



## Canadian Water Quality Guidelines for the Protection of Aquatic Life

## TRIALATE

**T**riallate is a popular preemergence carbamate herbicide with a CAS name and number of S-2,3,3-trichloroallyl diisopropylthiocarbamate and 2303-17-5, respectively. It is also known as bis(1-methylethyl)carbamothioic acid and S-(2,3,3-trichloro-2-propenyl) ester. Its molecular formula is  $C_{10}H_{16}Cl_3NOS$ . Pure triallate is an amber liquid, but it is commonly formulated into emulsifiable concentrates and granular products under such trade names as Avadex BW and Fortress (Agriculture and Agri-Food Canada 1997). Triallate controls wild oats, durum and spring wheat, and dry peas by inhibiting cell elongation, particularly in stem and leaf meristematic tissue (Worthing and Walker 1987; Tomlin 1994). Triallate is not manufactured in Canada.

Triallate may disperse through the environment by direct volatilization and subsequent atmospheric transport mechanisms, surface water runoff, and soil adsorption. Snowmelt runoff from fields treated the previous autumn may contribute to the presence of triallate in surface waters of the Canadian prairies (Williamson 1984; Waite et al. 1986). Because triallate is strongly adsorbed to soil particles, another major transport pathway from treated fields is soil erosion via surface runoff and atmospheric suspension. Triallate concentrations in the Ochre, Turtle, La Salle, and Assiniboine rivers in Manitoba are 3–150  $ng\cdot L^{-1}$  (Muir and Grift 1987; Williamson 1984). Triallate concentrations ranging from 1.58 to 6.77  $\mu g\cdot L^{-1}$  were detected in spring runoff and snowmelt in Saskatchewan (Grover et al. 1988).

Fate and persistence data for triallate in aquatic environments are limited, but adsorption onto particulate material is likely a major removal process (Smith and Fitzpatrick 1970; Therrien-Richards and Williamson 1987). Photochemical reactions, hydrolysis, and microbial degradation are not thought to be important (Smith 1969; McKercher and Thangudu 1982; USEPA 1983). Volatilization half-life of triallate in water was estimated to be approximately 1 week (USEPA 1983; Muir 1990).

Brown bullheads (*Ictalurus nebulosus*), brook sticklebacks (*Culaea inconstans*), and central mudminnows (*Umbra limi*) collected from the La Salle River contained maximum triallate concentrations of 4.2, 3.3, and 9.2  $\mu g\cdot kg^{-1}$ ,

respectively (Therrien-Richards and Williamson 1987). Triallate's log  $K_{ow}$  (4.6) suggests a relatively high bioconcentration potential, but a theoretical BCF of only 150 has been estimated (Chiou et al. 1977; Kenaga and Goring 1980). This discrepancy may be due to an ability of aquatic organisms to metabolize and excrete triallate, thus limiting its biotic accumulation.

### Water Quality Guideline Derivation

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

### Freshwater Life

Rainbow trout (*Oncorhynchus mykiss*) and channel catfish (*Ictalurus punctatus*) have 24-h  $LC_{50}$ s of 1.3 and 2.5  $mg\cdot L^{-1}$ , respectively, for technical grade triallate (95.3% a.i.). The 96-h  $LC_{50}$ s are 0.62 and 1.7  $mg\cdot L^{-1}$  for the respective species (Mayer and Ellersieck 1986). The formulated emulsifiable concentrate (46.3% a.i.) is slightly more toxic, with 24-h  $LC_{50}$ s of 1.3 and 1.8  $mg\cdot L^{-1}$  and 96-h  $LC_{50}$ s of 1 and 1.1  $mg\cdot L^{-1}$  for rainbow trout and channel catfish, respectively (Mayer and Ellersieck 1986). Fathead minnows (*Pimephales promelas*) exposed to technical grade triallate for 7 d had an  $LC_{100}$  of 531  $\mu g\cdot L^{-1}$  and an estimated  $LC_{50}$  of 330  $\mu g\cdot L^{-1}$ . No mortality occurred at 202  $\mu g\cdot L^{-1}$ . The NOEC and the LOEC for reduced growth of minnow fry are 125 and 202  $\mu g\cdot L^{-1}$ , respectively (Environment Canada 1989).

**Table 1. Water quality guidelines for triallate for the protection of aquatic life (CCME 1992).**

Aquatic life	Guideline value ( $\mu g\cdot L^{-1}$ )
Freshwater	0.24*
Marine	NRG†

\* Interim guideline.

† No recommended guideline.

The toxicity of triallate to invertebrate aquatic organisms is variable. For example, acute tests using technical triallate resulted in 48-h LC<sub>50</sub>s from 80 µg·L<sup>-1</sup> for first instar *Daphnia magna* to 2300 µg·L<sup>-1</sup> for fourth instar *Chironomus riparius* (Mayer and Ellersieck 1986; Buhl and Faerber 1989). Acute toxicity of the emulsifiable concentrate formulation ranged from a 48-h LC<sub>50</sub> of 57 µg·L<sup>-1</sup> for *D. magna* to an EC<sub>50</sub> of 1230 µg·L<sup>-1</sup> for *C. riparius* (Mayer and Ellersieck 1986; Buhl and Faerber 1989). The 7-d LC<sub>50</sub> for *Ceriodaphnia dubia* has been reported as 12 µg·L<sup>-1</sup>, though mortality occurs at triallate concentrations from 0.35 to 531 µg·L<sup>-1</sup> (Environment Canada 1989). *C. dubia* has a NOEC and LOEC for reduced daily production of young of 1.3 and 2.4 µg·L<sup>-1</sup>, respectively (Environment Canada 1989).

Triallate concentrations up to 10 000 µg·L<sup>-1</sup> inhibited chlorophyll production in *Chlorella pyrenoidosa* by <50% (Kratky and Warren 1971). Two- to 3-week exposure to the Far-Go formulation (10% a.i.; 6.2–11.2 µg·L<sup>-1</sup>) reduced population growth of *Selenastrum capricornutum* by 50% compared to the control (Turbak et al. 1986).

Laboratory microcosms simulating northern prairie wetlands were inoculated with triallate to give concentrations of 10, 100, and 1000 µg·L<sup>-1</sup> (Johnson

1986). Mortality (60 and 100%) of *D. magna* occurred in 48-h tests using contaminated water (100 and 1000 µg·L<sup>-1</sup>) recovered from the microcosms 14 d after treatment. In similar tests, *C. riparius* was 100 times less sensitive to triallate. The 100 and 1000 µg·L<sup>-1</sup> treatments reduced algal (*Selenastrum capricornutum*) cell counts >40% at 30 d posttreatment, yet increased photosynthetic activity as measured by a 20% increase in dissolved oxygen (Johnson 1986).

Sufficient data exist to derive an interim guideline for the protection of freshwater life. The interim value of 0.24 µg·L<sup>-1</sup> was calculated by multiplying the LOEC for inhibition of *C. dubia* reproduction (2.4 µg·L<sup>-1</sup>) by a safety factor of 0.1 (CCME 1991, 1992).

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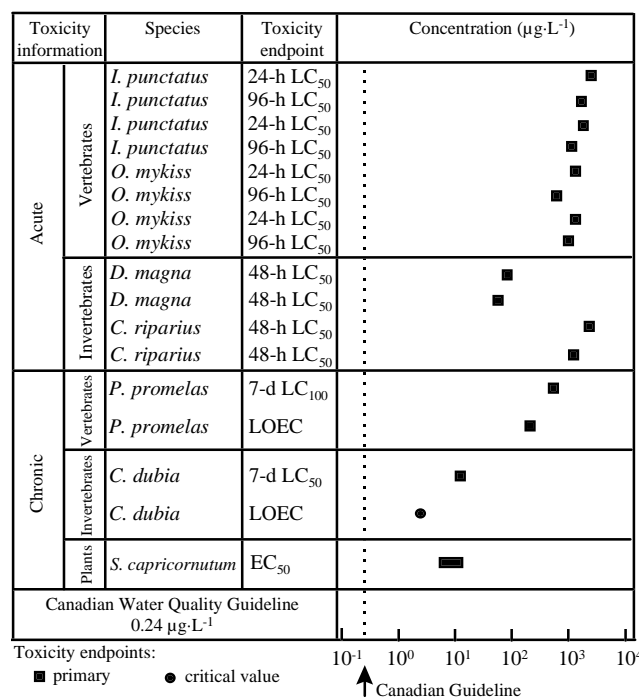


Figure 1. Freshwater toxicity effects diagram for triallate.

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