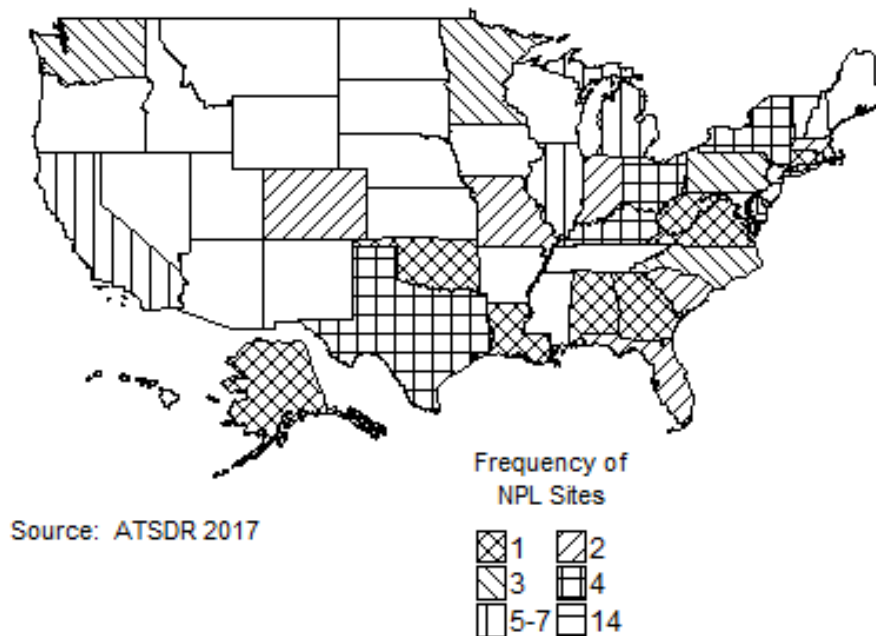


CHAPTER 5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

Bis(2-chloroethyl)ether has been identified in at least 89 of the 1,854 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (ATSDR 2017). However, the number of sites in which bis(2-chloroethyl)ether has been evaluated is not known. The number of sites in each state is shown in Figure 5-1.

Figure 5-1. Number of NPL Sites with Bis(2-Chloroethyl)Ether Contamination



- The most likely route of exposure to BCEE for the general population is via ingestion of BCEE in drinking water.
- A daily intake of BCEE from drinking water is estimated at 0.003 $\mu\text{g}/\text{kg}/\text{day}$.
- BCEE is primarily used as a chemical intermediate in pesticide manufacturing.
- BCEE will slowly volatilize from water and soil. Biodegradation is likely an important fate process for BCEE in water.

5. POTENTIAL FOR HUMAN EXPOSURE

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

Table 5-1 summarizes information on U.S. companies that reported the manufacture or use of bromodichloromethane in 2016 (TRI16 2017). Toxics Release Inventory (TRI) data should be used with caution since only certain types of industrial facilities are required to report. This is not an exhaustive list.

Table 5-1. Facilities that Produce, Process, or Use Bis(2-Chloroethyl)Ether

State ^a	Number of facilities	Minimum amount on site in pounds ^b	Maximum amount on site in pounds ^b	Activities and uses ^c
GA	1	100,000	999,999	2, 3, 6
KY	1	10,000	99,999	1, 3, 6
LA	7	0	9,999	1, 5, 12, 13
MO	1	100,000	999,999	1, 3, 4, 6, 9
OH	2	1,000	9,999	12
OK	1	10,000	99,999	7
TX	10	1,000	999,999	1, 5, 6, 12

^aPost office state abbreviations used.

^bAmounts on site reported by facilities in each state.

^cActivities/Uses:

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

Source: TRI16 2017 (Data are from 2016)

All BCEE produced in the United States is made by direct chlorination of ethylene glycol (Buckman Laboratories 1988). BCEE can also be produced by the treatment of ethylene chlorohydrin or 2-chloroethanol with sulfuric acid, or by chlorination of ethylene chlorohydrin at 80°C. Production of BCEE in the United States in 1986 was estimated to be 1,200 kkg (Buckman Laboratories 1988).

5.2.2 Import/Export

Imports of BCEE in 1977 were estimated to be about 590 kkg (HSDB 1988). Imports of BCEE in 1986 were estimated to be about 60 kkg (Buckman Laboratories 1988).

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5.2.3 Use

In the past, BCEE has been used as a solvent for fats, waxes, greases, and esters (Schrenk et al. 1933). It has also been used as a constituent of paints and varnishes, as a cleaning fluid for textiles, in the purification of oils and gasoline, in the manufacture of medicines and pharmaceuticals, as an intermediate in the synthesis of other chemicals, and as an insecticide and a soil fumigant (Browning 1965; Hake and Rowe 1963; HSDB 1988; Verschueren 1977; Windholz 1983).

BCEE is currently used primarily as a chemical intermediate for the manufacture of pesticides. The two major pesticide products made from BCEE are WSCP, an isoprene polymer used primarily as an algicide, and CDQ, a diquatery ammonium compound used as a microbicide and corrosion inhibitor in the petroleum industry. A small amount of BCEE (about 1%) is still used as a solvent.

5.2.4 Disposal

No information was located on the amounts of BCEE disposed of to the environment or to waste sites. Because BCEE is classified as a hazardous waste under the Resource Conservation and Recovery Act (RCRA), all BCEE waste must be disposed of in an authorized RCRA facility. Permitted disposal methods include incineration and land disposal, although EPA is currently considering possible restrictions on land disposal methods (40 CFR 268.11).

5.3 RELEASES TO THE ENVIRONMENT

The Toxics Release Inventory (TRI) data, presented in Table 5-2, should be used with caution because only certain types of facilities are required to report (EPA 2005). This is not an exhaustive list. Manufacturing and processing facilities are required to report information to the TRI only if they employ ≥ 10 full-time employees; if their facility 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

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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 2005).

Table 5-2. Releases to the Environment from Facilities that Produce, Process, or Use Bis(2-Chloroethyl) Ether^a

State ^c	RF ^d	Air ^e	Water ^f	UI ^g	Land ^h	Other ⁱ	Reported amounts released in pounds per year ^b		
							Total release		On- and off-site
							On-site ^j	Off-site ^k	
GA	1	1	0	0	0	0	1	0	1
KY	1	0	0	0	0	0	0	0	0
LA	7	13	3	0	0	0	16	0	16
MO	1	34	1	0	0	0	35	0	35
OH	2	0	0	0	0	0	0	0	0
OK	1	0	0	0	0	0	0	0	0
TX	10	48	0	0	0	0	48	0	48
Total	23	97	4	0	0	0	101	0	101

^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 onsite landfills, land treatment, surface impoundments, other land disposal, other landfills.

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

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

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

RF = reporting facilities; UI = underground injection

Source: TRI16 2017 (Data are from 2016)

5.3.1 Air

Estimated releases of 97 pounds (~0.044 metric tons) of BCEE to the atmosphere from 23 domestic manufacturing and processing facilities in 2016, accounted for about 96% of the estimated total environmental releases from facilities required to report to the TRI (TRI16 2017). These releases are summarized in Table 5-2.

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5.3.2 Water

Estimated releases of 4 pounds (~0.0018 metric tons) of BCEE to surface water from 23 domestic manufacturing and processing facilities in 2016, accounted for about 4% of the estimated total environmental releases from facilities required to report to the TRI (TRI16 2017). These releases are summarized in Table 5-2.

5.3.3 Soil

No BCEE was released to soil from 23 domestic manufacturing and processing facilities in 2016 (TRI16 2017). These releases are summarized in Table 5-2.

5.4 ENVIRONMENTAL FATE**5.4.1 Transport and Partitioning**

Little information was located on the transport or partitioning of BCEE in the environment. The vapor pressure of BCEE at 20°C is 0.7 mm Hg (Verschuere 1977), suggesting that volatilization from soil or water, while probably very slow, could be significant (Callahan et al. 1979). EPA (1987a) calculated a half-time for volatilization of BCEE from a river to be 3.4 days. Because BCEE is quite soluble in water (10,200 mg/L) (Verschuere 1977), it is expected that BCEE in air would tend to be removed by wet deposition, resulting in a cycle between water, soil, and air (Callahan et al. 1979). The relative distribution between these phases, however, is not known.

Because BCEE has good solubility in water and a relatively low log octanol-water partition coefficient (measured to be 1.1 by Veith et al. 1980), BCEE in aqueous media is not expected to adsorb strongly to sediments, nor is it likely to be bioaccumulated by aquatic organisms (Callahan et al. 1979). Consistent with this, a bioconcentration factor of 11 has been measured in sunfish by Veith et al. (1980).

For the same reasons, BCEE is not expected to adsorb strongly to soils, and would be expected to migrate in soil water. Consistent with this, Wilson et al. (1981) reported a soil retardation factor of <1.5 for sandy soil with low organic content, while other contaminants (e.g., di- and trichlorobenzene) had retardation factors of 3.4–9.4.

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5.4.2 Transformation and Degradation

Air. Callahan et al. (1979) reviewed the potential fate of BCEE in the environment and suggested that BCEE in a smog-like atmosphere would probably undergo photooxidative destruction with a half-life of approximately 4 hours. The rate of atmospheric photooxidation under other conditions was not estimated. Direct photolysis was judged to be an unimportant process, since BCEE does not absorb visible or near ultraviolet light (Callahan et al. 1979).

Water. Most ethers are very resistant to hydrolysis, and the rate of cleavage of the carbon-oxygen bond by abiotic processes is expected to be insignificant (Callahan et al. 1979). The carbon-chlorine bond is also quite stable to abiotic cleavage. Based on a measured hydrolysis rate constant of 1.5×10^{-5} minutes at 100°C , Mabey et al. (1982) estimated the half-life of the carbon-chlorine bond to be about 22 years at 20°C . This rate is somewhat slower than observed for simple alkyl halides (Callahan et al. 1979; Mabey et al. 1982), an effect that Mabey et al. (1982) attributed to the effect of the chloro-ethoxy group on the adjacent carbon.

Biodegradation may be an important fate process for BCEE in water. In laboratory studies, Tabak et al. (1981) found that in aqueous media inoculated with sewage, BCEE underwent 100% transformation within 7 days, and there was a rapid adaptation of the degradative microorganisms. Similar results were reported by Ludzack and Ettinger (1963), although in this case, there was a 25-day lag before adaptation occurred, and 30 more days were required to convert 80% of the BCEE to CO_2 . A second dose of BCEE added to the adapted medium was 80% oxidized in 15 days. Monsen (1986) reported that BCEE also underwent significant biodegradation (68%) in an anaerobic laboratory test pond designed to simulate an industrial primary lagoon. Losses via evaporation and sorption were minimal. In contrast to these findings, Dojlido (1979) did not observe significant biodegradation of BCEE in several laboratory test systems. The reason for this discrepancy is not certain, but may be due to insufficient incubation time (2 weeks) for the adaptation to occur. Biodegradation in surface waters would likely be slower than observed in the laboratory, but could lead to significant destruction of BCEE.

Sediment and Soil. Wilson et al. (1981) observed no significant transformation of BCEE percolated through soil for 45 days, but Kincannon and Lin (1986) found that BCEE was significantly degraded in a 97-day laboratory soil column study. The initial rate constant for degradation was reported to be 0.042 day^{-1} (half-time of 16.7 days). After 48 days, the rate increased to 0.086 day^{-1} (half-time of 8.0 days), suggesting that there was an acclimation of soil microbes occurring.

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5.5 LEVELS IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to BCEE depends, in part, on the reliability of supporting analytical data from environmental samples and biological specimens. Concentrations of BCEE in unpolluted atmospheres and in pristine surface waters are often so low as to be near the limits of current analytical methods. In reviewing data on BCEE 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.

Table 5-3 shows the lowest limit of detections that are achieved by analytical analysis in environmental media. An overview summary of the range of concentrations detected in environmental media is presented in Table 5-4.

Table 5-3. Lowest Limit of Detection Based on Standards^a

Media	Detection limit	Reference
Air	1 µg/m ³	Berck 1965
Water	0.005 µg/L	Dressman et al. 1977
Soil/sediment	1 mg/kg	EPA 1986a
Whole blood	No method identified	

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

Table 5-4. Summary of Environmental Levels of Bis(2-Chloroethyl)Ether

Media	Low	High	For more information
Outdoor air (ppbv)	No monitoring data were identified		
Indoor air (ppbv)	No monitoring data were identified		
Surface water (ppb)	Trace quantities measured		Section 5.5.2
Ground water (ppb)	840 µg/L (geometric mean)		Section 5.5.2
Drinking water (ppb)	0.01 µg/L	0.36 µg/L	Section 5.5.2
Food (ppb)	No monitoring data were identified		
Soil	No monitoring data were identified		

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

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Table 5-5. Bis(2-Chloroethyl)Ether Levels in Water, Soil, and Air of National Priorities List (NPL) Sites

Medium	Median ^a	Geometric mean ^a	Geometric standard deviation ^a	Number of concentrations	NPL sites
Water (ppb)	300	237	43,900	25	21
Soil (ppb)	6,950	1,060	12,800	14	10
Air (ppbv)	No data	No data	No data	No data	No data

^aConcentrations found in ATSDR site documents from 1981 to 2017 for 1,854 NPL sites (ATSDR 2017). Maximum concentrations were abstracted for types of environmental media for which exposure is likely. Pathways do not necessarily involve exposure or levels of concern.

5.5.1 Air

No studies were located with regard to concentrations of BCEE in ambient air. Based on the physical-chemical properties of BCEE, some release of BCEE into air from contaminated chemical waste sites or industrial settings is expected, but no quantitative data were located.

5.5.2 Water

In 1977, the EPA carried out an extensive study (the National Organics Monitoring Survey) of organic contaminants in finished drinking water supplies across the United States. BCEE was not detected in any samples in Phase I of the study, but the detection limit was only 5 µg/L. In phase II, the detection limit was lowered to 0.005 µg/L, and BCEE was detected in water from 13 of 113 cities sampled. The values ranged from 0.01 to 0.36 µg/L, with a mean concentration (for the 13 positive samples) of 0.1 µg/L (Dressman et al. 1977). In phase III of the Survey, BCEE was detected in drinking water from 8 of 110 cities, with a mean concentration of 0.024 µg/L. Trace quantities of BCEE have been reported in several rivers, including the Mississippi, the Delaware, and the Kanawha (EPA 1987a; Staples et al. 1985). BCEE was detected in groundwater at about 2% of waste disposal sites being investigated under Superfund, at a geometric mean concentration of around 840 µg/L (CLPSD 1988).

5.5.3 Sediment and Soil

BCEE was detected in soil at only 0.4% of waste sites monitored under Superfund, at geometric mean concentration of 140 ppb (CLPSD 1988).

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5.5.4 Other Media

No studies were located regarding the occurrence of BCEE in food or other media.

5.6 GENERAL POPULATION EXPOSURE

The primary known source of exposure for the general population is via the water supply. The reports of quantities in several drinking water supplies provided a mean value of approximately 0.1 ppb. Ingestion of approximately 2 L of water per day by an adult would provide a daily intake of 0.003 $\mu\text{g}/\text{kg}/\text{day}$ of BCEE.

5.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Even though there are no exposure data, those at greatest risk of exposure to BCEE are probably workers who are exposed to BCEE while on the job. Residents who live near waste sites or industrial facilities that permit escape of BCEE may also experience higher than average exposure to BCEE. Exposure would be most likely by ingestion of contaminated water, but inhalation exposure might also occur. The level and significance of such exposures can only be evaluated on a site-by-site basis.