Canadian Water Quality Guidelines for the Protection of Aquatic Life

HEXACHLORO-BUTADIENE

Hexachlorobutadiene (HCBD) has a CAS name and number of 1,1,2,3,4,4,-hexachloro-1,3-butadiene and 87-68-3, respectively. It has a chemical formula of C_4Cl_6 (Howard et al. 1991), is sparingly soluble in water (3.2 mg·L^{-1} at 25ºC) (Gradiski et al. 1975), and has a log K_{ow} of 4.9 (Chiou 1985). HCBD is prepared from hexyl oxide, polychlorobutanes, hexachlorobutene, or butadiene (Mumma and Lawless 1975; IARC 1979; CESARS 1995). It was mostly used as a solvent for longer-chain hydrocarbons and elastomers, as a hydraulic fluid, a heat transfer liquid and insulating fluid, and as a chemical intermediate in producing chlorofluorocarbons and lubricants. HCBD was also used to recover chlorine-containing gas in chlorine plants (IARC 1979; USEPA 1980; Manahan 1992; WHO 1994).

HCBD was never produced in Canada and was mainly released as a by-product from the production of tetrachloroethylene. It was also a by-product from the manufacture of trichloroethylene, carbon tetrachloride, vinyl chloride, allyl chloride, and epichlorohydrin (USEPA 1980; Kusz et al. 1984). It could be found in the fly ash during refuse combustion (Howard et al. 1991). It is no longer imported and the two Canadian tetrachloroethylene producers ceased production in 1985 and 1992.

Current Canadian sources are minor and may include landfill leachates, refuse combustion, and production of vinyl chloride, allyl chloride, and epichlorohydrin, which are not manufactured, processed, or used in quantities greater than 10 t in Canada (F. Lavalée 1996, Environment Canada, Ottawa, Ontario, pers. com.). The probable current major source is long-range transport. In aquatic systems, transport across international boundaries is limited (Chan 1993). EQC Level III fugacity model results show that when released to water, 71% initially remained in water, 15.9% went into air, 0.23% into soil, and 12.9% into sediment (Environment Canada 1996).

Remedial measures in the 1980s reduced HCBD loadings in the Canadian environment, and thus concentrations in aquatic systems are generally very low. Levels monitored downstream from industrial drains, for example, were at a maximum of 2.7 ng·L^{-1}. Sediment levels contained 310 µg·g^{-1} and levels in caged mussels *(Elliptio complenata)* following a 3-week exposure had a maximum of 36 µg·kg^{-1} (Farrara and Burt 1997).

HCBD will volatilize from aqueous phases, but not as readily as other short-chain, halogenated, aliphatic solvents. Due to its hydrophobic nature, HCBD will not remain in water for long periods and will partition into the atmosphere or be adsorbed to sediments (USEPA 1980). The half-life in water is proportional to organic matter and ranges from 4 to 52 weeks (Howard et al. 1991). In wastewaters, HCBD can undergo aerobic and anaerobic degradation, with aerobic degradation occurring in 7 d. In natural waters, no anaerobic degradation occurs (Tabak et al. 1981; Johnson and Young 1983; Govind et al. 1991; Howard 1991). Sediments are a sink, and it is expected to persist in sediments with high organic content. Sediment accumulation factors are estimated at 230–10 800 (BUA 1991). Its log K_{oc} of 4.9 signifies sorption to suspended particulates, which settle on bottom sediments. Desorption increases with increasing temperature and suspended solids (Oliver 1985).

Although HCBD bioconcentrates in tissues of freshwater invertebrates and fish (Pereira et al. 1988), it does not biomagnify to any appreciable extent, possibly because of its fast depuration rate (Environment Canada 1983). Reported BCFs range from 1.7 to 19 000 (BUA 1991). This may be due to differences in species metabolism or concentrations tested (ASTDR 1992).

Water Quality Guideline Derivation

The interim Canadian water quality guideline for HCBD for the protection of freshwater life was developed based on the CCME protocol (CCME 1991). For more information, see the supporting documents (Environment Canada 1998a and 1998b).

Table 1. Water quality guidelines for hexachlorobutadiene for the protection of aquatic life (Environment Canada 1998a).

Aquatic life	Guideline value (µg·L^{-1})
Freshwater	1.3*
Marine	NRG†

*Interim guideline.
†No recommended guideline.

Freshwater Life

The acute toxicity data for vertebrates includes 96-h LC_{50}s of 90 $\mu g \cdot L^{-1}$ for goldfish *(Carassius auratus)* (Leeuwangh et al. 1975), 100 $\mu g \cdot L^{-1}$ (Walbridge et al. 1983) and 102 $\mu g \cdot L^{-1}$ (USEPA 1978; Geiger et al. 1985) for fathead minnows *(Pimephales promelas)*, and 320 $\mu g \cdot L^{-1}$ for rainbow trout *(Oncorhynchus mykiss)* (USEPA 1980). Similar duration and endpoint tests on bluegill *(Lepomis macrochirus)* have provided values of 326 $\mu g \cdot L^{-1}$ (USEPA 1980) and 760 $\mu g \cdot L^{-1}$ (Mayer and Ellersieck 1986). Two studies on HCBD effects on zebrafish *(Brachydanio rerio)* produced 48-h LC_{50} values of 1000 $\mu g \cdot L^{-1}$ (Slooff 1979) and 260 $\mu g \cdot L^{-1}$ (Röederer et al. 1989).

The chronic toxicity values for fish include a 10-d study producing histological effects in the liver, gall bladder, and kidneys of largemouth black bass *(Micropterus salmoides)* at 32 $\mu g \cdot L^{-1}$ (Laseter et al. 1976). Other chronic tests with the guppy *(Poecilia reticulata)* resulted in 14-d LC_{50}s of 400 $\mu g \cdot L^{-1}$ (Könemann 1981) and 160 $\mu g \cdot L^{-1}$ (Hermens et al. 1985). Threshold concentrations (LOEL and NOEL) for nonlethal endpoints such as changes in zebrafish *(B. rerio)* feeding and breathing rates and coordination were 14 and 5 $\mu g \cdot L^{-1}$, respectively (Röederer et al. 1989). An even lower LOEL has been reported at 3.42 $\mu g \cdot L^{-1}$ based on changes to the corticosteroid level in the blood for largemouth bass *(M. salmoides)* (Laseter et al. 1976). The lowest acceptable chronic value was a 28-d LC_{50} and LOEL of 13 $\mu g \cdot L^{-1}$ for *P. promelas* (Benoit et al. 1982).

For invertebrates, 96-h LC_{50} values were 130 and 210 $\mu g \cdot L^{-1}$ for the isopod *Asellus aquaticus* and the snail *Lymnaea stagnalis*, respectively (Leeuwangh et al. 1975).

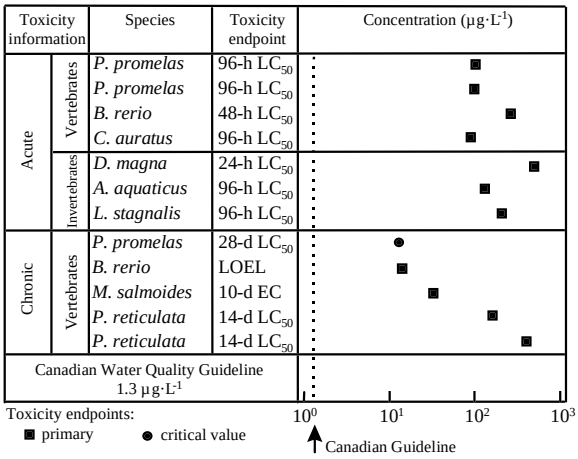

Figure 1. Select freshwater toxicity data for hexachlorobutadiene.

A 24-h NOEC of 80 $\mu g \cdot L^{-1}$ and an EC_{50} (immobilization) of 500 $\mu g \cdot L^{-1}$ were reported for *Daphnia magna* (Knie et al. 1983). Bacteria and plants are less sensitive, with EC_{10}s >900 $\mu g \cdot L^{-1}$ for bacteria and >25 $mg \cdot L^{-1}$ for plants (Knie et al. 1983).

The interim water quality guideline for HCBD for the protection of freshwater life is 1.3 $\mu g \cdot L^{-1}$. It was derived by multiplying the 28-d LOEL of 13 $\mu g \cdot L^{-1}$ for the fathead minnow *(P. promelas)* (Benoit et al. 1982) by a safety factor of 0.1 (CCME 1991).

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