Carbaryl (C₁₂H₁₁NO₂) (1-naphthyl-N-methylcarbamate, CAS 63-25-2) is a carbamate insecticide sold under the trade name Sevin. This white crystalline solid is slightly soluble in water (120 mg·L⁻¹ at 20°C). Acting as both a contact and a systemic (stomach) poison, carbaryl controls over 150 major pests in a wide variety of crops including sweet and field corn, cereal grains, legumes, turf, pastures, forest and shade trees, and fruit and vegetable crops. It also controls lice, fleas, ticks, and flies on poultry and livestock (Agriculture and Agri-Food Canada 1997). In 1990, 103,009 kg of carbaryl were sold in Canada, with over 60% being sold in Ontario and Manitoba (Agriculture Canada and Environment Canada 1992).

Carbaryl may contaminate aquatic systems through direct application, spray drift, leaching, runoff, dry/wet deposition, spills, dumping of tank residues, or equipment-washing operations. However, it has not been widely detected in Canadian waters (Frank et al. 1991). Of nine rivers sampled in New Brunswick between 1976 and 1983, only the Saint John River had detectable carbaryl residues, with a maximum of 1.7 µg·L⁻¹ (ENVIRODAT 1995). Carbaryl residues in water samples collected from eight rivers and lakes in Nova Scotia in 1984 were below the level of detection (LOD) of 0.05 µg·L⁻¹, except those from Silver Lake, which had carbaryl concentrations of 0.1 µg·L⁻¹ (I. Giroux 1996, Gouvernement du Québec, Ministère de l’Environnement et de la Faune, pers. com.).

Processes that determine the environmental fate and persistence of carbaryl include hydrolysis, photolysis, and adsorption. Carbaryl readily hydrolyzes in alkaline conditions into 1-naphthol, methylamine, and carbon dioxide at a rate of 20% per day at 20°C (Stewart et al. 1967). It also photolyzes rapidly in sunlight with rates varying seasonally from 2.5 to 25 d. In spring and summer, when carbaryl is usually applied, photolysis is four times faster than in winter (Lartiges and Garrigues 1995). Low pH and temperature, anoxic conditions, and high organic content of sediments increase the persistence of carbaryl (Hanazato and Yasuno 1989; Lartiges and Garrigues 1995). Owing to its low vapour pressure (1.36 × 10⁻⁶ mmHg [1.81 × 10⁻⁴] at 25°C), volatilization of carbaryl is limited, having a half-life >8.2 years (Howard 1991). Bacterial degradation of carbaryl is slow with a half-life >100 years (Verschueren 1983). Carbaryl degrades faster in seawater than in freshwater. Half-lives in seawater range from 22 d to <2 d at 6 and 22°C, respectively (Lartiges and Garrigues 1995).

Though carbaryl is assimilated by insects, plants, and animals, it is not expected to significantly bioaccumulate in fish considering BCFs in fish range from 9 to 34 (Howard 1991). The BCFs for algae, duckweed, snails, crayfish, and catfish are 4000, 3600, 300, 260, and 140, respectively (Verschueren 1983).

### Water Quality Guideline Derivation

The Canadian water quality guidelines for carbaryl for the protection of aquatic life were developed by the Ontario Ministry of Environment and Energy based on the CCME protocol (CCME 1991).

#### Freshwater Life

Data on the acute and chronic toxicity of carbaryl to freshwater organisms are available for numerous fish, invertebrate, and plant species. Toxicity values range over three orders of magnitude and vary with species and life stages of the organisms and with the formulation and age of the carbaryl solution. For example, a 96-h LC₅₀ static test using technical grade carbaryl (99.5% a.i.) reported values from 0.69 mg·L⁻¹ for lake trout, Salvelinus namaycush, to 20.0 mg·L⁻¹ for black bullheads, Ictalurus melas (Johnson and Finley 1980). In chronic tests, carbaryl affects the histology, enzymology, oxygen consumption, and hematology of fish. For example, Channa striatus exposed to sublethal concentrations of carbaryl (10 or 20 mg·L⁻¹) for 2, 8, 15, or 30 d exhibited histopathological changes in intestines and kidneys (Jauhar and Kulshrestha 1983). Growth and survival of larval fathead minnows (Pimephales promelas) and

<table>
<thead>
<tr>
<th>Aquatic life</th>
<th>Guideline value (µg·L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater</td>
<td>0.20</td>
</tr>
<tr>
<td>Marine</td>
<td>0.32*</td>
</tr>
</tbody>
</table>

*Interim guideline.

Table 1. Water quality guidelines for carbaryl for the protection of aquatic life (CCME 1997).
Figure 1. Select freshwater toxicity data for carbaryl.

bonytails (Gila elegans) and adult Colorado squawfish (Ptychocheilus lucius) significantly decreased at carbaryl concentrations between 0.4 and 6.8 µg·L⁻¹ (Carlson 1971; Norberg-King 1989; Beyers et al. 1994). Technical grade carbaryl is more toxic to fish than the formulated product (Johnson and Finley 1980).

The most sensitive invertebrate was the stonefly (Pteronarcys badia), with a 96-h LC₅₀ of 1.7 µg·L⁻¹ (Johnson and Finley 1980), but this study was ranked secondary. Carbaryl (technical grade) concentrations as low as 8.3 µg·L⁻¹ caused a 50% decrease in the reproduction of Ceriodaphnia dubia over a 96-h period (Oris et al. 1991). The 96-h LOEL for Daphnia ambigua was 2.0 µg·L⁻¹ (Hanazato 1991). Snails (Lymnaea stagnalis) exposed to 2000 µg·L⁻¹ carbaryl for 1 year had reduced growth, delayed egg laying, and increased mortality (Sedge and Bluzat 1983). The 96-h LC₅₀ for the aquatic insect Ranatra elongata was 620 µg·L⁻¹ under static conditions (Shukla et al. 1982).

The water quality guideline for carbaryl for the protection of freshwater life is 0.20 µg·L⁻¹. It was derived by multiplying the 96-h LOEC of 2.0 µg·L⁻¹ for the most sensitive organism to carbaryl, D. ambigua (Hanazato 1991), by a safety factor of 0.1 (CCME 1991, 1997). Note that the degradation product of carbaryl, 1-naphthol, is as much as 3.5 times more toxic to fish than carbaryl itself (Panwar et al. 1984). This guideline, therefore, may not protect against the toxicity of 1-naphthol.

Figure 2. Select marine toxicity data for carbaryl.

Sufficient acute and chronic toxicity data are available to derive an interim guideline for carbaryl (CCME 1991). Acute studies on striped bass (Morone saxatilis) and an estuarine teleost (Therapon jarbua) provided 96-h LC₅₀ values of 2.2 and 2.3 µg·L⁻¹, respectively (Lingaraja and Venugopalan 1978; Palawski et al. 1985). The schooling behaviour of Atlantic silversides (Menidia menidia) was altered by 0.1 mg·L⁻¹ of carbaryl (Weis and Weis 1974).

The interim water quality guideline for carbaryl for the protection of marine and estuarine life is 0.32 µg·L⁻¹. It was derived by multiplying the LOEC (a 12-h EC₅₀) of 6.3 µg·L⁻¹ (Hernandez et al. 1990) for the most sensitive organism to carbaryl, the sea urchin (Pseudoachinus magellanicus), by a safety factor of 0.05 (acute study; nonpersistent substance) (CCME 1991, 1997).
References


Reference listing:


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