Canadian Water Quality Guidelines for the Protection of Aquatic Life

CHLORINATED ETHENES

1,1,2-trichloroethene (trichloroethylene)

Trichloroethylene (C_2HCl_3; CAS 79-01-06) and TCE are common names for 1,1,2-trichloroethene; a colourless liquid with high volatility (vapour pressure = 8 kPa at 20°C) and moderate water solubility (1.1 $g \cdot L^{-1}$ at 20°C). TCE is a degreasing solvent in automotive and metal industries, and is used in dry cleaning facilities and various consumer products (Hughes et al. 1994). Canadian production of TCE ceased in 1985.

TCE enters the aquatic environment through industrial discharges, landfill leaching, accidental spills, and improper storage and disposal. Atmospheric transport and deposition of TCE is a significant route of entry to aquatic environments in nonindustrial areas (USEPA 1979). In the 1980s, surface water concentrations in Canada generally did not exceed 1 $\mu g \cdot L^{-1}$, though site-specific residues up to 90 $\mu g \cdot L^{-1}$ were reported (Kaiser and Comba 1983; 1986; Lum and Kaiser 1986). TCE concentrations in groundwater are generally higher due to minimal volatilization (Zoeteman et al. 1980). Residues from 0.06–425 $mg \cdot L^{-1}$ have been measured near industrial sites in British Columbia and Manitoba, respectively (Golder Associates 1989; UMA Engineering Ltd. 1992).

The low log K_{ow} (2.29) of TCE suggests that it will not bioconcentrate to a high degree. BCFs for freshwater organisms vary from 17 to 1160 for bluegill sunfish *(Lepomis macrochirus)* and green alga *(Chlorella fusca vacuolata)*, respectively (Barrows et al. 1980; Geyer et al. 1984). Further TCE residues in several marine species are reportedly ≤30.0 $mg \cdot kg^{-1}$ ww (Pearson and McConnell 1975; Ofstad et al. 1981; Wang et al. 1985).

Volatilization is the principal removal process for TCE from the aquatic environment. Laboratory studies have indicated half-lives from 17.7 min to 3.4 d, depending on the rate of mixing (Jensen and Rosenberg 1975; Dilling 1977; Peng et al. 1994). Estimated half-lives in shallow ponds, lakes, and rivers are <12 d (Smith et al. 1980; Lay et al. 1984). TCE may be more persistent in marine systems with estimated half-lives of 13–28 d (Wakeham et al. 1983). Freshwater rich in organic matter may lose up to 40% of dissolved TCE residues through sorption (Dilling et al. 1975). Limited microbial degradation occurs under anoxic conditions (Barrio-Lage et al. 1988).

Despite rapid dissipation rates, TCE may have long-term ecological effects. For example, in a natural pond community with an initial TCE concentration of 25.0 $mg \cdot L^{-1}$, zooplankton *(Daphnia* sp.*)* abundance and phytoplankton richness and abundance remained low 43 d after application, although 98% of the TCE had disappeared within 15 d (Lay et al. 1984).

Water Quality Guideline Derivation

The interim Canadian water quality guideline for 1,1,2-trichloroethene for the protection of freshwater life was developed based on the CCME protocol (CCME 1991a).

Freshwater Life

Acute toxicity (48- to 96-h LC_{50}) values for TCE vary from 28.2 to 213 $mg \cdot L^{-1}$ for juvenile American flagfish *(Jordanella floridae)* and golden orfes *(Leuciscus idus)*, respectively (Slooff et al. 1983; ATRG 1988). Fathead minnows *(Pimephales promelas)* exposed for 96 h to 21.9 $mg \cdot L^{-1}$ TCE experienced narcosis, gill swelling, melanization, and loss of equilibrium (Alexander et al. 1978). Following exposure to 5.0 $mg \cdot L^{-1}$ of TCE for 24 h, rainbow trout *(Oncorhynchus mykiss)* increased their respiration rate (Slooff 1979). Chronic toxicity data indicate that brook trout *(Salvelinus fontinalis)* experience a decrease in swim-up survival and 120-d fry weight and growth after exposure to 0.21 $mg \cdot L^{-1}$ (ATRG 1988). Flagfish fry suffer 100% mortality after exposure to 20.9 $mg \cdot L^{-1}$ TCE for 28 d (ATRG 1988).

Water fleas *(Daphnia magna)* are the most sensitive aquatic invertebrate to TCE with a 48-h EC_{50} for

Table 1. Water quality guidelines for 1,1,2-trichloroethene for the protection of aquatic life (CCME 1991b).

Aquatic life	Guideline value ($\mu g \cdot L^{-1}$)
Freshwater	21*
Marine	NRG†

*Interim guideline.
†No recommended guideline.

immobilization of 7.76 mg·L^{-1} (Abernethy et al. 1986). Other studies report 48-h LC_{50}s from 48.0 to 75.0 mg·L^{-1} for mosquitoes *(Aedes aegypti)* and polyps *(Hydra oligactis)*, respectively (Slooff et al. 1983). Some phytoplankton species are quite tolerant of TCE. For example, *Selenastrum capricornutum* has a 96-h NOEC for growth of 175 mg·L^{-1}, and *Scenedesmus pannonicus* has a 192-h NOEC of >1000 mg·L^{-1} TCE (Slooff et al. 1983).

The interim water quality guideline for TCE for the protection of freshwater life is 21 µg·L^{-1}. It was derived by multiplying the LOEC of 0.21 mg·L^{-1} for brook trout (ATRG 1988) by a safety factor of 0.1 (CCME 1991a, 1991b).

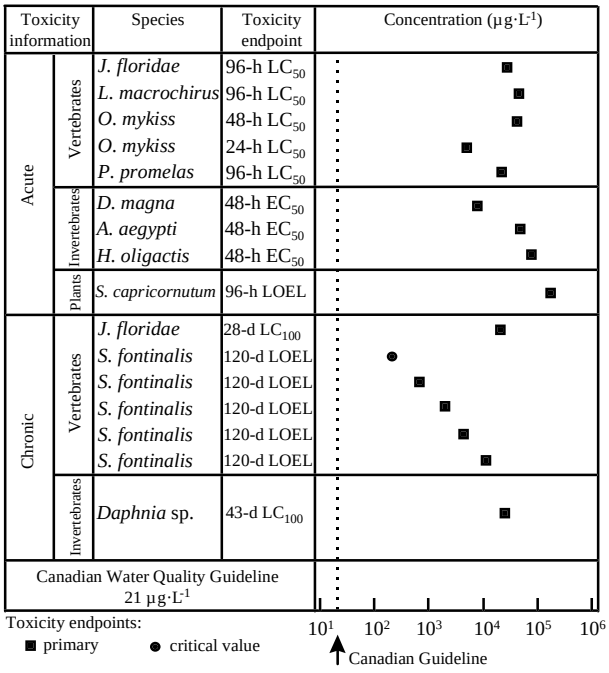

Figure 1. Select freshwater toxicity data for 1,1,2-trichloroethene.

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