Canadian Water Quality Guidelines for the Protection of Aquatic Life

SIMAZINE

Simazine ($C_7H_{12}ClN_5$) is a triazine herbicide with a CAS name and number of 2-chloro-4,6-bis(ethylamino)-1,3,5-triazine and 122-34-9, respectively. Simazine was first registered in Canada in 1963 under the trade names Simadex, Simmaprim, and Princep (Agriculture and Agri-Food Canada 1997).

Simazine is a selective herbicide used for the control of annual broadleaf and grass weeds in raspberries, loganberries, highbush blueberries, apples, pears, grapes, asparagus, and ornamentals. Noncrop uses include total weed control in industrial areas, at airports, and along shelterbelts and rights-of-way, and aquatic weed control in ditches, farm ponds, fish hatcheries, aquaria, and fountains (Agriculture and Agri-Food Canada 1997). Its mode of action is to inhibit photosynthetic electron transport (Tomlin 1994).

In 1987, 219 t of formulated simazine and 1684 t of technical grade simazine were imported into Canada (Statistics Canada 1988). With the exception of spills, concentrations of simazine detected in Canadian freshwater sources range from 0.0003 to 6 $\mu g \cdot L^{-1}$ (Frank et al. 1979; Frank 1981). Simazine contamination of freshwater may result from spraying directly into watercourses, vapour drift, and precipitation, or from surface runoff and groundwater intrusions from treated lands. Accidents and spills of simazine may also contaminate surface waters (CCME 1991a).

The major fate processes of simazine are microbial degradation and, possibly, photodegradation combined with sorption to sediments and aquatic plants (Muir 1991). Volatilization to the atmosphere is not a major fate process (Henry's law constant of 0.00034 $Pa \cdot m^3 \cdot mol^{-1}$) (Suntio et al. 1988). The hydrolysis half-life of simazine is 70 d at pH 5 and >200 d at pH 7 and 9 (Burkhard and Guth 1981). Simazine can be relatively persistent in aquatic systems, particularly shallow, well-mixed lakes and ponds (Jenkins and Buikema 1990).

Simazine does not bioaccumulate or biomagnify in the food web. The bioaccumulation potential is low as evidenced by BCFs <100. The depuration half-life in fish is <7 d following exposure if the organism is transferred to uncontaminated water, indicating that simazine is rapidly excreted or metabolized (Rodgers 1970; Mayer and Sanders 1977; Niimi 1987).

Water Quality Guideline Derivation

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

Freshwater Life

Simazine has a low toxicity to fish (WSSA 1983). The USDA (1984) concluded that simazine should not affect fish at concentrations below its water solubility. Reported 48-h LC_{50}s range from >10 $mg \cdot L^{-1}$ for medaka (Hashimoto and Nishiuchi 1981) to 85 $mg \cdot L^{-1}$ for rainbow trout (Alabaster 1969). Snow (1963) reported that simazine was not toxic to zooplankton and other animal life composing the diet of fish being cultured in the ponds. Laboratory tests on bottom organisms gave an acute LD_{50} of 28 $mg \cdot L^{-1}$ (Walker 1964).

Marchini et al. (1988) found the acute toxicity of simazine to *Daphnia magna* to be >3.5 $mg \cdot L^{-1}$ using 24-h and 48-h immobilization tests. Sanders (1970) found that *D. magna* and seed shrimp *(Cypridopsis vidua)* were immobilized after 48-h exposures to simazine concentrations of 1.0 and 3.2 $mg \cdot L^{-1}$, respectively.

The USDA's (1984) review of simazine lists LC_{50}s for stonefly larvae (*Pteronarcys* sp.) of 1.9 (96-h) to 50 (48-h) $mg \cdot L^{-1}$ and a 24-h LC_{50} for the freshwater copepod *Heliodiaptomus viduus* of 1.0 $mg \cdot L^{-1}$. While conducting 48-h LC_{50} tests with *D. pulex*, Fitzmayer et al.

Table 1. Water quality guidelines for simazine for the protection of aquatic life (CCME 1991a).

Aquatic life	Guideline value ($\mu g \cdot L^{-1}$)
Freshwater	10
Marine	NRG*

*No recommended guideline.

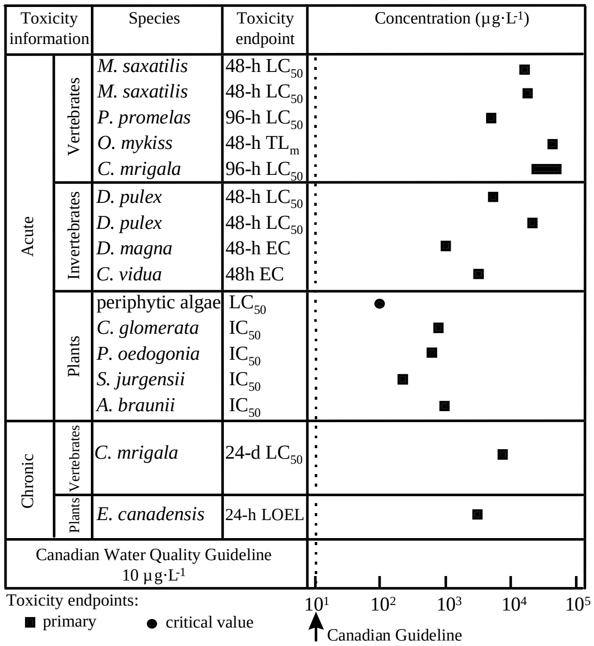

Figure 1. Select freshwater toxicity data for simazine.

(1982) noted that the daphnids became sedentary at simazine concentrations of 1 to 50 mg·L^{-1}. For *D. pulex* and *Moina macrocopa*, 3-h LC_{50}s were >40 mg·L^{-1} (Hashimoto and Nishiuchi 1981). A single amphibian toxicity (48-h TL_m) was >100 mg·L^{-1} for the tadpole of *Bufo bufo japonicus* (Hashimoto and Nishiuchi 1981).

Chronic NOELs for *Daphnia* sp. and mud crabs were 4 mg·L^{-1} and 1000 mg·L^{-1}, respectively (USDA 1984).

Kosanke et al. (1988) examined the effect of simazine on the ontogenesis of freshwater snail *(Lymnaea stagnalis)* embryos. At 20.1 µg·L^{-1} simazine, all eggs were killed (762 eggs). In other tests with molluscs, a 48-h LC_{50} value >100 mg·L^{-1} for the snails *Indoplanorbis exustus*, *Semisulcospira libertina*, and *Physa acuta* were reported (Hashimoto and Nishiuchi 1981).

After extensive studies of in situ enclosures, Goldsborough and Robinson (1986), arrived at a minimum periphyton community LC_{50} of 100 µg·L^{-1}. Data indicated rapid recovery of the organisms within the enclosures even after treatment with 5.0 mg·L^{-1}. Therefore, even though simazine may exert adverse effects on the organisms that form the basis of the aquatic food web, these effects are transient and do not translate to adverse effects on the organisms depending on the plankton community for food. The study by Kosanke et al. (1988), where effects of simazine were reported at concentrations of 20.1 µg·L^{-1}, was not used to establish the water quality guideline because no response curve was available for that study. The water quality guideline for simazine for the protection of freshwater life is 10 µg·L^{-1}. It was derived by multiplying the minimum plankton community LC_{50} of 100 µg·L^{-1} (Goldsborough and Robinson 1986) by a safety factor of 0.1 (CCME 1991a).

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