



Canadian Water Quality Guidelines for the Protection of Aquatic Life

BROMACIL

Bromacil ($C_9H_{13}BrN_2O_2$) is a substituted uracil herbicide. It is a colourless, odourless, crystalline solid that may be formulated alone or with either 2,4-D (Calmix) or diuron (Krovar). Bromacil has a CAS name and number of 5-bromo-6-methyl-3-(1-methylpropyl)-2,4(1*H*,3*H*)-pyrimidinedione and 314-40-9, respectively. Available as wettable powder, soluble concentrate, or granules, bromacil has a relatively high water solubility of $807 \text{ mg}\cdot\text{L}^{-1}$ at pH 5 and 25°C , but is soluble in various organic solvents.

Bromacil acts as a nonselective herbicide effective against most annual and perennial broadleaved weeds and grasses as well as some brush species by inhibiting photosynthesis at the electron transport chain (OMAF 1994; Agriculture and Agri-Food Canada 1997). In Canada, bromacil is registered for broadcast and spot ground application to control weeds and brush on noncropland such as industrial sites, storage areas, parking lots, airports, dry ditches, fence lines, and railroads (Agriculture Canada and Environment Canada 1990). In western Canada, bromacil is used to control weed growth in irrigation ditches (Environment Canada 1990).

In 1990, 2100 and 36 000 kg of bromacil were sold in Canada for domestic and commercial uses, respectively. Most of this was sold in Alberta (12 300 kg), Manitoba (9600 kg), and Ontario (9500 kg) (Agriculture Canada and Environment Canada 1990).

Surface waters may become contaminated by bromacil through spray drift, accidental spills, equipment-washing operations, and dumping of tank residues. Bromacil has a low log organic carbon partition coefficient (1.66 to 2.10) indicating that it adsorbs only slightly to soil organic carbon and is, therefore, mobile in soil (Montgomery 1993). The contamination of groundwater can thereby occur via leaching from treated areas and/or improper use and handling procedures (e.g., back-siphoning into wells). Occasionally, groundwater recharge by contaminated surface water contributes to groundwater contamination (Frank et al. 1987).

Bromacil does not absorb sunlight; therefore, photolysis in aquatic systems is minimal unless naturally occurring sensitizers such as humic acids, chlorophyll, and riboflavin are abundant (Acher and Salzman 1980; Acher 1984;). Volatilization of bromacil is also a minor route for environmental dissipation owing to its low vapour

pressure ($41 \text{ }\mu\text{Pa}$ at 25°C) (Tomlin 1994). Bromacil is slowly debrominated by microflora under anaerobic, methanogenic conditions but is not degraded under denitrifying or sulphate-reducing conditions (Adrian and Sulfito 1990). Smith et al. (1975) measured bromacil residues ($1 \text{ }\mu\text{g}\cdot\text{L}^{-1}$) in irrigation ditch water one year after application ($31 \text{ }\mu\text{g}\cdot\text{L}^{-1}$), suggesting that bromacil is relatively persistent in water.

Bromacil has a low log octanol–water partition coefficient ($\log K_{ow}$) of 1.87 at pH 7 and therefore is not likely to bioaccumulate in biota (Tomlin 1994). For example, the bioconcentration factors for 30-d old fathead minnows (*Pimephales promelas*) exposed for 17 d to $4.25 \text{ }\mu\text{g}\cdot\text{L}^{-1}$ or $35.11 \text{ }\mu\text{g}\cdot\text{L}^{-1}$ of ^{14}C -labelled bromacil were 2.8 and 3.5, respectively (Call et al. 1983).

Water Quality Guideline Derivation

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

Freshwater Life

Toxicity data indicate that bromacil is relatively nontoxic to fish. For example, acute (24- to 168-h LC_{50}) toxicity concentrations range from 71 to $186 \text{ mg}\cdot\text{L}^{-1}$ for four species of fish native to Canada. The most sensitive fish species are bluegill sunfish (*Lepomis macrochirus*) and rainbow trout (*Oncorhynchus mykiss*), with 48-h LC_{50} s of 71 and $75 \text{ mg}\cdot\text{L}^{-1}$, respectively (Sherman and Kaplan 1975). Fathead minnows (*Pimephales promelas*) are the most tolerant fish, with an LC_{50} of approximately $184 \text{ mg}\cdot\text{L}^{-1}$ for both 96-h static and 24-h flow-through tests (Call et al. 1987; Geiger et al. 1988). The 168-h

Table 1. Water quality guidelines for bromacil for the protection of aquatic life (CCME 1997).

Aquatic life	Guideline value ($\mu\text{g}\cdot\text{L}^{-1}$)
Freshwater	5.0*
Marine	NRG†

* Interim guideline.

† No recommended guideline.

flow-through LC₅₀ value for this fish is slightly lower at 167 mg·L⁻¹ (Call et al. 1987). Carp (*Cyprinus carpio*) showed similar tolerance to bromacil with a 48-h LC₅₀ of 164 mg·L⁻¹ (Sherman and Kaplan 1975). In a chronic test, fathead minnows exposed to bromacil concentrations from 1.0 to 29.0 mg·L⁻¹ during hatching and for 60 d thereafter did not have reduced hatching success, reduced survival rate to 60 d, or increased number of abnormal fry compared to controls. However, wet weight and length of fry measured at 60 d were significantly reduced at all exposures, except 1.9 mg·L⁻¹ (Call et al. 1983).

From the limited data found, bromacil appears to be relatively nontoxic to freshwater invertebrates. For example, third-instar *Chironomus tentans* larvae have a 96-h static LC₅₀ value of 210 mg·L⁻¹. *Daphnia magna* neonates have 48-h static EC₅₀ and LC₅₀ values of 313 mg·L⁻¹ and 363 mg·L⁻¹, respectively (Environment Canada 1996).

50% when exposed to 1 and 10 mg·L⁻¹ bromacil for 18 to 36 h (Kratky and Warren 1971).

The interim water quality guideline for bromacil for the protection of freshwater life is 5.0 µg·L⁻¹. It was derived by multiplying the 30-d LC₅₀s of 0.05 mg·L⁻¹ (Cullimore 1975) for the most sensitive organisms to bromacil, the green algae *Chlamydomonas terricola* and *Haematococcus lacustris* 34-1j, by a safety factor of 0.1 (CCME 1997).

References

Acher, A.J. 1984. Sunlight photooxidation of organic pollutants in wastewater. *Water Sci. Technol.* 17:623–632.

Acher, A.J., and S. Saltzman. 1980. Dye-sensitized photooxidation of bromacil in water. *J. Environ. Qual.* 9(2):190–194.

Adrian, N.R., and J.M. Sulfito. 1990. Reductive dehalogenation of a nitrogen heterocyclic herbicide in anoxic aquifer slurries. *Appl. Environ. Microbiol.* 56:292–294.

Agriculture and Agri-Food Canada. 1997. Regulatory Information on Pesticide Products (RIPP) Database (CCINFODISK). Issue 97-3. Produced by Agriculture and Agri-Food Canada and distributed by the Canadian Centre for Occupational Health and Safety. CD-ROM.

Agriculture Canada and Environment Canada. 1990. Pesticide registrant survey 1990 report. Agriculture Canada, Pesticides Directorate, and Environment Canada, Commercial Chemicals Branch, Ottawa.

Call, D.J., L.T. Brooke, and R.J. Kent. 1983. Toxicity, bioconcentration, and metabolism of five herbicides in freshwater fish. EPA/600/3-83-096, U.S. Environmental Protection Agency, Office of Research and Development, Duluth, MN.

Call, D.J., L.T. Brooke, R.J. Kent, M.L. Knuth, S.H. Poirier, J.M. Huot, and A.R. Lima. 1987. Bromacil and diuron herbicides: Toxicity, uptake, and elimination in freshwater fish. *Arch. Environ. Contam. Toxicol.* 16:607–613.

CCME (Canadian Council of Ministers of the Environment). 1991. Appendix IX—A protocol for the derivation of water quality guidelines for the protection of aquatic life (April 1991). In: Canadian water quality guidelines, Canadian Council of Resource and Environment Ministers. 1987. Prepared by the Task Force on Water Quality Guidelines. [Updated and reprinted with minor revisions and editorial changes in Canadian environmental quality guidelines, Chapter 4, Canadian Council of Ministers of the Environment, 1999, Winnipeg.]

—. 1997. Appendix XXIII—Canadian water quality guidelines: Updates (June 1997), arsenic, bromacil, carbaryl, chlorpyrifos, deltamethin, and glycols. In: Canadian water quality guidelines, Canadian Council of Resource and Environment Ministers. 1987. Prepared by the Task Force on Water Quality Guidelines.

Cullimore, D.R. 1975. The *in vitro* sensitivity of some species of Chlorophyceae to a selected range of herbicides. *Weed Res.* 15:401–406.

Environment Canada. 1990. Irrigation: Its implications with respect to ground water quality. Inland Waters Directorate, Western and Northern Region, Regina.

—. 1996. Acute toxicity of bromacil to *Daphnia magna* and *Chironomus tentans*. Prepared by B.A.R. Environmental, Inc. for Environment Canada, Science Policy and Environmental Quality Branch, Ottawa. Unpub.

Frank, R., B.S. Clegg, B.D. Ripley, and H.E. Braun. 1987. Investigations of pesticide contamination in rural wells, 1979–1984, Ontario, Canada. *Arch. Environ. Contam. Toxicol.* 16:9–22.

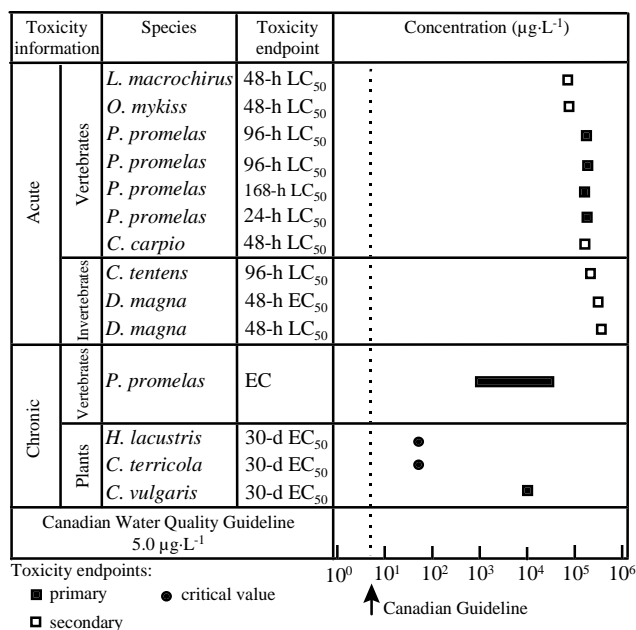


Figure 1. Select freshwater toxicity data for bromacil.

Aquatic plant toxicity data are only available for green algae. Algae growing in media containing 0.01–10 mg·L⁻¹ of bromacil have EC₅₀ values for growth inhibition from 0.05 mg·L⁻¹ for *Haematococcus lacustris* 34-1j and *Chlamydomonas terricola* to 10 mg·L⁻¹ for *Chlorella vulgaris*. Two species, *Chlorella ellipsoidea* and *Coccomyxa subellipsoidea*, were unaffected by all concentrations tested (Cullimore 1975). *Chlorella pyrenoidosa* suffered growth inhibition of approximately

- Geiger, D.L., D.J. Call, and L.T. Brooke. 1988. Acute toxicity of organic chemicals to fathead minnows (*Pimephales promelas*). Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI.
- Kratky, B.A., and G.F. Warren. 1971. The use of three simple, rapid bioassays on forty-two herbicides. *Weed Res.* 11:257–262.
- Montgomery, J.H. 1993. *Agrochemicals desk reference*, Environmental data. Lewis Publishers, Chelsea, MI.
- OMAF (Ontario Ministry of Agriculture and Food). 1994. 1994 Guide to weed control. Publication No. 75. Queen's Printer for Ontario, Toronto.
- Sherman, H., and A.M. Kaplan. 1975. Toxicity studies with 5-bromo-3-sec-butyl-6-methyluracil. *Toxicol. Appl. Pharmacol.* 34:189–196.
- Smith, A.E., R. Grover, G.S. Emmond, and H.C. Korven. 1975. Persistence and movement of atrazine, bromacil, monuron, and simazine in intermittently filled irrigation ditches. *Can. J. Plant Sci.* 55:809–816.
- Tomlin, C. (ed.). 1994. *The pesticide manual: A world compendium*. 10th ed. (Incorporating the *Agrochemicals handbook*.) British Crop Protection Council and Royal Society of Chemistry, Thornton Heath, UK.

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: Bromacil. In: *Canadian environmental quality guidelines, 1999*, Canadian Council of Ministers of the Environment, Winnipeg.

For further scientific information, contact:

Environment Canada
Guidelines and Standards Division
351 St. Joseph Blvd.
Hull, QC K1A 0H3
Phone: (819) 953-1550
Facsimile: (819) 953-0461
E-mail: ceqg-rcqe@ec.gc.ca
Internet: <http://www.ec.gc.ca>

For additional copies, contact:

CCME Documents
c/o Manitoba Statutory Publications
200 Vaughan St.
Winnipeg, MB R3C 1T5
Phone: (204) 945-4664
Facsimile: (204) 945-7172
E-mail: spceme@chc.gov.mb.ca