parnes 1974
Swinston Co.	Screen Printing	Personal	<0.47 - 25.7	12.9	7	29	Kominsky 1981
Garden City Engraving	Screen Printing	Area	<0.67 - 2.5	1.18	7	57	Salisbury 1983
Garden City Engraving	Screen Printing	Personal	<0.58 - 3.4	1.42	8	75	Salisbury 1983

<sup>a</sup> Mean of the positive samples

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effects of isophorone is available. Where adequate information is not available, ATSDR, in cooperation with the National Toxicology Program (NTP), is required to assure the initiation of a program of research designed to determine these health effects (and techniques for developing methods to determine such health effects). The following discussion highlights the availability, or absence, of exposure and toxicity information applicable to human health assessment. A statement of the relevance of identified data needs is also included. In a separate effort, ATSDR, in collaboration with NTP and EPA, will prioritize data needs across chemicals that have been profiled.

### 5.7.1 Data Needs

**Physical and Chemical Properties.** Physical and chemical properties are essential for estimating the partitioning of a chemical in the environment. Many physical and chemical properties are available for isophorone, but most do not have extensive experimental descriptions accompanying the data; therefore, an evaluation of the accuracy of the data is difficult. Specifically, measured vapor pressure,  $K_{oc}$ , and Henry's Law constant at environmentally significant temperatures would help to remove doubt regarding the accuracy of the estimated data. The data on physical properties form the basis of much of the input requirements for environmental models that predict the behavior of a chemical under specific conditions, including hazardous waste landfills. The data on the chemical properties, on the other hand, can be useful in predicting certain environmental fates of this chemical.

**Environmental Fate.** Sensitized photolysis studies in water and oxidation/reduction studies in both air and water are lacking, as are biodegradation studies in surface and groundwaters. These kinds of studies are important, since they represent the fundamental removal mechanisms available to isophorone in the environment. In addition, the kinetic studies for the atmospheric reactions are important for understanding the significance of a removal mechanism and predicting the reactions that may control the fate of a chemical in the environment.

**Exposure Levels in Environmental Media.** Environmental monitoring data are not available for soil and air, and the data available for water, sediments, and biota are not sufficient to determine ambient concentrations. These data would be helpful in determining the ambient concentrations of isophorone so that exposure estimates of the general population and the bioconcentration factor of this chemical in aquatic organisms can be made.

**Exposure Levels in Humans.** No information is available concerning exposure levels of isophorone in humans. A data base would be helpful in determining the current exposure levels, and thereby allowing an estimation of the average daily dose associated with various sources (e.g., living near a hazardous waste site: drinking water containing isophorone). A monitoring

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program involving analyses of human tissues would be useful in assessing the magnitude of environmental exposures. Monitoring of human tissues from different locations and seasons and using different category of the population would be helpful so that the effects of such variables as occupational, geographical, and seasonal can be assessed.

**Exposure Registries.** An exposure registry (e.g., for occupationally exposed groups) currently is not available. The development of a registry of exposures would provide a useful reference tool in assessing exposure levels and frequencies. In addition, a registry developed on the basis of exposure sources would allow an assessment of the variations in exposure levels from one source to another and the effect of geographical, seasonal, regulatory actions on the level of exposure within a certain source. These assessments, in turn, would provide a better understanding of the needs for research or data acquisition based on the current exposure levels.

### 5.7.2 On-going Studies

No on-going studies were located in the available literature,