Canadian Water Quality Guidelines for the Protection of Aquatic Life

LINURON

Linuron ($C_9H_{10}Cl_2N_2O_2$) is a substituted phenyl urea herbicide with a CAS name and number of N-(3, 4-dichlorophenyl)-N-methoxy-N-methylurea and 41205-21-4, respectively. Pure linuron is a colourless crystalline solid with a water solubility of 81 mg·L^{-1} at 24°C. Trade names for linuron include Afalon and Lorox, or when formulated with metolachlor, Dulain (Tomlin 1994).

Linuron is registered to control a variety of annual weeds on field and garden crops such as corn, carrots, potatoes, fruit trees, wheat, oats, and barley (Du Pont, 1991; Tomlin 1994). Linuron is also registered for noncrop use to control broadleaf weeds, triazine-resistant weeds, and annual grasses on turf grass, shelter belts, and rights-of-way (WSSA 1989). In 1990, 272 t of linuron were sold in Canada, with 80% being sold in Ontario for application on fruits and vegetables (Agriculture Canada and Environment Canada 1990).

Linuron is absorbed by plant roots and transported passively via the xylem to leaves, where it inhibits photosynthesis by disrupting photosystem II (photosynthetic electron transport) (USEPA 1984). Linuron is generally most effective when applied to soil because absorption and translocation through leaves is poor (Bayer and Yamaguchi 1965). The selective phytotoxicity of linuron results from the differential uptake, translocation, and metabolism of linuron by different plant species (OMAF 1989).

Contamination of aquatic environments occurs from direct application, or indirectly through spray drift, leaching, runoff events, and dry/wet deposition events. Extreme pollution may result from spills, dumping of tank residues, or equipment-washing operations. Despite the extensive use of linuron in Canada, there is little information on water contamination. A linuron concentration of 0.03 µg·L^{-1} was detected in 1 out of 24 surface water samples collected in July of 1986 at Little Presque Isle Stream, New Brunswick (O'Neill and Bailey 1987). Surface waters from Holland River in Simcoe County, Ontario, were contaminated with 1100 µg·L^{-1} linuron from an unknown source (Frank et al. 1987). In Quebec, linuron concentrations from 0.08 to 3.4 µg·L^{-1} were detected in 76 out of 576 surface water samples from regions with intensive corn cultivation (Berryman and Giroux 1994).

Few studies have examined the persistence of linuron in water. Stephenson and Kane (1984) found that linuron disappeared exponentially from small enclosures in ponds with calculated half-lives from 16 to 40 d. The fate of linuron in natural water depends in part on its sorption to sediments and suspended particles. The half-life for linuron (5 mg·L^{-1}) in an unsterilized water/sediment system with high organic matter content and pH 6.5 is 7 d, but under sterilized alkaline conditions it is 42 weeks (Du Pont 1986a). Sorption may enhance linuron degradation by facilitating surface-associated chemical and microbial processes (Means and Wijayaratne 1982).

Data on the bioaccumulation and bioconcentration of linuron in aquatic organisms are limited. Bluegill sunfish *(Lepomis macrochirus)* exposed to 0.1 or 0.95 mg·L^{-1} of linuron for 4 weeks had whole BCFs of 49 and 38, respectively (Du Pont 1984). Residues were concentrated in the viscera with BCFs of 240 and 170 for the low and high exposure levels, respectively (Du Pont 1984). The BCFs for snails (*Physa* sp.) and fish *(Gambusia affinis)* measured 540 and 2310, respectively, when tested within a Metcalf model ecosystem (Francis et al. 1985). Kenaga (1980) predicted BCFs of 48 and 54 from the K_{oc} and water solubility of linuron. Linuron, therefore, has a low to moderate potential for bioconcentration.

Water Quality Guideline Derivation

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

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

Aquatic life	Guideline value (µg·L^{-1})
Freshwater	7.0*
Marine	NRG†

*Interim guideline.
†No recommended guideline.

Freshwater Life

Acute toxicity data are available for four fish species native to Canada. Rainbow trout *(Oncorhynchus mykiss)* has a 48-h LC_{100} of 30.6 $mg \cdot L^{-1}$ and 96-h LC_{50} values from 3.2 to 16.4 $mg \cdot L^{-1}$ (Lysak and Marcinek 1972; Du Pont 1973, 1986b; Linders et al. 1990). Channel catfish *(Ictalarus punctatus)*, brown bullheads *(Ictalarus nebulosus)*, and bluegill sunfish have 96-h LC_{50}s of 2.9, 5.2, and 16.2, respectively (Du Pont 1986b; Mayer and Ellersieck 1986; Linders et al. 1990). Acute 48-h EC_{50} values for immobility of invertebrates range from 0.12 $mg \cdot L^{-1}$ for water fleas *(Daphnia magna)* to 2.9 $mg \cdot L^{-1}$ for larval midges *(Chironomus plumosus)* (Mayer and Ellersieck 1986). O'Brien and Prendeville (1979) reported a 12-h LOEL of 2.5 $mg \cdot L^{-1}$ and a 72-h NOEL of 0.25 $mg \cdot L^{-1}$ for increase in cell membrane permeability in duckweed *(Lemna minor)*. Linuron also reduces green algal growth by approximately 50% at 0.05 and 10 $mg \cdot L^{-1}$ for *Chlorella vulgaris* and *Mesotaenium caldariorum*, respectively (Cullimore 1975; Stephenson and Kane 1984). The interim water quality guideline for linuron for the protection of freshwater life is 7.0 $\mu g \cdot L^{-1}$. It was derived by multiplying the lowest acceptable effect concentration, a 5-d EC_{50} value of 70 $\mu g \cdot L^{-1}$ for growth inhibition of duckweed (Stephenson and Kane 1984), by a safety factor of 0.1 (CCME 1991).

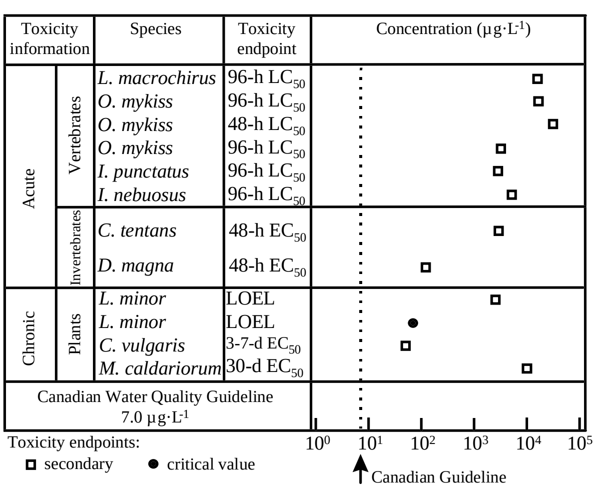

Figure 1. Select freshwater toxicity data for linuron.

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