Canadian Water Quality Guidelines for the Protection of Aquatic Life

CHLORINATED BENZENES

1,2,4-trichlorobenzene

Liquid or solid 1,2,4-trichlorobenzene (CAS 120-80-1, molecular weight 181.45, melting point 16.95ºC) is used industrially as a dye carrier, an intermediate in chemical productions (especially herbicides), a degreasing agent, and a lubricant (CIS 1991). Trichlorobenzene congeners are not produced or widely used in Canada. Approximately 2 600 000 t of trichlorobenzene, however, are present in transformer dielectric fluids either in use or stored before disposal, and modest amounts (<2000 kg) were imported into Canada in 1992 for the maintenance of existing transformer dielectric fluid (E.D. Brien 1993, Environment Canada, Ottawa, pers. com.). The principle sources of environmental contamination are likely spillage of these dielectric fluids and long-range transborder transport and deposition. Losses associated with the use of trichlorobenzenes as an industrial solvent, and via industrial effluents and landfill leachates are also expected. There is evidence of production of trichlorobenzenes from microbial degradation and plant metabolism of more highly chlorinated benzenes, but it is not considered to be a major source (Government of Canada 1993). There are no quantified estimates of source contributions for trichlorobenzenes in Canada (Government of Canada 1993).

1,2,4-Trichlorobenzene is likely one of the more common chlorobenzene congeners in the environment, because of its commercial applications, dissipative use patterns, and long environmental persistence.

1,2,4-Trichlorobenzene has been reported at low levels at various sites in the Great Lakes basin ranging from 0.008 to 120 $\mu g \cdot L^{-1}$. Higher levels were reported in the early 1980s. More recently, maximum levels from the Niagara River at Niagara-on-the-Lake were reported to be 0.0025 $\mu g \cdot L^{-1}$ (NRDIG 1990). As well, elevated concentrations have been found in the effluents from a variety of municipal and industrial facilities in Ontario and Nova Scotia (Government of Canada 1993).

Levels of 1,2,4-trichlorobenzene in invertebrates and fish ranged from 0.6 to 33 $\mu g \cdot kg^{-1}$ (ww). The values in the upper part of the range are for organisms collected in the lower Niagara River and its plume in Lake Ontario. Levels at other locations were in the lower part of the range or not detectable (Government of Canada 1993).

Mackay et al. (1992) have modelled the environmental fate of each of the chlorobenzenes using several versions of a fugacity-based model and available information. These modelling results indicate that chlorobenzene behaviour varies as a function of the degree of chlorination. The simplest model, Fugacity Level I, demonstrates that 1,2,4-trichlorobenzene tends to partition mainly into air, some into soil, and a small amount into water, because of its vapour pressure (61 Pa) and low water solubility (40 $mg \cdot L^{-1}$). Level II modelling indicates that the primary removal processes for all chlorobenzenes are in air. For 1,2,4-trichlorobenzene, removal is mainly by advection (e.g., deposition, sedimentation) and chemical reaction. Photodegradation is slow, resulting in atmospheric half-lives of 2–6 weeks. In the aquatic environment, 1,2,4-trichlorobenzene is found mostly in organic phases (organisms, sediments) or associated with suspended/ dissolved organic material rather than dissolved in the water phase (log octanol–water partition coefficient 4.1), with half-lives of 6–18 weeks in the water and 1.1–3.4 years in the sediment.

Water Quality Guideline Derivation

The interim Canadian water quality guidelines for 1,2,4-trichlorobenzene for the protection of aquatic life were developed based on the CCME protocol (CCME 1991). For more information, see the Canadian Environmental Protection Act (CEPA) assessment report and supporting document (Government of Canada 1993) and the supporting document (Environment Canada 1997).

Freshwater Life

Data on acute toxicity for fish are for rainbow trout *(Oncorhynchus mykiss)* with a 96-h LC_{50} of 1320 $\mu g \cdot L^{-1}$ (Holcombe et al. 1987) and a 96-h LC_{50} of 1520 $\mu g \cdot L^{-1}$ (Ahmad et al. 1984). For invertebrates, a 96-h LC_{50} of 930

Table 1. Water quality guidelines for 1,2,4-trichlorobenzene for the protection of aquatic life (Environment Canada 1997).

Aquatic life	Guideline value ($\mu g \cdot L^{-1}$)
Freshwater	24*
Marine	5.4*

*Interim guideline.

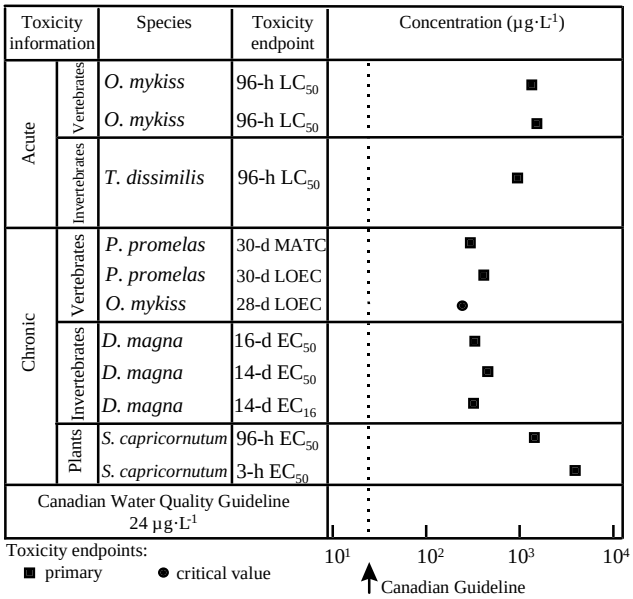

Figure 1. Select freshwater toxicity data for 1,2,4-trichlorobenzene.

µg·L^{-1} for the midge *Tanytarsus dissimilis* was found (Holcombe et al. 1987).

As chronic data for fish, LeBlanc (1984) reported a 30-d MATC of 290 µg·L^{-1} (MATC is the geometric mean of a NOEC of 210 µg·L^{-1} and a LOEC of 410 µg·L^{-1}) for fathead minnows *(Pimephales promelas)*. Chronic results for invertebrates are a 16-d EC_{50} (based on reproduction) of 330 µg·L^{-1} for *Daphnia magna* (De Wolf et al. 1988) and a 14-d EC_{50} and 14-d EC_{16} (reduced fertility) of 450 µg·L^{-1} and 320 µg·L^{-1}, respectively, for *D. magna* (Calamari et al. 1983).

Calamari et al. (1983) reported that the alga *Selenastrum capricornutum* exhibited a 96-h EC_{50} of 1400 µg·L^{-1}, based on growth inhibition, and a 3-h EC_{50} of 3900 µg·L^{-1}, based on inhibition of photosynthesis.

The interim water quality guideline for 1,2,4-trichlorobenzene for the protection of freshwater life is 24 µg·L^{-1}. It was derived by multiplying the 28-d early-life-stage LOEC (growth) of 243 µg·L^{-1} (Hodson et al. 1991) for the most sensitive organism to 1,2,4-trichlorobenzene, the rainbow trout *(O. mykiss)*, by a safety factor of 0.1 (CCME 1991).

Marine Life

The interim water quality guideline for 1,2,4-trichlorobenzene for the protection of marine life is 5.4 µg·L^{-1}.

Furay and Smith (1995) reported 96-h LC_{50}s of 2990 µg·L^{-1} for sole *(Solea solea)* and 3650 µg·L^{-1} for flounder *(Platichthys flesus)*, respectively. Bengtsson and Tarkpea (1983) reported a 96-h LC_{50} of 2600 µg·L^{-1} for bleak *(Alburnus alburnus)*.

Clark et al. (1987) reported a 96-h LC_{50} of 540 µg·L^{-1} for the grass shrimp *(Palaemonetes pugio)* (Class Malacostraca). Also, Abernethy et al. (1988) reported a 24-h LC_{50} of 3320 µg·L^{-1} for the brine shrimp *(Artemia nauplii)* (Class Branchiopoda). The USEPA (1978) reported a 96-h EC_{50} for reduction in chlorophyll *a* of 5980 µg·L^{-1} for the marine diatom *Skeletonema costatum*.

The interim water quality guideline for 1,2,4-trichlorobenzene for the protection of marine life is 5.4 µg·L^{-1}. It was derived by multiplying the 96-h LC_{50} of 540 µg·L^{-1} (Clark et al. 1987) for the most sensitive organism to 1,2,4-trichlorobenzene, the grass shrimp *(P. pugio)* (Class Malacostraca), by a safety factor of 0.01 (acute study) (CCME 1991).

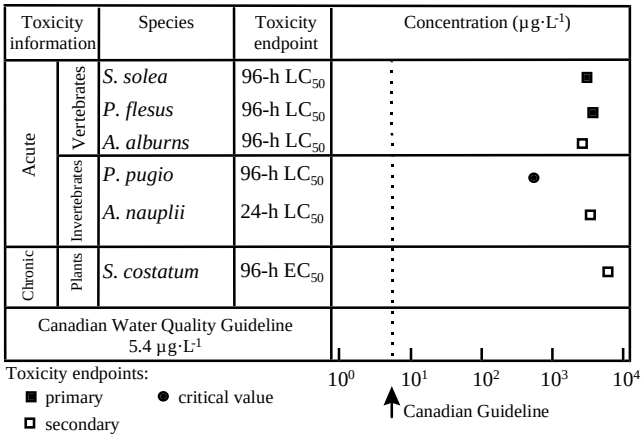

Figure 2. Select marine toxicity data for 1,2,4-trichlorobenzene.

References

Abernethy, S.G., D. Mackay, and L.S. McCarty. 1988. "Volume fraction" correlation for narcosis in aquatic organisms: The key role of partitioning. Environ. Toxicol. Chem. 7:469–481.

Ahmad, N., D. Benoit, L. Brooke, D. Call, A. Carlson, D. DeFoe, J. Huot, A. Moriatry, J. Richter, P. Subat, G. Veith, and C. Wallbridge. 1984. Aquatic toxicity tests to characterize the hazard of volatile organic chemicals in water: A toxicity summary - parts I and II. EPA-600/3-84-009. U.S. Environmental Protection Agency, Duluth MN.

Bengtsson, B.E. and M. Tarkpea. 1983. The acute aquatic toxicity of some substances carried by ships. Mar. Pollut. Bull. 14:213–214.

Calamari, D., S. Galassi, F. Setti, and M. Vighi. 1983. Toxicity of selected chlorobenzenes to aquatic organisms. Chemosphere 12:253–262.

CCME (Canadian Council of Ministers of the Environment). 1991. Appendix IX—A protocol for the derivation of water quality guidelines for the protection of aquatic life (April 1991). In: Canadian water quality guidelines, Canadian Council of Resource and Environment Ministers. 1987. Prepared by the Task Force on Water Quality Guidelines. [Updated and reprinted with minor revisions and editorial changes in Canadian environmental quality guidelines, Chapter 4, Canadian Council of Ministers of the Environment, 1999, Winnipeg.]

CIS (Camford Information Services). 1991. CPI product profiles: Chlorobenzenes (mono, di, tri, tetra, penta, hexachlorobenzenes). CIS, Don Mills, ON.

Clark, J.R., J.M. Patrick Jr., J.C. Moore, and E.M. Lores. 1987. Waterborne and sediment-source toxicities of six organic chemicals to grass shrimp *Palaemonetes pugio* and amphioxus *Branchiostoma caribaeum*. Arch. Environ. Contam. Toxicol. 16:401–407.

De Wolf, W., J.H. Canton, J.W. Deneer, R.C.C. Wegman, and J.L.M. Hermens. 1988. Quantitative structure-activity relationships and mixture-toxicity studies of alcohols and chlorohydrocarbons: Reproducibility of effects on growth and reproduction of *Daphnia magna*. Aquat. Toxicol. 12:39–49.

Environment Canada. 1997. Canadian water quality guidelines for chlorinated benzenes. Supporting document. Environment Canada, Science Policy and Environmental Quality Branch, Ottawa. Unpub. draft doc.

Furay, V.J., and S. Smith. 1995. Toxicity and QSAR of chlorobenzenes in two species of benthic flatfish, flounder (*Platichthys flesus* L.) and sole *(Solea solea* L.*)*. Bull. Environ. Contam. Toxicol. 54:36–42.

Government of Canada. 1993. Trichlorobenzenes. Canadian Environmental Protection Act Priority Substances List Assessment Report. Health and Welfare Canada and Environment Canada, Ottawa.

Hodson, P.V., R. Parisella, B. Blunt, B. Gray, and K.L.E. Kaiser. 1991. Quantitative structure-activity relationships for chronic toxicity of phenol, *p*-chlorophenol, 2,4-dichlorophenol, pentachlorophenol, *p*-nitrophenol, and 1,2,4-trichlorobenzene to early life stages of rainbow trout *(Oncorhynchus mykiss)*. Canadian Technical Report of Fisheries and Aquatic Sciences 1784. Fisheries and Oceans Canada, Mont-Joli, QC.

Holcombe, G.W., G.L. Phipps, A.H. Sulaiman, and A.D. Hoffman. 1987. Simultaneous multiple species testing: acute toxicity of 13 chemicals to 12 diverse freshwater amphibian, fish, and invertebrate families. Arch. Environ. Contam. Toxicol. 16:697–710.

LeBlanc, G.A. 1984. Comparative structure-toxicity relationships between acute and chronic effects to aquatic organisms. In: QSAR in environmental toxicology. K.L.E. Kaiser, ed. D. Reidel Publishing Company, Dordrecht, Holland.

Mackay, D., W.Y. Shiu, and K.C. Ma. 1992. Illustrated handbook of physical-chemical properties and environmental fate for organic chemicals I. Monoaromatics, chlorobenzenes, and PCBs. Lewis Publishers Inc., Boca Raton, FL.

NRDIG (Niagara River Data Interpretation Group), 1990. Joint evaluation of the upstream/downstream Niagara River monitoring data. Prepared by the Niagara River Data Interpretation Group, River Monitoring Committee, Final Report, November 1990. (Cited in Government of Canada 1993.)

USEPA (U.S. Environmental Protection Agency). 1978. In-depth studies on health and environmental impacts of selected water pollutants. (Table of data available from Charles E. Stephan.) USEPA, Duluth, MN.

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: Chlorinated benzenes—1,2,4-Trichlorobenzene. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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