



Canadian Water Quality Guidelines for the Protection of Aquatic Life

CHLORINATED ETHENES 1,1,2,2-tetrachloroethene (tetrachloroethylene)

Tetrachloroethylene (CAS 127-18-4), PCE, and PERC are common names for 1,1,2,2-tetrachloroethene. PCE (C_2Cl_4) is a nonflammable, colourless liquid that is nearly insoluble in water (solubility = $150 \text{ mg}\cdot\text{L}^{-1}$ at 20°C), but very volatile (vapour pressure = 2.4 kPa at 22°C). Although Canadian production of PCE ceased in 1992, Canada imported $\sim 11\,600 \text{ t}$ in 1994 for use in dry cleaning and degreasing (62%) and in the industrial and petroleum (38%) sectors. Under the Canadian Environmental Protection Act, use of PCE in dry cleaning is expected to decrease 30% by the year 2000 through new technology and personnel training (Government of Canada 1996).

Sources of PCE aquatic contamination include industrial discharges, landfill leachate, accidental spills, and improper storage and disposal of waste. Owing to its chemical nature, long-range atmospheric transport of PCE is possible (Comba and Kaiser 1983). In the 1980s, surface water contamination ranged from 0.002 to $190 \text{ }\mu\text{g}\cdot\text{L}^{-1}$ in the St. Clair and St. Lawrence Rivers, respectively (Lum and Kaiser 1987). PCE is known to coalesce to form dense, nonaqueous puddles on the bottom of water bodies (e.g., St. Clair River) (Lau and Marsalek 1986). PCE's low affinity for soils (low K_{oc}) makes it mobile (Giger and Molnar-Kubica 1978). Groundwater contamination by PCE has been detected throughout Canada with concentrations normally between 1 and $300 \text{ }\mu\text{g}\cdot\text{L}^{-1}$; however, concentrations up to $80\,000 \text{ }\mu\text{g}\cdot\text{L}^{-1}$ have occurred due to close proximity to dry cleaning facilities, landfill leachate and/or impeded volatilization (Jackson et al. 1988; R. Doyle 1992, Ontario Ministry of the Environment, Ottawa, pers. com.; M. Laengner 1992, Ontario Ministry of the Environment, Barrie, Ontario, pers. com.).

Volatilization is the dominant removal process of PCE from aquatic systems (Callahan et al. 1979). Addison et al. (1983) predicted PCE would partition as follows: 99.7% to air, 0.26% to water, 0.008% to soil, 0.008% to sediment, and $5.0\cdot 10^{-6}\%$ to aquatic biota. Though laboratory tests produce short volatilization half-lives (25.6 min to 1.1 d), estimates from field studies range from 5 to 36 d depending on season, wind, and mixing conditions (Dilling et al. 1975; Zoetman et al. 1980; Wakeham 1983; Lay et al. 1984; Peng et al. 1994). Sequential dechlorination of PCE by microbes occurs under anoxic conditions, producing vinyl chloride, a toxic, highly volatile carcinogen (Barrio-Lage et al. 1986).

Owing to its low K_{ow} (2.53–3.40), PCE does not bioconcentrate (Banerjee et al. 1980; Hansch and Leo 1985). The BCFs vary from 39 to 61.5 for rainbow trout (*Oncorhynchus mykiss*) and larval fathead minnows (*Pimephales promelas*), respectively (Barrows et al. 1980; Ahmad et al. 1984).

Water Quality Guideline Derivation

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

Freshwater Life

Rainbow trout and flagfish (*Jordanella floridae*) show comparable sensitivity to PCE with maximum 96-h LC_{50} s of 4.99 and $8.4 \text{ mg}\cdot\text{L}^{-1}$, respectively (Shubat et al. 1982; Smith et al. 1991). Fathead minnows are more tolerant of PCE with 96-h LC_{50} s from 13.5 to $23.8 \text{ mg}\cdot\text{L}^{-1}$ (Veith et al. 1983; Broderius and Kahl 1985). Sublethal (96-h EC_{50}) effects including loss of schooling behaviour and equilibrium, hypoactivity, darkened colouration, and increased respiratory rate occur in fathead minnows at $8.45 \text{ mg}\cdot\text{L}^{-1}$ (Geiger et al. 1985). Chronic exposure gives similar toxicity thresholds. For example, survival of embryo and larval flagfish exposed for 10 d decreases to 55% at $4.85 \text{ mg}\cdot\text{L}^{-1}$ and to 20% at $7.81 \text{ mg}\cdot\text{L}^{-1}$ (Smith et al. 1991). Adult brook char (*Salvelinus fontinalis*) exposed to $1.52 \text{ mg}\cdot\text{L}^{-1}$ for 120 d experience reduced growth (weight). Juveniles suffer reduced survival (to 61%) at $2.66 \text{ mg}\cdot\text{L}^{-1}$ (ATRG 1988). Growth and survival of fathead minnow embryos and larvae decreases at $1.4 \text{ mg}\cdot\text{L}^{-1}$ (Ahmad et al. 1984).

Limited data suggest invertebrates are slightly more tolerant

Table 1. Water quality guidelines for 1,1,2,2-tetrachloroethene for the protection of aquatic life (CCME 1993).

Aquatic life	Guideline value ($\mu\text{g}\cdot\text{L}^{-1}$)
Freshwater	111*
Marine	NRG ^{†*}

* Interim guideline.

† No recommended guideline.

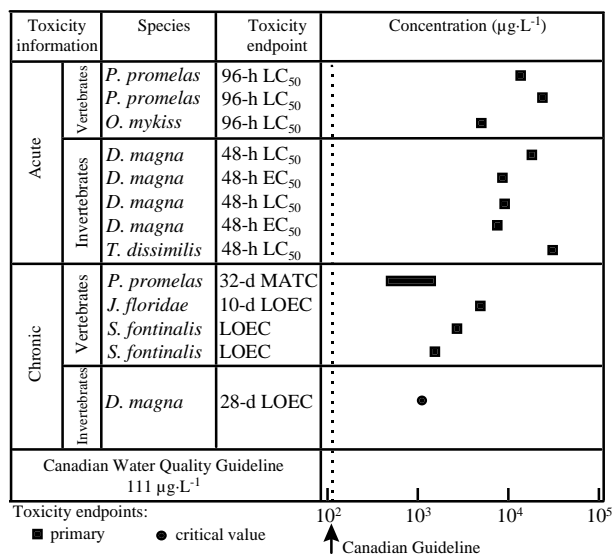


Figure 1. Select freshwater toxicity data for 1,1,2,2-tetrachloroethene.

to PCE than fish. For example, midge larvae (*Tanytarsus dissimilis*) have a reported 48-h LC₅₀ of 30.8 mg·L⁻¹ (Call et al. 1983). Water fleas (*Daphnia magna*) have a 48-h LC₅₀ and EC₅₀ for immobilization of 18.1 and 8.5 mg·L⁻¹, respectively. Stressed (unfed) populations have lower LC₅₀ and EC₅₀ values: 9.1 and 7.5 mg·L⁻¹ (Call et al. 1983; Richter et al. 1983). *D. magna* exposed for 28 d to PCE suffer reduced growth (7.6%) and reproduction (62%) at levels as low as 1.11 mg·L⁻¹ (Call et al. 1983; Richter et al. 1983). In outdoor mesocosms, complete mortality of *D. magna* populations occurred within 2 and 4 d at high (250 mg·L⁻¹) and low (25 mg·L⁻¹) initial (calculated) concentrations, respectively. PCE was also lethal to the algae *Spirogyra* sp., *Anabaena flos-aquae*, and *Stichococcus bacillaris*, but positively affected *Actinophrys* sp. (Lay et al. 1984).

The interim water quality guideline for 1,1,2,2-tetrachloroethene for the protection of freshwater life is 111 $\mu\text{g}\cdot\text{L}^{-1}$ (CCME 1993). It was derived by multiplying the LOEL of 1.11 mg·L⁻¹ for *D. magna* (Richter et al. 1983) by a safety factor of 0.1 (CCME 1991).

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