Canadian Water Quality Guidelines for the Protection of Aquatic Life

CHLORINATED BENZENES
monochlorobenzene

Monochlorobenzene (CAS 108-90-7, molecular weight 112.6) is a liquid used as a pesticide carrier (i.e., solvent for insecticides), a reagent in the production of rubber polymers, and as a solvent carrier for textile dyes (CIS 1991). Monochlorobenzene is not produced in Canada.

Monochlorobenzene is not commonly found in quantifiable amounts in groundwater in Canada. In areas of known chemical contamination, however, levels as high as 5310 $\mu g \cdot L^{-1}$ have been found. Otherwise, levels exceeding the detection limits are usually 10 $\mu g \cdot L^{-1}$ or less and rarely exceed 100 $\mu g \cdot L^{-1}$. Monochlorobenzene is also not commonly found at quantifiable levels in surface waters in Canada (detection limits range from 0.5–1 $\mu g \cdot L^{-1}$) (Government of Canada 1992).

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 monochlorobenzene tends to partition into air, with small amounts going to water and soil, as it has a relatively high vapour pressure (1580 Pa) and low water solubility (484 $mg \cdot L^{-1}$). Level II modelling indicates that the primary removal processes for all chlorobenzenes are in air. For monochlorobenzene, removal is by advection (e.g., deposition, sedimentation) and chemical reaction (approximately 30%). Photodegradation is slow, resulting in atmospheric half-lives of 4–12 d. In the aquatic environment, monochlorobenzene 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 2.8), with half-lives of 6–18 weeks in the water and 1.1–3.4 years in the sediment. Although minor, biotransformation does occur at a slow rate, with a half-life of 6–18 weeks.

Water Quality Guideline Derivation

The interim Canadian water quality guidelines for monochlorobenzene 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 1992) and the supporting document (Environment Canada 1997).

Freshwater Life

Acute and chronic endpoint data were found for fish and amphibians. Acute bioassay results for 48-h, 96-h, and 96-h LC_{50}s were 4100, 4700, and 7460 $\mu g \cdot L^{-1}$ for rainbow trout *(Oncorhynchus mykiss)*, as reported by Calamari et al. (1983), Dalich et al. (1982), and Hodson et al. (1984), respectively.

In chronic exposure bioassays, Black et al. (1982) reported reduced egg hatchabilities of 10% after a 23-d exposure at 13 $\mu g \cdot L^{-1}$ for rainbow trout *(O. mykiss)*, of 6% after a 5.5-d exposure at 44 $\mu g \cdot L^{-1}$ for the northwestern salamander *(Ambystoma gracile)*, and of 5% after a 5-d exposure at 11 $\mu g \cdot L^{-1}$ for the leopard frog *(Rana pipiens)*. The respective corresponding 4-d posthatching mortalities are reported as a 27-d LC_{10} of 13 $\mu g \cdot L^{-1}$ for trout, a 9.5-d LC_{10} of 44 $\mu g \cdot L^{-1}$ for the salamander, and a 9-d LC_6 of 11 $\mu g \cdot L^{-1}$ for the frog. Using the same experimental procedure, Birge et al. (1979) reported 4-d posthatching mortalities as 7.5-d LC_{50}s of 880 $\mu g \cdot L^{-1}$ for goldfish hatchlings *(Carassius auratus)* and 50 $\mu g \cdot L^{-1}$ for largemouth bass hatchlings *(Micropterus salmoides)*. The corresponding 7.5-d LC_1s were 1.0 $\mu g \cdot L^{-1}$ and 10 $\mu g \cdot L^{-1}$ for embryonic and larval stages of bass and goldfish, respectively. However, these LC_1s are not considered to be statistically significant enough to derive a guideline value.

The lowest acute toxicity test result for invertebrates is by Calamari et al. (1983), who reported a 24-h EC_{50} for immobilization of *Daphnia magna* of 4300 $\mu g \cdot L^{-1}$. A recent

Table 1. Water quality guidelines for monochlorobenzene for the protection of aquatic life (Environment Canada 1997).

Aquatic life	Guideline value ($\mu g \cdot L^{-1}$)
Freshwater	1.3*
Marine	25*

*Interim guideline.

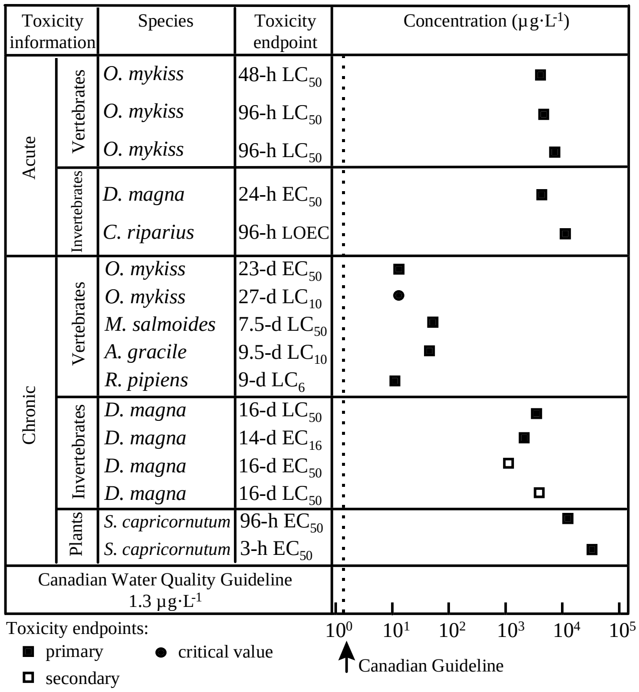

Figure 1. Select freshwater toxicity data for monochlorobenzene.

study with midges *(Chironomus riparius)* by van der Zandt et al. (1994) reported a 96-h NOEC at 721 $\mu g{\cdot}L^{-1}$ and a 96-h LOEC at 11 300 $\mu g{\cdot}L^{-1}$, based on some behavioural changes.

The lowest chronic invertebrate data are for *D. magna*, with a 16-d NOEC based on growth of 320 $\mu g{\cdot}L^{-1}$ (de Wolf et al. 1988), 16-d LC_{50}s of 3390 $\mu g{\cdot}L^{-1}$ (De Wolf et al. 1988) and 3900 $\mu g{\cdot}L^{-1}$ (Hermens et al. 1984), 16-d EC_{50}s based on growth of 3390 $\mu g{\cdot}L^{-1}$ (Hermens et al. 1985) and on reproduction of 1100 $\mu g{\cdot}L^{-1}$ (Hermens et al. 1984), and a 14-d EC_{50} and EC_{16} (reduced fertility) of 2500 $\mu g{\cdot}L^{-1}$ and 2100 $\mu g{\cdot}L^{-1}$, respectively (Calamari et al. 1983).

Calamari et al. (1983) reported a 96-h EC_{50} of 12 500 $\mu g{\cdot}L^{-1}$ (growth inhibition) and a 3-h EC_{50} of 33 000 $\mu g{\cdot}L^{-1}$ (photosynthesis inhibition) for the alga *Selenastrum capricornutum*.

The interim water quality guideline for monochlorobenzene for the protection of aquatic life is 1.3 $\mu g{\cdot}L^{-1}$. It was derived by multiplying the 27-d LC_{10} (4-d posthatching) of 13 $\mu g{\cdot}L^{-1}$ for rainbow trout (Black et al. 1982) by a safety factor of 0.1 (CCME 1991).

Marine Life

The interim water quality guideline for monochlorobenzene for the protection of marine life is 25 $\mu g{\cdot}L^{-1}$. It was derived by multiplying the growth rate reductions of 10% after 40-d exposures of 253.4 $\mu g{\cdot}L^{-1}$ for the sand crab *Portunus pelagicus* (Mortimer and Connell, 1995) by a safety factor of 0.1 (CCME 1991). For acute fish toxicity data, Furay and Smith (1995) reported 96-h LC_{50}s of 5820 $\mu g{\cdot}L^{-1}$ for sole *(Solea solea)* and 6610 $\mu g{\cdot}L^{-1}$ for flounder *(Platichthys flesus)*, while Heitmuller et al. (1981) reported a 48-h LC_{50} at 8900 $\mu g{\cdot}L^{-1}$ for sheepshead minnows *(Cyprinodon aggregata).* Available acute marine invertebrate data consist of a 96-h LC_{50} at 16 300 $\mu g{\cdot}L^{-1}$ for opossum shrimp *(Mysidopsis bahia)* (Class Malacostraca) (USEPA 1980) and a 24-h LC_{50} at 40 900 $\mu g{\cdot}L^{-1}$ for the brine shrimp *(Artemia nauplii)* (Class Branchiopoda) (Abernethy et al. 1988). Mortimer and Connell (1995) also reported growth rate reductions of 50% after 40-d exposures of 573.0 $\mu g{\cdot}L^{-1}$, for the sand crab *P. pelagicus*.

Data for marine algae were 96-h EC_{50}s for chlorophyll *a* inhibition and reduction in cell numbers of 343 000 and 341 000 $\mu g{\cdot}L^{-1}$, respectively, for the diatom *Skeletonema costatum* (USEPA 1978). Cowgill et al. (1989) reported 96-h EC_{50}s for reductions in cell count and cell volume of 203 000 and 201 000 $\mu g{\cdot}L^{-1}$, respectively, for the same species of diatom.

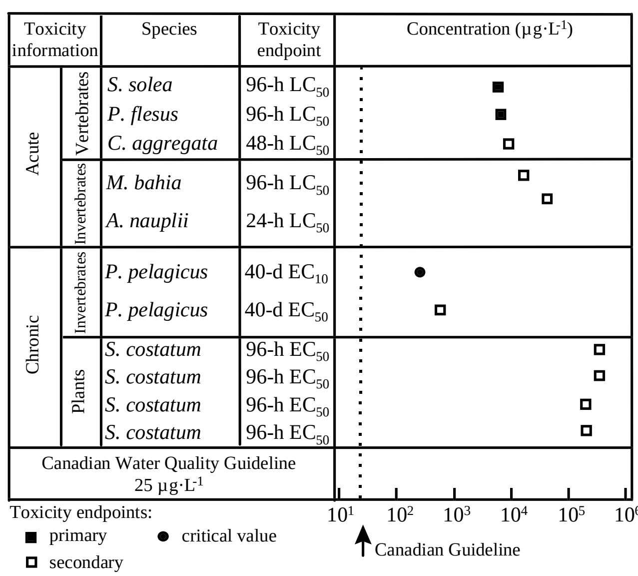

Figure 2. Select marine toxicity data for monochlorobenzene.

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.

Birge, W.J., J.A. Black, J.E. Hudson, and D.M. Bruser. 1979. Embryo-larval toxicity tests with organic compounds. In: Aquatic toxicology, L.L. Marking and R.A. Kimerle, eds. ASTM ST 667. American Society for Testing and Materials, Philadelphia.

Black, J.A., W.J. Birge, W.E. McDonnell, A.G. Westerman, and B.A. Ramey. 1982. The aquatic toxicity of organic compounds to embryo-larval stages of fish and amphibians. Report no. 133. University of Kentucky, Water Resources Research Institute, Lexington, KY.

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.

Cowgill, U.M., D.P. Milazzo, and B.D. Landenberger. 1989. Toxicity of nine benchmark chemicals to *Skeletonema costatum*, a marine diatom—short communication. Environ. Toxicol. Chem. 8:451–455.

Dalich, G.M., R.E. Larson, and W.H. Gingerich. 1982. Acute and chronic toxicity studies with monochlorobenzene in rainbow trout. Aquat. Toxicol. 2:127–142.

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. 1992. Chlorobenzene. Canadian Environmental Protection Act Priority Substances List Assessment Report. Environment Canada and Health Canada, Ottawa.

Heitmuller, P.T., T.A. Hollister, and P.R. Parrish. 1981. Acute toxicity of 54 industrial chemicals to sheepshead minnows *Cyprinodon variegatus*. Bull. Environ. Contam. Toxicol. 27:596–604.

Hermens, J., H. Canton, P. Janssen, and R. de Jong. 1984. Quantitative structure-activity relationships and toxicity studies of mixtures of chemicals with anaesthetic potency: Acute lethal and sublethal toxicity to *Daphnia magna*. Aquat. Toxicol. 5:143–154.

Hermens, J., E. Brockhuyzen, H. Canton, and R. Wegman. 1985. Quantitative structure activity relationships and mixture toxicity studies of alcohols and chlorohydrocarbons: Effects on growth of *Daphnia magna*. Aquat. Toxicol. 6:209–217.

Hodson, P.V., D.G. Dixon, and K.L.E. Kaiser. 1984. Measurement of median lethal dose as a rapid indication of contaminant toxicity to fish. Environ. Toxicol. Chem. 3:243–254.

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.

Mortimer, M.R., and D.W. Connell. 1995. Effect of exposure to chlorobenzenes on growth rates of the crab *Portunus pelagicus* (L). Environ. Sci. Technol. 29 (8): 1881–1886.

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.

———.1980. Ambient water quality criteria for chlorinated benzenes. EPA 440/5-80-028. USEPA, Washington, DC.

van der Zandt, P.T.J., F. Heinis, and A. Kikkert. 1994. Effects of narcoticindustrial pollutants on behaviour of midge larvae *(Chironomus riparius)* (Meigen), Diptera: A quantitative structure–activity relationship. Aquat. Toxicol. 28:209–221.

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: Chlorinated benzenes—Monochlorobenzene. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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Excerpt from Publication No. 1299; ISBN 1-896997-34-1

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