Canadian Water Quality Guidelines for the Protection of Aquatic Life

ALDICARB

Aldicarb is a soil-applied granular methylcarbamate oxime insecticide, acaricide, and nematicide with the IUPAC name 2-methyl-2-(methylthio) propionaldehyde *o*-(methylcarbamoyl)oxime; the CAS name and number 2-methyl-2-(methylthio)propanal o-[(methylamino) carbonyl]oxime and 116-06-3, respectively; and the chemical formula $C_7H_{14}N_2O_2S$. Aldicarb, a colourless crystal, is highly soluble in water (6 $g{\cdot}L^{-1}$), has a low affinity for most soil types (log K_d < 4 $L{\cdot}kg^{-1}$) (Hough et al. 1975; Cohen et al. 1984), and has a log octanol–water partition coefficient (log K_{ow}) of 1.359 (WHO 1991). Aldicarb also has a low vapour pressure of 13 mPa at 20°C (RSC 1991). Concentrations of aldicarb in the environment are generally reported as total aldicarb residues (TAR) because of the toxicity of the two major aldicarb transformation products, aldicarb sulphoxide (ASO) and aldicarb sulphone (ASO_2).

Aldicarb was first introduced to the Canadian market in 1975 registered by Rhône-Poulenc Canada Inc. It was sold as a 10% a.i. granular formulation called Temik 10G (Pest Control Products Act No. 12347) (Agriculture Canada 1989) and was distributed by May and Baker Canada Inc. (Agriculture Canada 1989). Aldicarb was used primarily to control root maggots on sugar beets (Alberta Agriculture 1989) and has been used for flea beetles, Colorado potato beetles, leafhoppers, and aphids on potatoes. Aldicarb was used extensively before its voluntary withdrawal from use on potatoes in 1990. During 1983, 5000 to 10 000 kg (a.i.) were applied to approximately 3000 ha in Prince Edward Island (Matheson et al. 1987), and 5230 kg were applied in Ontario (McGee 1984). The registration of aldicarb for all uses in Canada was discontinued in 1996 (PMRA 1998).

Aldicarb is readily absorbed by plant roots and translocated throughout the plant, acting as both a systemic and a soil pesticide. Consumption of treated plant tissue and contact with treated soil causes the inhibition of acetylcholinesterase enzymes necessary for proper nervous system function in target and nontarget organisms (Gillis and Walker 1986; Harkin et al. 1986; Matheson et al. 1987; Mink et al. 1989).

In aquatic environments, microbial oxidation is the most important process governing the dissipation in surface waters while anaerobic microbial hydrolysis is important in groundwater. Volatilization, photolysis, adsorption to sediment, and bioconcentration are not expected to significantly affect dissipation, based on environmental dissipation data and physicochemical properties. Aldicarb is not likely to be released to the atmosphere (CCME 1993).

High solubility in water and low soil affinity give aldicarb the potential to leach through agricultural soils and contaminate shallow groundwater aquifers (Maathuis et al. 1988). Subsequent contamination of surface water sources may occur when these systems are recharged by groundwater. Aldicarb may also be introduced to surface water systems via runoff from treated areas or from accidents and spills. Detectable levels of TAR (limit of detection [LOD] = 0.01 $\mu g{\cdot}L^{-1}$) were measured in 4 out of 47 surface water samples taken in Prince Edward Island during 1983 and 1984, but not in samples from New Brunswick or Ontario (LOD not reported) (Hiebsch 1988). Data from numerous sites across Canada (and the United States) indicated that aldicarb use resulted in significant contamination of groundwater resources (CCME 1993). Samples containing detectable levels of aldicarb were collected from Prince Edward Island, New Brunswick, Nova Scotia, Ontario, and Quebec (CCME 1993). Contamination was found to reach levels as high as 61, 44, 35, and 33 $\mu g{\cdot}L^{-1}$ in private wells near aldicarb-treated potato fields in the Quebec municipalities of Ste-Sophie, Lavaltrie, Ste-Basile, and Pont Rouge, respectively (LOD not reported) (Giroux 1993).

Water Quality Guideline Derivation

The interim Canadian water quality guidelines for aldicarb for the protection of aquatic life were developed based on the CCME protocol (CCME 1991).

Table 1. Water quality guidelines for aldicarb for the protection of aquatic life (CCME 1993).

Aquatic life	Guideline value ($\mu g{\cdot}L^{-1}$)
Freshwater	1*†
Marine	0.15*†

*Applies to the concentration of total aldicarb residues (comprising aldicarb, ASO, and ASO_2).

†Interim guideline.

Freshwater Life

The interim water quality guideline for aldicarb for the protection of freshwater life is 1 μg·L^{-1}. Of the species tested, the water flea *Daphnia laevis* was the most sensitive to aldicarb and its metabolites. In a 21-d test, Foran et al. (1986) reported that concentrations of 0.01 mg·L^{-1} of aldicarb or ASO resulted in reductions in survivorship (48–81%), fecundity (81–91%), and body size at first reproduction (21%) relative to controls. The age to first brood was also delayed from 5.5 d (controls) to 12.0 d (with aldicarb) and 16.0 d (with ASO) under this exposure regime ($p < 0.05$). These effects resulted in a significant reduction in population growth. The interim guideline was derived by multiplying the LOEL of 0.01 mg·L^{-1} (Foran et al. 1986) by a safety factor of 0.1 (CCME 1991). The interim guideline applies to the concentration of total aldicarb residues (comprising aldicarb, ASO, and ASO_2) in water.

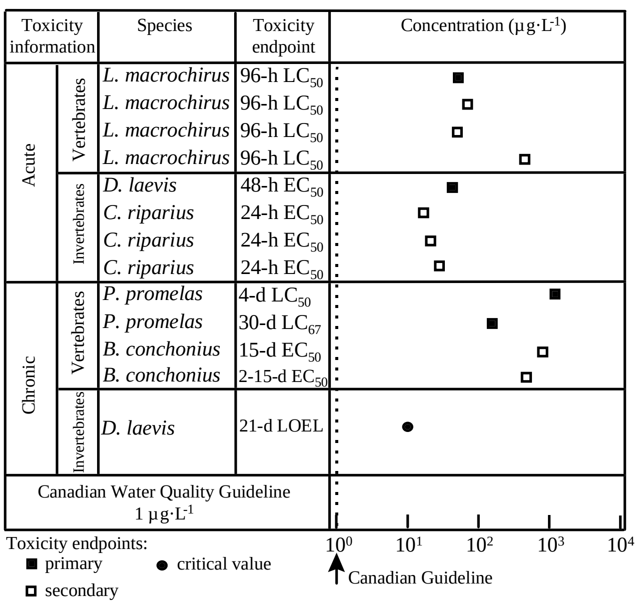

Figure 1. Select freshwater toxicity data for aldicarb.

Data on the toxicity of aldicarb to freshwater biota were available for fish, invertebrates, and one plant species. Growth of the green alga *Chlamydomonas moewusii* was not inhibited at levels as high as 15.2 mg·L^{-1}. Acute toxicity data for three species of invertebrates ranged from 0.017 to 93 mg·L^{-1}, while the single chronic test gave a value of 0.01 mg·L^{-1}. Available data on acute toxicity of aldicarb for five species of freshwater fish ranged from 0.05 to 1.6 mg·L^{-1}. No chronic effects were observed at 0.1 mg·L^{-1} with bluegill sunfish *(Lepomis macrochirus)* (UCC 1973), but were observed at 0.156 mg·L^{-1} with fathead minnow larvae *(Pimephales promelas)* (Pickering and Gilliam 1982).

Marine Life

The interim water quality guideline for aldicarb for the protection of marine life is 0.15 μg·L^{-1}. It was derived by multiplying the 28-d chronic test LOEC for significantly higher mortality of 0.0015 mg·L^{-1} (USEPA 1981) for the most sensitive organism the mysid shrimp, *Mysidopsis bahia*, by a safety factor of 0.1 (CCME 1991). As with the interim guideline for freshwater life, the interim guideline for marine life applies to the concentration of total aldicarb residues (comprising aldicarb, ASO, and ASO_2) in water.

Data on the toxicity of aldicarb to marine biota were available for fish, invertebrates, and one species of plant. Growth of the diatom *Skeletonema costatum* was not inhibited at levels as high as 50 mg·L^{-1}. Acute toxicity data for four species of invertebrates ranged from 0.0012 to 8.8 mg·L^{-1}, while the single chronic test gave a value of 0.0015 mg·L^{-1}. Available data on acute toxicity of aldicarb for four species of marine fish ranged from 0.04 to 0.3 mg·L^{-1} (CCME 1993). No chronic toxicity data for marine fish were available.

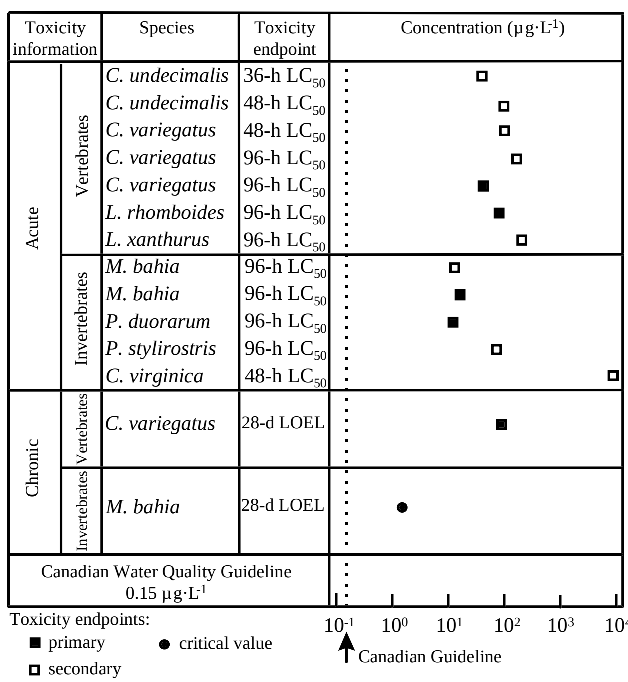

Figure 2. Select marine toxicity data for aldicarb.

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