

4.0 ENVIRONMENTAL TRANSPORT AND FATE

PRINCIPAL FINDINGS

- Both EDB and EDC:
 - Have low to moderate sorptive affinity for aquifer solids
 - Are relatively mobile in groundwater
 - Can volatilize from solution
 - Do not bioconcentrate or bioaccumulate in food chains
 - Biodegrade under both aerobic and anaerobic conditions
- EDB biodegrades more rapidly anaerobically (half-life of 15 to 50 days) than aerobically (half-life of 35 to 360 days)
- EDC biodegrades more rapidly aerobically (half-life of 100 days) than anaerobically (half-life of 400 days)

This section provides an overview of the environmental transport and fate of EDB and EDC. Much of the discussion is based on the physical and chemical properties discussed in Section 3.0 of this report. Key sources of information used in describing environmental fate include toxicological profiles for EDB and EDC published by ATSDR (Refs. 4-1 and 4-2) and a human health risk assessment protocol and technical fact sheets on EDB and EDC published by EPA (Refs. 4-7, 4-8, and 4-9).

EDB has been historically released into the environment as a result of its use as a lead scavenger and fumigant, improper land disposal of wastes containing EDB, and accidental EDB releases during its production and use in the manufacturing industry (Ref. 4-1). EDC has been historically released into the environment as a result of its use as a lead scavenger, grain fumigant, chemical intermediate, and extraction and cleaning solvent; improper land disposal of wastes containing EDC; and accidental EDC releases during its production (Ref. 4-2).

The physical, chemical, and microbiological processes that control the transport and fate of EDB and EDC in soil and groundwater are described below.

4.1 TERRESTRIAL TRANSPORT AND FATE

The terrestrial transport and fate of EDB and EDC depend on the adsorption properties of these compounds with respect to soil particles, the depth of EDB- or EDC-contaminated soil, and the bioavailability of the chemicals for microbial degradation.

4.1.1 Terrestrial Transport and Fate of EDB

The soil organic carbon/water partition coefficient, K_{oc} , is used to evaluate the adsorption properties of a compound with respect to soil particles (Ref. 4-7). The log K_{oc} value for

EDB is reported to be 1.45 (Ref. 4-7), indicating that EDB exhibits low to moderate soil adsorption and consequently high mobility in soil and the ability to leach quickly into groundwater (Refs. 4-7 and 4-10). The vapor pressure of EDB (that is, the pressure of EDB vapor in equilibrium with EDB liquid at a particular temperature) is 11 mm Hg at 25 °C (Ref. 4-1), which indicates that EDB readily partitions to the atmosphere from dry soil.

Henry's Law Constant provides a measure of the extent of chemical partitioning between air and water at equilibrium. The higher the constant, the more likely a chemical is to volatilize than to remain in water. The dimensionless value of Henry's Law Constant for EDB is 0.0133 (Ref. 4-7) indicating that volatilization of EDB from moist surfaces is expected to be an important environmental fate process (Ref. 4-5).

Direct photolysis of EDB in the troposphere is not a common phenomenon, but EDB can break down as a result of its reaction with photochemically produced hydroxyl radicals. The half-life of this reaction has been estimated to be 32 to 40 days (Refs. 4-1 and 4-8). EDB does not bioconcentrate in terrestrial food chains (Refs. 4-1 and 4-10).

EDB readily undergoes aerobic biodegradation in surface soil (Ref. 4-8), with the fastest degradation occurring at or near the soil surface. EDB is moderately persistent deeper in the soil, and a representative half-life has been estimated to be 100 days (Ref. 4-4). Biodegradation of EDB under anaerobic conditions and abiotic degradation are limited (Ref. 4-10). In fields where gaseous EDB has been applied as a soil fumigant, 99 percent of the EDB is entrapped or sorbed by the soil micropores (Ref. 4-8). This entrapped or sorbed EDB is unavailable for chemical or microbiological reactions (Ref. 4-12) and consequently is resistant to biodegradation, chemical transformation, and mobilization and may persist for long periods of time (Ref. 4-1). In one field study, EDB was detected in soil 19 years after its last known application (Ref. 4-8); the specific location of the field study was not provided. Sorbed EDB slowly leaches from micropore sites to contaminate groundwater (Ref. 4-1).

4.1.2 Terrestrial Transport and Fate of EDC

The vapor pressure of EDC (12 mm Hg at 25 °C) and its Henry's Law Constant (0.0401) indicate that EDC can partition into the air from dry and moist soil surfaces (Refs. 4-2 and 4-7). Volatilization losses occur more slowly for EDC present in subsurface soil (Ref. 4-2). In air, EDC undergoes photolytic degradation by reacting with hydroxyl radicals formed by sunlight. Significant removal of EDC from air by oxidation or direct photolysis is not expected. EDC molecules that do not undergo photolysis can persist in the atmosphere for more than 5 months and can be carried over long distances (Ref. 4-2). Based on its log K_{oc} value of 1.58 (Ref. 4-7), EDC is expected to have high mobility in soil and should be available for transport into subsurface soil or groundwater (Ref. 4-6). EDC percolates rapidly through sandy soil (Ref. 4-9).

EDC is biodegraded in soil, where a half-life value of 52 days has been reported (Ref. 4-2). The presence of methane can increase the rate of aerobic biodegradation of EDC in

soil. However, higher concentrations of EDC may prove to be toxic to microbial populations, thus decreasing the rate of biodegradation. In a respirometer study, a concentration of 0.51 mg of EDC per gram of soil resulted in a 50 percent inhibition of microbial respiration (Ref. 4-2).

4.2 GROUNDWATER TRANSPORT AND FATE

The groundwater transport and fate of EDB and EDC depend on the adsorption properties of these compounds with respect to suspended solids and sediment in the water column, their rate of leaching from soil to groundwater, and the presence of other compounds such as methane and hydrogen sulfide (H₂S).

4.2.1 Groundwater Transport and Fate of EDB

Once EDB enters groundwater, the primary mass transport processes that come into play include advection and hydrodynamic dispersion. Other processes, such as hydrolysis and biodegradation reactions, tend to retard or restrict the movement of EDB (Ref. 4-12).

Based on its log K_{oc} value of 1.45, EDB is not expected to adsorb to suspended solids and sediment in the water column (Ref. 4-5). Its dimensionless Henry's Law Constant of 0.0133 (Ref. 4-7) indicates that volatilization of EDB from groundwater pumped to the surface and exposed to atmosphere is an important environmental fate process (Ref. 4-1). Once volatilization has occurred, EDB can react with photochemically produced hydroxyl radicals (Ref. 4-1). Compared to its rate of volatilization to the atmosphere, the biotic and abiotic degradation of EDB in groundwater is slow (Ref. 4-1). EDB is resistant to abiotic hydrolysis, and its hydrolytic half-life has been reported to range from 6 to 13.2 years at 20 °C (Refs. 4-8 and 4-10).

A study reported that the half-life of EDB was reduced from 22 years to 16 years when 50 millimole (mM) phosphate buffer was added to water at pH 7 and 15°C. The addition of 1mM sulfide to the 50 mM phosphate buffer at 15 °C further reduced the half-life of EDB to 160 days (Ref. 4-3). Biotic hydrolysis (biodegradation) of EDB is enhanced in the presence of a natural catalyst such as H₂S or the bisulfide ion (HS⁻), with the time required for hydrolysis decreasing from several years to approximately 2 months (Refs. 4-3, 4-10, and 4-12). Ethylene glycol and bromide ions are major products of the hydrolysis reactions (Ref. 4-12).

Table 1 provides a summary of data on EDB biodegradation under aerobic and anerobic conditions. Biodegradation of EDB in groundwater occurs aerobically with a half-life of 35 to 360 days and anerobically with a half-life of 15 to 50 days. The rates of natural anaerobic biodegradation of EDB are very comparable to the rates of natural anaerobic biodegradation of benzene. Table 2 provides a summary of natural biodegradation of benzene under anaerobic conditions.

Table 4-1: Biodegradation of EDB under aerobic and anaerobic conditions

Material	Condition	Initial Concentration (mg/L)	Half Life (days)	Reference
Acclimated Aquifer	Anaerobic	0.005	50	4-16
Aquifer with Landfill Leachate	Anaerobic	0.2	15	4-17
Pristine Aquifer	Aerobic	0.006	63	4-14
Pristine Aquifer	Aerobic	0.006	84	4-14
Pristine Aquifer	Aerobic	1	>180	4-18
Acclimated Aquifer	Aerobic	0.005	74	4-16
Acclimated Aquifer	Aerobic	0.005	35 to 360	4-16
Acclimated Soil	Aerobic	0.006	2	4-15
Acclimated Soil	Aerobic	15	210	4-15

Table 4-2: Biodegradation of Benzene under anaerobic conditions

	Half Life (days)	
Mean	68 ^a	66 ^b
Median	Not Available	170 ^b

^a Ref. 4-19^b Ref. 4-13

4.2.2 Groundwater Transport and Fate of EDC

Based on its Henry's Law Constant of 0.0401 (Ref. 4-7), EDC is expected to primarily volatilize from water surfaces (Ref. 4-2), with a reported half-life of several hours to 10 days. Based on its log K_{oc} value of 0.0401 (Ref. 4-7), EDC is not expected to adsorb to suspended solids and sediment in the water column (Ref. 4-9). Plants and fish take up small amounts of EDC, but the chemical is not known to bioconcentrate in fish or other aquatic organisms or to bioaccumulate in the food chain (Ref. 4-2). Biodegradation of EDC in groundwater occurs aerobically with a half-life of 100 days and anaerobically with a half-life of 400 days (Ref. 4-2).

In groundwater, EDC is resistant to hydrolysis and breaks down very slowly because of a lack of functional groups that hydrolyze under environmental conditions (Ref. 4-6). The half-life for the hydrolysis reaction has been found to be 49,000 years at a pH of 9 and 15 °C and decreases in the presence of H₂S. This suggests that hydrolysis may occur in hypoxic groundwater where H₂S occurs naturally (Ref. 4-2).

4.3 REFERENCES

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