



This fact sheet provides Canadian water quality guidelines for sulfolane for the protection of agricultural water uses (Table 1). A scientific supporting document is also available (Environment Canada 2005).

### Background Information

Sulfolane ( $C_4H_8SO_2$ ; CAS 126-33-0) is a solvent used for gas treating in a variety of industrial processes. It is known under a variety of synonyms and trade names including bondelane A, 2,3,4,5-tetrahydrothiophene-1,1-dioxide, and tetramethylene sulfone. It has a molecular weight of  $120.17 \text{ g}\cdot\text{mol}^{-1}$ , a density of  $1.276 \text{ g}\cdot\text{cm}^{-3}$  at  $15^\circ\text{C}$ , an aqueous solubility of  $1,266,000 \text{ mg}\cdot\text{L}^{-1}$  at  $20^\circ\text{C}$ , a  $\log K_{oc}$  of 0.07, a mean  $K_d$  in aquifer materials of  $0.08 \text{ L}\cdot\text{kg}^{-1}$ , a vapour pressure at  $20^\circ\text{C}$  of  $1.33 \times 10^{-3} \text{ kPa}$ , and a Henry's law constant of  $8.9 \times 10^{-10} \text{ atm}\cdot\text{m}^{-3}\cdot\text{mol}^{-1}$ .

The total worldwide production of sulfolane is estimated at between 18,000 and 36,000 tons per year. Commercially, sulfolane is available as anhydrous sulfolane and as sulfolane containing 3% deionized water.

Sulfolane is widely used for gas treatment processes including: sour gas sweetening, hydrogen selenide removal from gasification of coal, shale, or tarsands; olefin removal from alkanes; nitrogen, helium, and argon removal from natural gas; atmospheric  $\text{CO}_2$  removal in nuclear submarines; ammonia and  $\text{H}_2\text{S}$  removal from waste streams; and  $\text{H}_2\text{S}$ , hydrogen chloride (HCl), nitrous oxide ( $\text{N}_2\text{O}$ ), and  $\text{CO}_2$  removal from various streams. In addition to gas treatment, sulfolane is also used as a polymer solvent, polymer plasticizer, polymerization solvent, and in electronic/electrical applications (Kirk-Othmer 1999).

Reports on the presence of anthropogenic sulfolane in the environment are limited to data collected in the vicinity of sour gas processing facilities in Western Canada (CAPP 1997; Wrubleski and Drury 1997). The maximum measured sulfolane concentrations in groundwater were  $800 \text{ mg}\cdot\text{L}^{-1}$  in shallow till and  $88 \text{ mg}\cdot\text{L}^{-1}$  in bedrock. The only report of sulfolane occurring naturally in the environment was in a composite sample of a sponge (*Batzella*) and tunicate (*Lissoclinum*) which contained approximately  $50 \text{ mg}\cdot\text{kg}^{-1}$  (dry-weight) $^{-1}$  sulfolane (Barrow and Capon 1992).

### Environmental Fate and Behaviour

Laboratory studies indicate that the major physical and chemical processes that determine the transport and distribution of sulfolane in soil and water are adsorption and leaching. Sulfolane is poorly adsorbed to soil and has a high aqueous solubility and low volatility. Sulfolane is highly mobile in the subsurface.

Sorption of sulfolane to soil particles is low with sulfolane partitioning preferentially into porewater (Luther et al. 1998). The high aqueous solubility of sulfolane, in combination with the low  $K_{oc}$  and  $K_d$ , provides the potential for high concentrations of sulfolane to be present in soil porewater. Volatilisation of sulfolane is minimal due to the low Henry's law constant.

Biodegradation of sulfolane has been investigated in an activated sludge system, in wastewater treatment, in laboratory microcosm studies using contaminated aquifer sediments, and as part of a natural attenuation study in natural wetlands. Most studies have demonstrated that sulfolane biodegrades in nutrient-enriched aerobic microcosms from a variety of sulfolane-contaminated environmental samples (Fedorak and Coy 1996). Published sulfolane biodegradation rates and lag times are highly variable. Data from microcosm and field studies indicate that under typical groundwater conditions (aerobic or anaerobic, but very low in nutrients, particularly phosphate), sulfolane degradation may be very slow or non-existent. However, under conditions typical of surface water (aerobic, sufficient nutrients) it has been shown that sulfolane degradation can be relatively rapid, with complete removal occurring after 5 to 11 weeks (Environment Canada 2005).

**Table 1. Water quality guidelines for sulfolane for the protection of agricultural water uses (Environment Canada 2005).**

Use	Guideline value ( $\text{mg}\cdot\text{L}^{-1}$ )
Irrigation water	0.5 <sup>a</sup>
Livestock water	NRG <sup>b</sup>

<sup>a</sup>Interim guideline.

<sup>b</sup>No recommended guideline.

Uptake of sulfolane by wetland vegetation was studied as part of a research program to evaluate natural attenuation processes in contaminated wetlands (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 sulfolane-impacted wetland were included in the study (CAPP 1999, 2000; Headley et al. 1999a,b). Analytical results indicated highly variable sulfolane 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. The maximum measured sulfolane concentration in water within the wetland was  $185 \text{ mg}\cdot\text{L}^{-1}$ , and concentrations measured in the plants were as high as  $256 \text{ mg}\cdot\text{kg}^{-1}$ .

### Water Quality Guideline Derivation

The interim Canadian water quality guideline for sulfolane for irrigation water was developed based on the CCME protocol (CCME 1999).

### Irrigation Water

The Canadian water quality guideline for sulfolane for irrigation was developed according to the CCME protocol (CCME 1999). Irrigation guidelines were calculated for: (1) cereals, tame hays, and pasture crops; and (2) other crops.

Data for two hay/pasture crop species, alfalfa (*Medicago sativa*) and timothy (*Phleum pratense*), and two other crop species, lettuce (*Lactuca sativa*) and carrot (*Daucus carota*), were available for four soil types – loam, artificial soil, till, and sandy soil (CAPP 2001). Endpoints measured included emergence, root elongation, shoot elongation, and increase in biomass. The data were classified as primary toxicological data. The toxicological data set was sufficient to derive interim guidelines. LOECs, corrected for analytical concentration, ranged from  $47 \text{ mg}\cdot\text{kg}^{-1}$  for reduced emergence of lettuce in artificial soil to  $14,000 \text{ mg}\cdot\text{kg}^{-1}$  for reduced emergence of alfalfa in loam.

A species maximum acceptable toxicant concentration (SMATC) was calculated for the most sensitive species/endpoint/soil combination for: (1) cereals, tame hays, and pasture crops; and (2) other crops. The species/endpoint/soil combination resulting in the lowest SMATC was root elongation in lettuce grown in till. The acceptable soil concentration (ASC), which is an estimate of the soil concentration that would not result in adverse effects on crops over the course of one growing season,

was calculated for this species as the geometric mean of the NOEC ( $23 \text{ mg}\cdot\text{kg}^{-1}$ ) and the LOEC ( $47 \text{ mg}\cdot\text{kg}^{-1}$ ) divided by a safety factor of 10. The ASC for lettuce was  $3 \text{ mg}\cdot\text{kg}^{-1}$ . The SMATC was calculated by multiplying the ASC for lettuce ( $3 \text{ mg}\cdot\text{kg}^{-1}$ ) by the soil bulk density ( $1,300 \text{ kg}\cdot\text{m}^{-3}$ ) and the soil bulk volume of a hectare to a depth of 0.15 m ( $100 \text{ m} \times 100 \text{ m} \times 0.15 \text{ m}$ ), and dividing by the irrigation rate ( $1.2 \times 10^7 \text{ L}\cdot\text{ha}^{-1}\cdot\text{yr}^{-1}$ ) to give an SMATC of  $0.5 \text{ mg}\cdot\text{L}^{-1}$ . The SMATC for lettuce, being the lowest of all species, was adopted as the interim water quality guideline for irrigation.

### References

- Barrow, R.A., and R.J. Capon. 1992. Sulfolane as a natural product from the sponge/tunicate composite, *Batzella* sp./*Lissoclinum* sp. *J. Nat. Prod.* 55:1330-1331.
- CAPP (Canadian Association of Petroleum Producers). 1997. Evaluation of the fate of sulfolane and DIPA in the subsurface at sour gas processing plant sites. Report prepared by the Departments of Biological Sciences and Renewable Resources, University of Alberta, CAPP Pub#1997-0004.
- . 1998. 1997 investigation of hydrocarbon attenuation in natural wetlands, Vol. I and II. Unpublished report prepared by Komex International Ltd., File No. K197-4545.
- . 1999. 1998 investigation of hydrocarbon attenuation in natural wetlands, Vol. I and II. Unpublished report prepared by Komex International Ltd., File No. K198-4545H.
- . 2000. 1999 investigation of hydrocarbon attenuation in natural wetlands, Vol. I and II. Unpublished report prepared by Komex International Ltd., File No. C45450105.
- . 2001. Soil and water quality guidelines for sulfolane and diisopropanolamine (DIPA): environmental and human health. Report prepared by Komex International Limited for the Canadian Association of Petroleum Producers.
- CCME (Canadian Council of Ministers of the Environment). 1999. Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg.
- Environment Canada. 2005. Canadian Environmental Quality Guidelines for Sulfolane (Water and Soil). Scientific Supporting Document. Ecosystem Health: Science-based Solution Report No. 1-12. National Guidelines and Standards Office, Environment Canada, Ottawa. (in press)
- Fedorak, P.M., and D.L. Coy. 1996. Biodegradation of sulfolane in soil and groundwater samples from a sour gas plant. *Environ. Technol.* 17:1093-1102.
- Headley, J.V., K.M. Peru, and L.C. Dickson. 1999a. Gas chromatographic-mass spectrometric determination of sulfolane in wetland vegetation exposed to sour gas-contaminated groundwater. *J. Chromatogr.* 859: 69-75.
- . 1999b. Ion-exchange electrospray ionization liquid chromatography mass spectrometry and tandem mass spectrometry of alkanolamines in wetland vegetation exposed to sour-gas contaminated groundwater. *Rapid Commun. Mass Spectrom.* 13: 730-736.
- Kirk-Othmer. 1999. Encyclopedia of chemical technology. Fourth Edition, 1999. John Wiley & Sons.
- Luther, S.M., M.J. Dudas, and P.M. Fedorak. 1998. Sorption of sulfolane and diisopropanolamine by soils, clays and aquifer materials. *J. Contam. Hydrol.* 32:159-176.
- Wrubleski, R.M., and C.R. Drury. 1997. Chemical contamination of groundwater at gas processing plants the problem. Twenty-third annual aquatic toxicity workshop, Calgary, Alberta, Canada, October 7-9, 1996. *Can. Tech. Rep. Fish. Aquat. Sci.* 0:3-4.

## Reference listing:

Canadian Council of Ministers of the Environment. 2005. Canadian water quality guidelines for the protection of agricultural water uses: Sulfolane. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

## For further scientific information, contact:

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

## For additional copies, contact:

CCME Documents  
Toll-Free: 1-800-805-3025  
[www.ccme.ca](http://www.ccme.ca)

©Canadian Council of Ministers of the Environment 2005  
Excerpt from Publication No. 1299; ISBN 1-896997-34-1

Aussi disponible en français.