



Canadian Water Quality Guidelines for the Protection of Aquatic Life

DELTA METHRIN

Deltamethrin is a synthetic pyrethroid insecticide developed in 1974 (Elliott et al. 1974). Its Chemical Abstracts Service (CAS) name is [1R-[1 α (S*),3 α]]-cyano(3-phenoxyphenyl)methyl 3-(2,2-dibromoethyl)-2,2-dimethylcyclopropanecarboxylate, its CAS registry number is 52918-63-5, and its empirical formula is C₂₂H₁₉Br₂NO₃. Deltamethrin has a water solubility of <2 $\mu\text{g}\cdot\text{L}^{-1}$ and a log octanol–water partition coefficient (log K_{ow}) of 4.6 at 25°C (Tomlin 1994).

Deltamethrin was first registered for use in Canada in 1982 under the trade name of Decis (Agriculture Canada and Environment Canada 1995). It is a fast-acting non-systemic insecticide with contact and stomach action (Tomlin 1994). It is used to control Colorado potato beetles, leaf hoppers, cutworms, tentiform leaf miners, bertha army worms, flea beetles, diamond-back moths, grasshoppers, and tarnished plant bugs (Agriculture Canada and Environment Canada 1995).

Deltamethrin contamination of aquatic resources may occur via spray drift, storms, and irrigation water runoff from fields. Concentrations in Canadian freshwater sources range from 10 $\text{ng}\cdot\text{L}^{-1}$ (Julien et al. 1987) to 24 $\mu\text{g}\cdot\text{L}^{-1}$ (Ernst 1987). Reported concentrations in sediment range from 3 to 5 $\text{ng}\cdot\text{g}^{-1}$ (Muir et al. 1985a).

Environmental fate processes include hydrolysis, photolysis, adsorption, volatilization, microbial degradation, and isomerization. Pseudo first-order half-lives ranged from 1.5 to 5.1 h at the surface and from 13.6 to 16.7 h in subsurface water (Muir et al. 1987). Volatilization from the surface microlayer may be a major route of dissipation of deltamethrin, evidenced by its Henry's law constant in water of $12.6\pm 4.1 \text{ Pa}\cdot\text{m}^3\cdot\text{mol}^{-1}$ (Muir et al. 1985a). Isomerization occurs readily in the presence of sunlight (NRCC 1986).

Water Quality Guideline Derivation

The Canadian water quality guideline for deltamethrin for the protection of freshwater life was developed based on the CCME protocol (CCME 1991).

Freshwater Life

Deltamethrin is toxic to fish (WHO 1990). Acute toxicities (96-h LC_{50} s) ranged from 0.36 $\mu\text{g}\cdot\text{L}^{-1}$ for bluegill sunfish (*Lepomis macrochirus*) (Sousa 1990) to 4.7 $\mu\text{g}\cdot\text{L}^{-1}$ for brown trout (*Salmo trutta*) (L'Hoste et al. 1979). L'Hotellier and Vincent (1986) and Smith and Stratton (1986) noted that for fish, the 96-h LC_{50} s for deltamethrin were around 1 $\mu\text{g}\cdot\text{L}^{-1}$.

Chronic toxicity tests with zebra danio (*Brachydanio rerio*) reported a 35-d EC_{50} of 0.8 $\mu\text{g}\cdot\text{L}^{-1}$ based on a reduction in hatching rate. Juveniles experienced a 50% mortality after exposure to 0.52 $\mu\text{g}\cdot\text{L}^{-1}$ for 35 d. At the lowest concentration tested (0.50 $\mu\text{g}\cdot\text{L}^{-1}$), survival and ontogenesis were also affected (Gorge and Nagel 1990).

The following 96-h exposures were considered chronic because they spanned a number of developmental stages in the juvenile fish. The 96-h LC_{50} for deltamethrin in ethanol and deltamethrin as Decis for Atlantic salmon juveniles (*Salmo salar*) were 1.97 $\mu\text{g}\cdot\text{L}^{-1}$ and 0.59 $\mu\text{g}\cdot\text{L}^{-1}$, respectively (Zitko et al. 1979). A smaller, but opposite, difference was noted for pumpkinseed sunfish (*L. gibbosus*), where the 96-h LC_{50} was 0.58 $\mu\text{g}\cdot\text{L}^{-1}$ for the technical and 0.87 $\mu\text{g}\cdot\text{L}^{-1}$ for the formulated product (Waltersdorfer and Schulze 1976).

A single study on amphibians reported an LC_{50} of 0.93 $\mu\text{g a.i.}\cdot\text{L}^{-1}$ for *Bufo bufo* (tadpoles of the common toad) exposed to Decis (L'Hotellier and Vincent 1986).

Consistent with the phylogenetic relationship between crustacea and the arthropod pests for which deltamethrin was developed, crustaceans including cladocera,

Table 1. Water quality guidelines for deltamethrin for the protection of aquatic life (CCME 1997).

Aquatic life	Guideline value ($\mu\text{g}\cdot\text{L}^{-1}$)
Freshwater	0.0004
Marine	NRG*

*No recommended guideline.

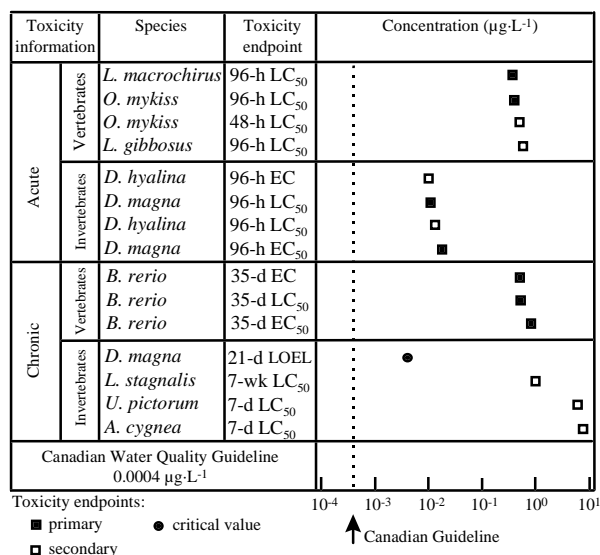


Figure 1. Select freshwater toxicity data for deltamethrin.

amphipods, isopods, and crayfish are sensitive to synthetic pyrethroids (NRCC 1986). Acute toxicity values for *Daphnia magna* were reported: EC₅₀s for juveniles ranged between 0.018 µg·L⁻¹ (96-h) and 0.290 µg·L⁻¹ (24-h); LC₅₀s ranged from 0.01 µg·L⁻¹ (96-h; neonates) to 520 µg·L⁻¹ (24-h; juvenile) (Xiu et al. 1989). A chronic value (LOEL) of 0.0041 µg·L⁻¹, based on growth, was also reported (McNamara 1991).

Hill (1985) reported an LC₅₀ of 0.005 µg·L⁻¹ for a mayfly (*Baetis rhodani*). The sediment concentrations required to immobilize chironomid larvae within 24 h (*Chironomus tentans*, fourth instar) ranged between 0.20 and 0.22 µg·kg⁻¹ (Muir et al. 1985b).

For larvae and pupae of 12 mosquito species, the 24-h LC₅₀ and LC₉₀ for deltamethrin ranged between 0.02 and 1.50 µg·L⁻¹ (NRCC 1986). Jordan (1986) reported that the embryos of *Tubifex tubifex* exposed to deltamethrin (25.0 µg·L⁻¹) for 20 d exhibited 50% mortality.

Deltamethrin does not seem to be phytotoxic. Several studies identified some accumulation of deltamethrin in plant tissues (Muir et al. 1985a; Caquet et al. 1992). Giddings (1990) reported a 96-h EC₅₀ (photoinhibition) of 1700 µg·L⁻¹ for *Selenastrum capricornutum*.

The water quality guideline for deltamethrin for the protection of freshwater life is 0.0004 µg·L⁻¹. It was derived by multiplying the LOEL of 0.0041 µg·L⁻¹ (McNamara 1991) for the most sensitive organism, *D. magna*, by a safety factor of 0.1 (CCME 1991). It should be noted that the lowest limit of detection reported

was 0.1 ng·L⁻¹ (Maguire et al. 1989), a value that is similar to the Canadian water quality guideline for the protection of aquatic life. Therefore, any detection of deltamethrin in aquatic systems is potentially an indication that the freshwater aquatic life is being negatively affected.

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For further scientific information, contact:

Environment Canada
Guidelines and Standards Division
351 St. Joseph Blvd.
Hull, QC K1A 0H3
Phone: (819) 953-1550
Facsimile: (819) 953-0461
E-mail: ceqg-rcqe@ec.gc.ca
Internet: <http://www.ec.gc.ca>

For additional copies, contact:

CCME Documents
c/o Manitoba Statutory Publications
200 Vaughan St.
Winnipeg, MB R3C 1T5
Phone: (204) 945-4664
Facsimile: (204) 945-7172
E-mail: spcme@chc.gov.mb.ca