Canadian Water Quality Guidelines for the Protection of Aquatic Life

DIISOPROPANOLAMINE

This fact sheet provides Canadian water quality guidelines for Diisopropanolamine (DIPA) for the protection of freshwater aquatic life (Table 1). Insufficient data were available to derive a guideline for marine aquatic life. A scientific supporting document is also available (Environment Canada 2005).

Background Information

DIPA ($C_6H_{15}NO_2$; CAS 110-97-4) is used in a number of commercial, industrial, and household applications. It is known under a variety of synonyms, including bis(2-hydroxypropyl)amine, 1,1'-iminobis(2-propanol) and 1,1'-iminodipropan-2-ol. It has a molecular weight of 133.19 $g{\cdot}mol^{-1}$, a density of 0.989 $g{\cdot}cm^{-3}$ at 25°C, an aqueous solubility of 870,000 $mg{\cdot}L^{-1}$ at 25°C, a mean K_d in aquifer materials of 2.2 $L{\cdot}kg^{-1}$, a vapour pressure at 42°C of 2.7×10^{-3} kPa, and a Henry's law constant of 1.72×10^{-7} $atm{\cdot}m^{-3}{\cdot}mol^{-1}$.

In North America, the Dow Chemical Company (Dow) is the dominant DIPA producer. In 1995, the US production was estimated by Dow to be approximately 7,000 tons per year. DIPA is available as commercial grade compound (98% pure, containing a maximum of 0.5% water) and as low freezing grade DIPA containing 10 or 15% water.

DIPA applications include cosmetics and personal care products, gas treating, detergents, metalworking fluids, coatings, corrosion inhibitors, and cement applications. Cosmetic and personal care applications of DIPA include the manufacture of lotions, shampoos, soaps, and cosmetics. DIPA is also used together with sulfolane in the Sulfinol^{TM} process to remove hydrogen sulphide and carbon dioxide from a natural gas stream.

Reports on the presence of anthropogenic DIPA in the environment are limited to data collected at sour gas processing facilities in western Canada (CAPP 1997; Wrubleski and Drury 1997). The maximum measured DIPA concentration in groundwater was 590 $mg{\cdot}L^{-1}$ in a shallow till aquifer (Greene et al. 1999). No studies were found that had detected DIPA as a naturally-occurring compound in the environment.

Environmental Fate and Behaviour

Laboratory studies have shown that the major physical and chemical process that determines the transport and distribution of DIPA in soil and water is cation exchange. DIPA acts as a weak base in soil pore water and other aqueous systems. Its pKa value of 8.9 indicates that DIPA becomes more protonated at pH values less than 8.9 (Kim et al. 1987). Dissolving DIPA in water may increase the pH. The protonated form of DIPA is strongly sorbed to the clay minerals in soil. DIPA has a high aqueous solubility and low volatility. The mobility of DIPA in the subsurface is controlled by its sorption to soil.

Sorption of DIPA by aquifer materials is relatively independent of organic carbon content, but a strong function of cation exchange capacity (Luther et al., 1998). The soil-water distribution coefficient (K_d) for DIPA in equilibrium with pure montmorillonite (16 to 42 $L{\cdot}kg^{-1}$) was much higher than for humus-rich soil (2.0 $L{\cdot}kg^{-1}$). The mean K_d in soils and aquifer materials was 2.2 $L{\cdot}kg^{-1}$. Luther et al. (1998) reported DIPA retardation coefficients of 3.2, 5.3, and 12 for weathered sandstone, weathered shale/sandstone, and clay-rich till, respectively. These values indicate that, particularly in the presence of clay-rich sediments, DIPA migration is significantly retarded relative to groundwater flow velocity.

The biodegradation of DIPA has been investigated in acclimated sewage sludge, refinery wastewater, laboratory microcosm studies using contaminated and uncontaminated aquifer materials, and as part of a natural

Table 1. Water quality guidelines for DIPA for the protection of aquatic life (Environment Canada 2005).

Aquatic Life	Guideline value ($mg{\cdot}L^{-1}$)
Freshwater	1.6[a]
Marine	NRG[b]

[a] Interim guideline.

[b] No recommended guideline.

attenuation study in natural wetlands. Most studies have demonstrated that DIPA biodegrades in aerobic microcosms from a variety of DIPA-contaminated environmental samples. Published DIPA biodegradation rates and lag times are highly variable. Biodegradation rates range from 0 to 70 mg·L^{-1}·day^{-1}. Lag times range from <1 to 220 days.

Witzaney and Fedorak (1996) reviewed previous work conducted on DIPA biodegradation. The review showed that some studies provided evidence of DIPA degradation (Bridié et al. 1979; Chong 1994), whereas results of Rothkopf and Bartha (1984) suggested that DIPA did not support microbial growth. Gieg et al. (1998) conducted nutrient-amended aerobic and anaerobic microcosm studies at 8° and 28°C using a variety of materials from contaminated and uncontaminated aquifers. Under aerobic conditions at 28°C, DIPA was completely removed. DIPA removal was significantly slower at 8°C and complete DIPA removal was not achieved. Under anaerobic conditions, DIPA biodegradation was confirmed to occur at 28°C under NO_3^-, Mn^{4+}, and Fe^{3+} reducing conditions. At 8°C, evidence of anaerobic degradation under NO_3^-, Mn^{4+}, and Fe^{3+} reducing conditions was observed in a limited number of microcosms.

Uptake of DIPA by wetland vegetation was studied as part of a research program to evaluate natural attenuation processes in contaminated wetands (CAPP 1998, 1999, 2000). Roots, stems, leaves, flower heads, seed heads, and berries of cattail, dogwood, sedge, marsh reed grass, cow parsnip, and smooth brome growing in a DIPA-impacted wetland were included in the study (CAPP 1999, 2000; Headley et al. 1999a,b). Analytical results indicated highly variable DIPA concentrations for different parts of the same species (e.g., roots versus leaves), between different plant species (e.g., cattail leaves versus sedge leaves), and even between different samples of the same part of the same species. Although the maximum measured DIPA concentration in water in the wetland was only 13 mg·L^{-1}, DIPA concentration as high as 208 mg·kg^{-1} were measured in the plants.

Water Quality Guideline Derivation

Freshwater Life

The Canadian water quality guideline for DIPA for the protection of freshwater aquatic life was developed using the CCME protocol (CCME 1991).

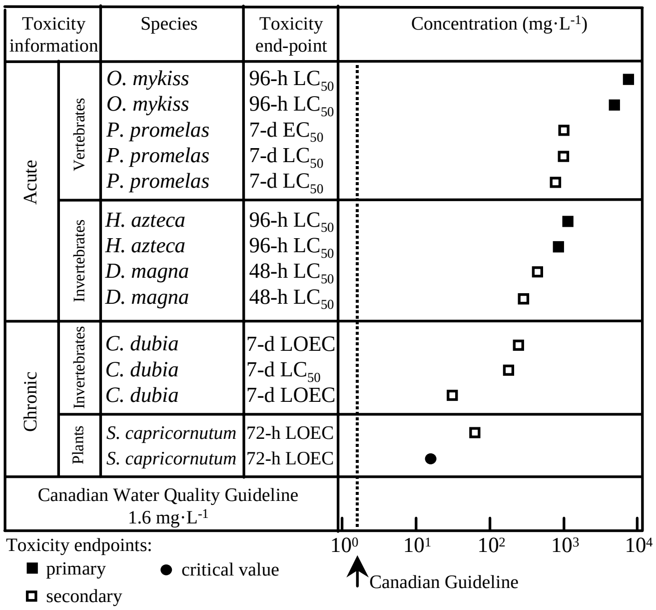

Figure 1. Select freshwater toxicity data for DIPA.

Available data on the toxicity of DIPA to freshwater biota were screened for data quality based on the CCME (1991) protocol. Primary and secondary data are summarized in Figure 1 and are the only data considered in the following discussion. Sufficient data were available to meet the requirements for interim guideline development. Estimates of the acute toxicity of DIPA to freshwater fish and invertebrates range from 788 – 7,698 mg·L^{-1} and 289 – 1,128 mg·L^{-1}, respectively.

No chronic studies were available for freshwater fish. Chronic results for invertebrates include a 7-day LOEC for *Ceriodaphnia dubia* reproduction of 31 mg·L^{-1}, and a 7-day LOEC for *Ceriodaphnia dubia* survival of 250 mg·L^{-1} (ERAC 1998). Chronic results for algae include a 72-hour LOEC for *Selenastrum capricornutum* growth of 16 mg·L^{-1}.

The interim DIPA water quality guideline for the protection of freshwater life is 1.6 mg·L^{-1}. It was derived by multiplying the 72-h LOEC for *Selenastrum capricornutum* growth of 16 mg·L^{-1} (the lowest chronic LOEC for the most sensitive species studied) by a safety factor of 0.1 (CCME 1991).

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