Canadian Water Quality Guidelines for the Protection of Aquatic Life

ANILINE

Aniline (C_6H_7N) has been mainly used in Canada to manufacture chemicals such as mercaptobenzothiazole (MBT), 2-mercaptobenzothiazyl disulphate (MBTS), and zinc 2-mercaptobenzothiazole used in the production of rubber (CIS 1990). Aniline has also been used as a hardener in industrial epoxies and as a corrosion inhibitor (OMOE 1980). Aniline has a CAS name and number of benzeneamine and 62-53-3, respectively, and is highly soluble in water (35 $g \cdot L^{-1}$) (Merck Index 1983). Aniline is not produced in Canada, and domestic use has declined from 1300 t in 1983 to 28 t in 1990 (CIS 1990; Statistics Canada 1990). In 1991, however, use in Canada increased to 107 t (Maguire and Bobra 1992).

Aniline occurs naturally in minute quantities in coal tars. Most of the aniline found in the environment, however, has resulted from wastewater effluents and atmospheric emissions from industries associated with its use or production. Aniline may enter soil environments during spills, underground coal gasification, or through leachate from industrial landfill sites (Stuermer et al. 1982; Howard 1989). Aniline is a breakdown product of pesticides that contain nitroaromatic compounds and may be found in soil and water associated with the use of these pesticides (Lu and Metcalf 1975; El-Dib and Aly 1976; Hallas and Alexander 1983).

The only reported detections of aniline in Canadian surface waters were found near a former industrial site. Concentrations ranged from 41 to 300 $mg \cdot L^{-1}$ at the site (Lesage et al. 1990) and concentrations of up to 8% were also found in the dense nonaqueous phase liquid beneath the former waste-holding lagoon (CH_2M Hill Engineering 1991).

Aniline biodegrades and photodegrades extensively, and, to some extent, adsorbs to sediment and humic material (Howard 1989). Microbial degradation was found to be the most significant removal process after studying the effects of hydrolysis, ionization, photolysis, volatilization, partitioning, and microbial degradation on aniline (Sanders 1979). The half-life for combined photolysis and biodegradation in an estuary was reported to be 27 h (Hwang et al. 1987). Hwang et al. (1987) concluded that photolysis was a more effective process only in the surface waters.

The Henry's law constant of $1.9 \cdot 10^{-6}$ $atm \cdot m^{-3} \cdot mol^{-1}$ (USEPA 1985) and vapour pressure of 40 Pa (Verschueren 1983) suggests volatilization of aniline is very slow. Lyons et al. (1984) reported that volatilization accounted for only 0.002% of aniline removal per day from pond water. In the atmosphere, aniline will degrade primarily by direct photolysis (half-life of 2.1 d) or by reaction with photochemically produced hydroxy radicals (half-life of 3.3 h) (Howard 1989). Oxidation is not expected to be a significant removal process (Filby and Güsten 1978).

The relatively low log octanol–water partition coefficient for aniline (log K_{ow} = 0.90) suggests that it does not have a high bioaccumulation potential (Kenaga 1980). Calculated BCF values for fish are <10; therefore, aniline is unlikely to bioconcentrate in aquatic organisms (Freitag et al. 1982; Isnard and Lambert 1988).

Water Quality Guideline Derivation

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

Freshwater Life

Acute toxicity (96-h LC_{50}) values for fish range from 10.6 $mg \cdot L^{-1}$ for rainbow trout *(Oncorhynchus mykiss)* (Abram and Sims 1982) to 187 $mg \cdot L^{-1}$ for goldfish *(Carassius auratus)* (Holcombe et al. 1987). The 7-d LC_{50} estimate for juvenile rainbow trout was 8.2 $mg \cdot L^{-1}$ (Abram and Sims 1982). Acute toxicity (48-h LC_{50}) values for invertebrates ranged from 0.10 $mg \cdot L^{-1}$ for *Daphnia pulex*

Table 1. Water quality guidelines for aniline for the protection of aquatic life (CCME 1993).

Aquatic life	Guideline value ($\mu g \cdot L^{-1}$)
Freshwater	2.2
Marine	NRG*

*No recommended guideline.

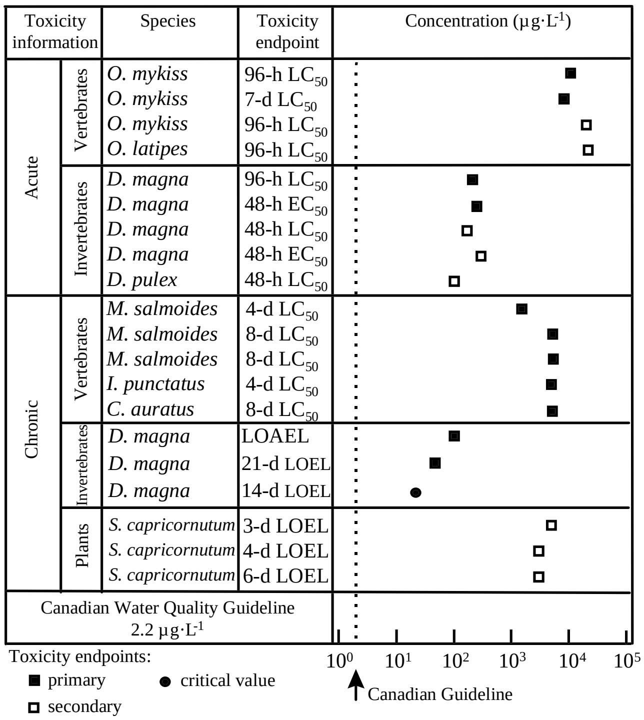

Figure 1. Select freshwater toxicity data for aniline.

(Canton and Adema 1978) to 800 mg·L^{-1} for the snail (*Lymnaea stagnalis)* (Slooff et al. 1983).

Chronic toxicity (LC_{50}) values, for fish eggs at hatching, were 5.5 (4.5 d), 9.3 (4.0 d), and 32.7 mg·L^{-1} (3.5 d) for catfish, goldfish, and bass, respectively (Birge et al. 1979). When the exposure time was extended to 4 d posthatch, the LC_{50}s were 5.0, 5.5, and 11.8 mg·L^{-1} for catfish, goldfish, and bass, respectively. At 8 d posthatch exposure, the LC_{50}s were 5.1 and 5.4 mg·L^{-1} for the goldfish and the bass, respectively. A 28-d LC_{50} of 39 mg·L^{-1} was found for the zebra fish *(Brachydanion rerio)* (van Leeuwen et al. 1990).

In chronic toxicity data available for *Daphnia magna*, the 14-d LOEC was found to be 21.8 µg·L^{-1} (Gersich and Milazzo 1990). Toxicity estimates for algae range from an 8-d toxic threshold of 0.16 mg·L^{-1} for the blue-green alga *Anacystis aeruginosa* (Bringmann and Kühn 1978) to a 12 to 13-d inhibiting effect on growth of 183.9 mg·L^{-1} for the green alga *Chlorella vulgaris* (Ammann and Terry 1985).

The water quality guideline for aniline for the protection of freshwater life (2.2 µg·L^{-1}) was derived by multiplying the LOEC of 21.8 µg·L^{-1} (Gersich and Milazzo 1990) for the most sensitive organism to aniline, the water flea *(D. magna)*, by a safety factor of 0.1 (CCME 1993).

References

Abram, F.S.H., and I.R. Sims. 1982. The toxicity of aniline to rainbow trout. Water Res. 16:1309–1312.

Ammann, H.M., and B. Terry. 1985. Effect of aniline on *Chlorella vulgaris.* Bull. Environ. Contam. Toxicol. 35(2):234–239.

Birge, W.J., J.A. Black, J.E. Hudson, and D.M. Bruser. 1979. Embryo-larval toxicity tests with organic compounds. In: Aquatic toxicology, L.L. Marking and R.A. Kimerle, eds. Proc. 2d Ann. Symp. Aquat. Toxicol., ASTM Special Tech. Publ. 667, pp. 131–147, Philadelphia.

Bringmann, G. and R. Kühn. 1978. Testing of substances for their toxicity threshold: Model organisms *Microcystis (Diplocystis) aeruginosa* and *Scenedesmus quadricauda*. Mitt. Int. Ver. Limnol. 21:275–284.

Canton, J.H. and D.M.M. Adema. 1978. Reproducibility of short-term and reproduction toxicity experiments with *Daphnia magna* and comparison of the sensitivity of *Daphnia magna* with *Daphnia pulex* and *Daphnia cucullata* in short-term experiments. Hydrobiologia 59(2):135–140.

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.]

———. 1993. Appendix XIII—Canadian water quality guidelines: Updates (October 1993), aniline, 3,5-dimethylaniline, and tetrachloroethylene. In: Canadian water quality guidelines, Canadian Council of Resource and Environment Ministers. 1987. Prepared by the Task Force on Water Quality Guidelines.

CH_2M Hill Engineering. 1991. Research and development of permanent onsite solutions for contamination of groundwater at waste disposal and industrial sites in Canada. Final report. Prepared for Supply and Services Canada. CH_2M Hill Engineering, Guelph, ON.

CIS (Camford Information Services). 1990. CPI product profiles: Aniline. CIS, Don Mills, ON.

El-Dib, M.A., and O.A. Aly. 1976. Persistence of some phenylamide pesticides in the aquatic environment. III. Biological degradation. Water Res. 10:1055–1059.

Filby, W.G., and H. Güsten. 1978. Rate constants for the reaction of oxygen atoms with some potential photosmog inhibitors. Atmos. Environ. 12:1563–1565.

Freitag, D., H. Geyer, A. Kraus, R. Viswanathan, D. Kotzias, A. Attar, W. Klein, and F. Korte. 1982. Ecotoxicological profile analysis. VII. Screening chemicals for their environmental behaviour by comparative evaluation. Ecotoxicol. Environ. Saf. 6:60–81.

Gersich, F.M. and D.P. Milazzo. 1990. Evaluation of a 14-day static renewal toxicity test with *Daphnia magna* Straus. Arch. Environ. Contam. Toxicol. 19:72–76.

Hallas, L.E. and M. Alexander. 1983. Microbial transformation of nitroaromatic compounds in sewage effluent. Appl. Environ. Microbiol. 45(4):1234–1241.

Holcombe, G.W., G.L. Phipps, A.H. Sulaiman, and A.D. Hoffman. 1987. Simultaneous multiple species testing: acute toxicity of 13 chemicals to 12 diverse freshwater amphibian, fish, and invertebrate families. Arch. Environ. Contam. Toxicol. 16:697–710.

Howard, P.H. 1989. Handbook of environmental fate and exposure data for organic chemicals. Vol. I. Large production and priority pollutants. Lewis Publishing, Chelsea, MI.

Hwang, H.M., R.E. Hodson, and R.F. Lee. 1987. Degradation of aniline and chloroanilines by sunlight and microbes in estuarine water. Water Res. 21(3):309–316.

Isnard, P., and S. Lambert. 1988. Estimating bioconcentration factors from octanol–water partition coefficient and aqueous solubility. Chemosphere 17:21–34.

Kenaga, E.E. 1980. Predicted bioconcentration factors and soil sorption coefficients of pesticides and other chemicals. Ecotoxicol. Environ. Saf. 4:26–38.

Lesage, S., J.K. Ritch, and E.J. Treciokas. 1990. Characterization of groundwater contaminants at Elmira, Ontario, by thermal desorption, solvent extraction GC-MS and HPLC. Water Pollut. Res. J. Can. 25(3):275–292.

Lu, P.Y., and R.L. Metcalf. 1975. Environmental fate and biodegradability of benzene derivatives as studied in a model aquatic ecosystem. Environ. Health Perspect. 10:269–284.

Lyons, C.D., S.E. Katz, and R. Bartha. 1984. Mechanisms and pathways of aniline elimination from aquatic environments. Appl. Environ. Microbiol. 48(3):491–496.

Maguire, R.J. 1991. Environmental chemistry of the four aromatic amines to be assessed under the Canadian Environmental Protection Act: Aniline, 3,5-dimethylaniline, benzidine, and 3,3-dichlorobenzidine. National Water Research Institute, Canadian Centre for Inland Waters, Burlington, ON.

Maguire, R.J., and A. Bobora. 1992. Supporting document—Environmental section: Canadian Environmental Protection Act assessment of aniline, 3,5-dimethylaniline, benzidine and 3,3'-dichlorobenzidine. National Water Research Institute, Canadian Centre for Inland Waters, Burlington, ON.

Merck Index: An encyclopedia of chemicals, drugs, and biologicals. 1983. 10th ed. Merck and Company, Inc., Rahway, NJ.

OMOE (Ontario Ministry of the Environment). 1980. Environmental aspects of selected aromatic amines and azo dyes in Ontario. Report No. ARB-TDA-83-79. Toronto. (Cited in Maguire 1991.)

Sanders, W.M., III. 1979. Exposure assessment: A key issue in aquatic toxicology. In: Aquatic toxicology, L.L. Marking and R.A. Kimerle, eds., Proc. 2d. Ann. Symp. Aquat. Toxicol, ASTM Special Tech. Publ. 667, pp. 271–283, Philadelphia.

Slooff, W., J.H. Canton, and J.L.M. Hermens. 1983. Comparison of the susceptibility of 22 freshwater species to 15 chemical compounds. I. (Sub)acute toxicity tests. Aquat. Toxicol. 4:113–128.

Statistics Canada. 1990. Import data for 1989: International Trade Division. Ottawa. (Cited in Magure 1991.)

Stuermer, D.H., D.J. Ng, and C.J. Morris. 1982. Organic contaminants in groundwater near an underground coal gasification site in northeastern Wyoming. Environ. Sci. Technol. 16:582–587.

USEPA (U.S. Environmental Protection Agency). 1985. Health and environmental effects profile for aniline. USEPA, Cincinnati, OH.

van Leeuwen, C.J., D.M.M. Adema, and J. Hermens. 1990. Quantitative structure–activity relationships for fish early life stage toxicity. Aquat. Toxicol. 16:321–334.

Verschueren, K. 1983. Handbook of environmental data on organic chemicals. 2d ed. Van Nostrand Reinhold Co., Toronto.

Reference listing:

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

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