Canadian Water Quality Guidelines for the Protection of Aquatic Life

TEBUTHIURON

Tebuthiuron ($C_9H_{16}N_4OS$) is a substituted urea herbicide with a CAS name and number of N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea and 34014-18-1, respectively. Tebuthiuron was first registered in Canada in 1974 under the trade names of Spike and Herbec (Agriculture Canada 1997).

Tebuthiuron is a nonselective herbicide used for total control of annual and perennial broadleaf weeds and grasses in noncrop areas such as permanent pastures, railway roadbeds, roadsides, and rights-of-way. Its mode of action is through inhibition of photosynthetic electron transport (Tomlin 1994).

Direct contamination of surface waters can occur from aerial or ground application because of spray drift. Indirect contamination can occur through runoff from treated areas or leaching into groundwater and subsequent recharging to surface waters. Extreme contamination of surface water and groundwater may result from pesticide spills, deliberate dumping of tank residues, or improper equipment-washing operations (CCME 1995).

A total of 7.6 t of tebuthiuron was sold in Canada in 1990, with 48% being sold in Quebec, 35% in Saskatchewan, 11% in Alberta, and the remainder in Ontario and Manitoba (Agriculture Canada and Environment Canada 1990). Contamination of Canadian freshwater sources from tebuthiuron range in value from 0.1–0.3 $\mu g \cdot L^{-1}$ (Berryman and Giroux 1994) to 600 $\mu g \cdot L^{-1}$ (G. Wood 1994, Health Canada, Ottawa, pers. com.).

The fate of tebuthiuron in water depends on precipitation and the rates of microbial degradation and photodegradation. Photodegradation of tebuthiuron was reported to be 42.5% after 15 d (Rainey and Magnussen 1976). Level I fugacity modelling predicted that 99.7% of tebuthiuron in the environment would partition into water (CESARS 1990). Hydrolysis of tebuthiuron is not a major fate process (Mosier and Saunders 1976). Tebuthiuron is highly soluble in water (2.5 $g \cdot L^{-1}$) and has a low absorption coefficient (log K_{ow} = 1.79) allowing it to leach through soils and contaminate shallow groundwater aquifers (USEPA 1994).

Studies suggest that although tebuthiuron can accumulate in some aquatic biota, biomagnification in the aquatic food chain is not likely. Concentrations of 2.2–2.5 $\mu g \cdot g^{-1}$ were detected in bluegill muscle and 2.3–3.7 $\mu g \cdot g^{-1}$ in rainbow trout muscle after 4 d of exposure. After 7 d of exposure, the levels of tebuthiuron in the muscles were lower (1.9–3 $\mu g \cdot g^{-1}$) in both species. After being transferred to clean water for 3–7 d, the level in the muscles diminished significantly (Gibson and Herberg n.d). Samples of the macrophyte *Hydrilla* sp. contained measurable quantities of tebuthiuron residues indicating moderate bioaccumulation. No tebuthiuron residue, however, was detected (detection limit = 100 $\mu g \cdot g^{-1}$) in fathead minnow tissue (Hamelink and Kehr 1976).

Water Quality Guideline Derivation

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

Freshwater Life

Tebuthiuron is relatively nontoxic to freshwater fish. Reported acute toxicities (96-h LC_{50}) ranged from 112 to 144 $mg \cdot L^{-1}$ (Bionomics 1972). Chronic studies on fish larvae reported NOELs and LOELs ranging from 9.3 to 26 $mg \cdot L^{-1}$ and from 18 to 53 $mg \cdot L^{-1}$, respectively (Todd et al. 1981; Meyerhoff et al. 1985).

Table 1. Water quality guidelines for tebuthiuron for the protection of aquatic life (CCME 1995).

Aquatic life	Guideline value ($\mu g \cdot L^{-1}$)
Freshwater	1.6*
Marine	NRG†

*Interim guideline.

†No recommended guideline.

One study on amphibians reported a LOEL of 100 $mg \cdot L^{-1}$ for bullfrogs *(Rana catesbeiana)* (Todd et al. 1984). The 24-h, 48-h, and 72-h LC_{50} values were estimated at 398, 332, and 316 $mg \cdot L^{-1}$, respectively, and the 96-h LC_{50} was estimated to be between 398 and 306 $mg \cdot L^{-1}$.

A study by Negilsky and Cocke (1989a) indicated a high toxicity of tebuthiuron to freshwater vascular plants. Reported NOEL and LOEL values for duckweed plants *(Lemna gibba)* were 0.091 $mg \cdot L^{-1}$ and 0.19 $mg \cdot L^{-1}$, respectively, based on specific growth rate, terminal frond, plant counts, and biomass. An EC_{50} value of 0.235 $mg \cdot L^{-1}$ for specific growth rate was also determined.

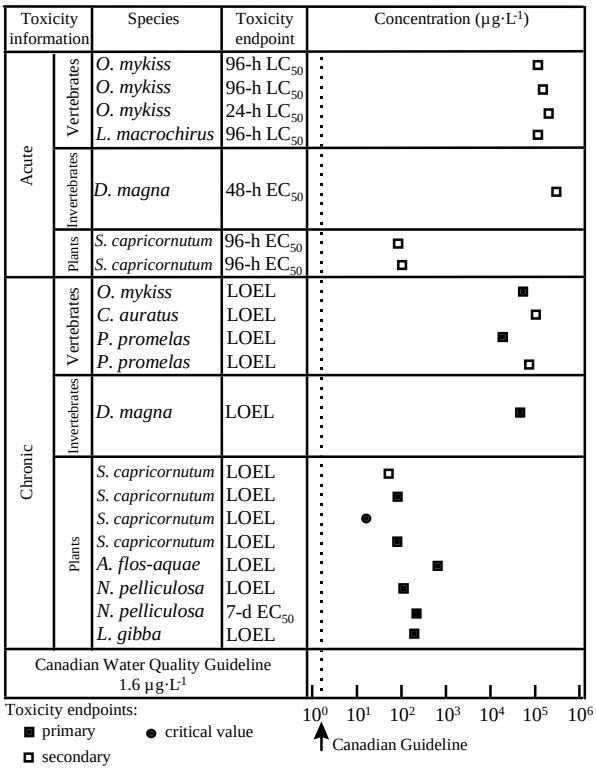

Figure 1. Select freshwater toxicity data for tebuthiuron.

Tebuthiuron is a potential threat to aquatic plants because it inhibits photosynthesis, is readily soluble in water, and is resistant to hydrolysis. Reported NOEL values ranged from 0.052 to 0.31 $mg \cdot L^{-1}$ and LOEL values ranged from 0.11 to 0.62 $mg \cdot L^{-1}$ (Negilsky et al. 1989; Negilsky and Cocke 1989b; Day 1993).

Algal toxicity studies with *Selenastrum capricornutum* have indicated that tebuthiuron is toxic at low levels. Acute toxicity values (EC_{50}s) ranged from 0.08 $mg \cdot L^{-1}$, based on a decrease in growth rate (Blaise and Harwood 1991), to 0.307 $mg \cdot L^{-1}$, based on the maximum specific growth rate (Meyerhoff et al. 1985). Adams et al. (1985) reported a NOEL range of 0.01–0.05 $mg \cdot L^{-1}$ using various endpoints (cell number, area under growth curve, growth rate, and elevation of growth curve). Reported LOEL values ranged from 0.016 $mg \cdot L^{-1}$, based on the density of the algal population, to 0.168 $mg \cdot L^{-1}$, based on algal biomass (Todd et al. 1983).

The interim water quality guideline for tebuthiuron for the protection of freshwater life is 1.6 $\mu g \cdot L^{-1}$ (CCME 1995). It was derived by multiplying the LOEL of 0.016 $mg \cdot L^{-1}$ (Todd et al. 1983) for the most sensitive organism to tebuthiuron, the alga *S. capricornutum*, by a safety factor of 0.1 (CCME 1991).

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