Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses

SIMAZINE

Simazine ($C_7H_{12}ClN_5$) is a selective herbicide used for the control of annual broadleaf and grass weeds. Crop uses include weed control in corn, established asparagus, bird's foot trefoil, raspberries, loganberries, blackberries, highbush blueberries, alfalfa, apples and pears established one year or more, grapes, woody ornamentals, nursery and Christmas tree plantations, and pasture and rangeland (Agriculture Canada 1989, OMAF 1989; Agriculture and Agri-Food Canada 1997). In Nova Scotia, simazine is registered in forestry as a conifer release herbicide, and in forestry nurseries as a pre-emergent herbicide (P. Neily 1990, Nova Scotia Department of Lands and Forests, Truro, Nova Scotia, pers. com.). Noncrop uses for simazine include nonselective weed control in industrial areas, at airports, and along shelterbelts and rights-of-way, and aquatic weed control in ditches, farm ponds, recirculating water cooling towers, fish hatcheries, aquaria, and fountains (Agriculture Canada 1997).

Microbial degradation may be the dominant pathway of simazine degradation in soil (WSSA 1983). The loss of simazine by photodecomposition, volatilization, and photolysis were found to be insignificant fate processes (WSSA 1983; USEPA 1988). It has been found that organic matter in the soil enhances the nonbiological hydroxylation of simazine (Esser et al. 1975).

The results from the experiments initiated by the European Weed Research Society (EWRS) were summarized by Walker et al. (1983) and Chen et al. (1983). Field half-life estimates for simazine ranged from <14 to 100 d. Significant correlations between laboratory half-lives and soil organic carbon content, clay content, and pH were found. The studies also found that changes in temperature from 10 to 30ºC resulted in two- to five-fold increase in degradation rates. The effect of soil moisture content on degradation rates was more variable. In some soils the rate of degradation was reduced considerably in dry soils; half-lives at 20% field capacity were twice as long as those at 90% field capacity. The USEPA (1987) concluded that under aerobic soil conditions, simazine loss depends mainly on soil moisture and temperature. The average half-life of simazine under anaerobic soil conditions is >12 weeks while the half-life under aerobic soil conditions is 8–12 weeks (USEPA 1988).

For more information on the use, environmental concentrations, and chemical properties of simazine, see the fact sheet on simazine in Chapter 4 of *Canadian Environmental Quality Guidelines*.

Water Quality Guideline Derivation

The interim Canadian water quality guideline for irrigation was adopted from the Ontario Ministry of the Environment's water quality guideline (OMOE 1984). The interim Canadian water quality guideline for livestock water was developed in 1991 following the principles formalized in the CCME protocol (CCME 1993).

Irrigation Water

Pringle et al. (1978) studied the effect of simazine residues in irrigation water on six crops. Simazine was applied at concentrations of 0.01 and 0.10 $mg \cdot L^{-1}$ in the irrigation water and crops were harvested 7 and 30 d after treatment. No simazine residues were found in corn grain or pinto bean pods, while trace amounts were found in pinto bean foliage and cucumbers. Concentrations ranging from 0.6 to 2.9 $\mu g \cdot kg^{-1}$ were reported in tomatoes, sugar beets, and corn foliage. The highest residues of simazine were found in alfalfa (6.4 $\mu g \cdot kg^{-1}$). The authors suggested that simazine concentrations of up to 0.10 $mg \cdot L^{-1}$ in irrigation water would result in little simazine accumulation in various crops. The OMOE (1984) noted that concentrations of triazine herbicides (including simazine) as low as 0.5 $\mu g \cdot L^{-1}$ might injure seedling crops.

Table 1. Water quality guidelines for simazine for the protection of agricultural water uses (CCME 1991).

Use	Guideline value ($\mu g \cdot L^{-1}$)
Irrigation water	0.5*
Livestock water	10*

*Interim guideline.

In the absence of sufficient information, an interim Canadian water quality guideline for simazine in irrigation water of 0.5 $\mu g \cdot L^{-1}$ (CCME 1991) is recommended by choosing the lowest value at which toxic effects may occur (OMOE 1984).

Livestock Water

Available data indicate that simazine exhibits low acute toxicity via oral, dermal, and inhalation routes of exposure to birds and laboratory animals. Reported oral LD_{50}s ranged from 972 to 5000 $mg \cdot kg^{-1}$ (Gaines and Linder 1986).

Ruminants appear to be more susceptible to simazine poisoning than laboratory animals. A single oral dose of 500 $mg \cdot kg^{-1}$ bw was lethal to sheep (Hapke 1968). Palmer and Radeleff (1972) showed that repeated but smaller doses of simazine were also fatal to sheep; 50 $mg \cdot kg^{-1}$ was fatal after 31 doses, 100 $mg \cdot kg^{-1}$ after 14 doses, and 400 $mg \cdot kg^{-1}$ after 9 doses. A short-term NOEL (10 d) for sheep was 25 $mg \cdot kg^{-1}$ per day (USDA 1984). A feed concentration of 20–50 $mg \cdot kg^{-1}$ per day for 6–10 d caused a 5–21% weight loss in cattle, while a dose of 100 $mg \cdot kg^{-1}$ per day for 7 d caused noticeable morbidity. The short-term NOEL for a 10-d feeding study in cattle was 10 $mg \cdot kg^{-1}$ per day (USDA 1984).

Simazine appears to have low chronic toxicity to birds and mammals (NAS 1977). Chronic toxicity data from a 2-year feeding study with dogs produced a NOEL of 5 mg $\cdot kg^{-1}$ bw per day (WHO 1988). The lowest LOAEL reported by the USEPA (1987) was 1.4 $mg \cdot kg^{-1}$ per day for a study concerned with the histological changes in the organs of sheep following exposures to simazine for up to 22 weeks.

The World Health Organization reported that simazine appears to be devoid of significant mutagenic or genotoxic activity, however, the International Agency for Research on Cancer has not yet evaluated simazine as the information is apparently inadequate for a full evaluation (WHO 1988).

A three-generation reproduction study with rats fed 100 $mg \cdot kg^{-1}$ for 93 weeks produced a NOEL >100 $mg \cdot kg^{-1}$ for reproductive performance (USEPA 1988).

No data are available concerning the chronic toxicity of simazine to livestock; the USDA (1984) provided a 10-d NOEL for cattle of 10 $mg \cdot kg^{-1}$ per day. In the absence of sufficient information, the procedure recommended in the protocol (CCME 1993) of adopting the guideline value for human drinking water supplies (10 $\mu g \cdot L^{-1}$) (Health and Welfare Canada 1989; republished without change in Health Canada 1996) is followed to develop an interim Canadian water quality guideline for livestock water. This results in an interim guideline for simazine of 10 $\mu g \cdot L^{-1}$ for the protection of livestock (CCME 1991; adoption updated 1998).

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