Water Quality

Ambient Water Quality Guidelines for Sulfolane

Overview Report

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Summary

This document is one in a series which establishes ambient water quality guidelines for British Columbia. It is based on a technical report prepared for the Canadian Association of Petroleum Producers by Komex International Limited of Calgary. The guidelines (Table 1) are safe conditions or levels which have province-wide application and are set to protect various water uses. This report sets guidelines for sulfolane to protect freshwater aquatic life and agricultural water uses such as irrigation water and livestock watering. Guidelines for drinking water, recreational water, and industrial water uses were not recommended.

A major use of the guidelines is to set ambient water quality objectives. The objectives are the guidelines modified or adopted to protect the most sensitive designated water use in a particular body of water. The objectives are used in the preparation of waste management plans, pollution prevention plans, waste management permits, orders, or approvals. The latter three are the only documents that have legal status. The guidelines are also used in contaminated site remediation.

Table 1. Summary of Recommended Guidelines for Sulfolane. All guidelines are maximum values.

Water Use	Guideline (mg Sulfolane/L)
Freshwater Aquatic Life	50 mg/L
Marine Aquatic Life	Insufficient Data
Irrigation	8.4 mg/L
Livestock Watering	14 mg/L

Top

Preface

The ministry of Water, Land and Air Protection develops province-wide ambient water quality guidelines for variables that are important in the surface waters of British Columbia. This work has the following goals:

1. to provide guidelines for the evaluation of data on water, sediment, and biota
2. to provide guidelines for the establishment of site-specific ambient water quality objectives

Ambient water quality objectives for specific waterbodies are based on the guidelines and also consider present and future uses, waste discharges, hydrology/limnology/oceanography, and existing background water quality. The process for establishing water quality objectives is more fully outlined in *Principles for*

Preparing Water Quality Objectives in British Columbia, copies of which are available from Water Quality Section of the Water Management Branch.

Neither guidelines nor objectives which are derived from them have any legal standing. The objectives, however, can be used to calculate allowable limits or levels for contaminants in waste discharges. These limits are set out in waste management permits and thus have legal standing. The objectives are not usually incorporated as conditions of the permit.

The definition adopted for a guideline is 'a maximum and/or a minimum value for a physical or biological characteristic of water, sediment or biota, which should not be exceeded to prevent specified detrimental effects from occurring to a water use under specified environmental conditions.

The guidelines are province-wide in application, are use-specific, and are developed for some or all of the following specific water uses:

- Source water for drinking, public water supply, and food processing1;
- Aquatic life and wildlife;
- Agriculture (livestock watering and irrigation);
- Recreation and aesthetics2; and
- Industrial (water supplies).

The guidelines are set after considering the scientific literature, guidelines from other jurisdictions, and general conditions in British Columbia. The scientific literature gives information on the effects of toxicants on various life forms. This information is not always conclusive because it is usually based on laboratory work which, at best, only approximates actual field conditions. To compensate for this uncertainty, guidelines have built-in safety factors which are conservative but reflect natural background conditions in the province.

The site-specific water quality objectives are, in most cases, the same as guidelines. However, in some cases, such as when natural background levels exceed the guidelines, the objectives could be less stringent than the guidelines. In relatively rare instances, for example if the resource is unusually valuable or of special provincial significance, the safety factor could be increased by using objectives which are more stringent than the guidelines. Another approach in such special cases is to develop site-specific guidelines by carrying out toxicity experiments in the field. This approach is costly and time-consuming and therefore seldom used.

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[1]The guidelines apply to an ambient raw water source before it is diverted or treated for domestic use. The Ministry of Health Services regulates the quality of water for domestic use after it is treated and delivered by a water purveyor.

[2]Guidelines relating to public health at bathing beaches will be the same as those developed by the Ministry of Health Services,

which regulates the recreation and aesthetic water uses.

Guidelines are subject to review and revision as new information becomes available, or as other circumstances dictate.

· Top

Introduction

Sulfolane is an organic chemical used for a wide variety of industrial applications. Sulfolane has traditionally been used during aromatic extraction and removal of acid gases from the natural gas stream during gas processing. Additional applications of sulfolane include its use as a solvent in plasticizing, electronic/electrical, and textile industries.

Sulfolane is a colourless, highly polar, water-soluble compound with exceptional chemical and thermal stability, and unusual solvent properties. Due to the low potential for sulfolane to sorb to sediments or soils and retardation coefficients in aquifer sediments that indicate sulfolane will migrate at a similar velocity to groundwater flow, sulfolane is predicted to be highly mobile in the subsurface. Biodegradation under typical aquifer conditions may be insignificant; however, biodegradation rates may be increased by the addition of phosphorous and/or nitrogen to aerobic systems and previous exposure of the microbial degrader community to sulfolane.

An extensive literature search was conducted to identify toxicity data for sulfolane to humans, mammals, freshwater and marine aquatic life, terrestrial plants, and other organisms.

For freshwater aquatic life, toxicological data were identified for vertebrates (rainbow trout (*Oncorhynchus mykiss*), fathead minnow (*Pimephales promelas*), goldfish (*Carassius auratus*), mosquito fish (*Gambusia sp*.), and stickleback); invertebrates (water fleas (*Daphnia magna* and *Ceriodaphnia dubia*) and a sideswimmer (*Hyalella azteca*)); plants (green algae (*Selenastrum capricornutum*) and duckweed (*Lemna minor*)); and other freshwater aquatic organisms (cyanobacterium (*Aphanizomenon flos-aquae*) and diatom (*Cyclotella meneghiana*)). Of the acceptable data, the lowest chronic LOEC reported was 500 mg/L for the 7 day reproduction endpoint for *Ceriodaphnia dubia*.

For marine aquatic life, toxicological data were identified for invertebrates (copepod (*Acartia tonsa*), oyster (*Crassostrea gigas*), and mysid shrimp (*Mysidopsis bahia*) and the marine bacterium (*Vibrio fischerii*). The lowest EC50 of the acceptable data in the acute marine dataset was 52 mg/L for *Acartia tonsa* immobilization.

For terrestrial plants, toxicological data were identified for four species (lettuce (*Lactuca sativa*), carrot (*Daucus carota*), alfalfa (*Medicago sativa*), and timothy (*Phleum pratense*)). The lowest effect in the terrestrial plant dataset was 440 mg/kg for a root elongation LOEC in alfalfa grown in till.

Toxicological data were identified for mammalian laboratory animals, but not for livestock species or birds. Data were available for the rat, mouse, guinea pig, and rabbit. Four acute and three subchronic/chronic data studies were available. LD_{50} (oral administration to guinea pig) to 2,504 mg/kg body weight (oral

administration to white rat). The subchronic/chronic NOAEL from inhaled exposure to sulfolane was reported to be 20 mg/m^3. The subchronic NOAEL from the most applicable study for ingested sulfolane was 2.9 mg/kg bw/day.

Toxicological data for human exposures to sulfolane via drinking water or recreational uses were not available. Hence sulfolane water quality guidelines for these water uses were not proposed in this document.

Top

Recommended Guidelines

The recommended guidelines, summarized in Table 1 and discussed below, are based on a report prepared for Canadian Association of Petroleum Producers by Komex International Limited of Calgary. The guidelines went through the CCME's Water Quality Task Group review process and were posted on the Ministry of Water, Land and Air Protection website for a wider review by stakeholders and the public for a period of six months.

1. DRINKING WATER

Toxicological data were sufficient to develop a guideline for source water used for drinking purposes. Health Canada has not developed a drinking water guideline for sulfolane.

2. FRESHWATER AQUATIC LIFE

It is recommended that the maximum concentration of sulfolane in water should not exceed 50 mg/L to protect freshwater aquatic life.

Rationale

Toxicological data were sufficient to develop an interim guideline that meets Canadian Council of Ministers of the Environment requirements. The recommended guideline (50 mg/L) is based on the application of a 10-fold safety factor to the lowest LOEC in the chronic dataset (500 mg/L for Ceriodaphnia dubia).

3. MARINE AND ESTUARINE LIFE

Toxicological data were not sufficient to meet Canadian Council of Ministers of the Environment and the Ministry of Water, Land and Air Protection requirements for the derivation of a marine guideline. Therefore, a marine life guideline for sulfolane is not available at this time.

4. RECREATION

There were not sufficient data available to develop a guideline for the protection of recreational water uses from sulfolane.

5. IRRIGATION

The maximum concentration of sulfolane in irrigation water should not exceed 8.4 mg/L to protect agricultural crops. The Canadian Council of Ministers of the Environment (CCME) does not have a guideline to protect agricultural crops from adverse effects of sulfolane.

Rationale

Toxicological data were sufficient to develop an interim guideline that meets Canadian Council of Ministers of the Environment requirements. Four guidelines were calculated for two soil types "poor soil" (*e.g.*, sand or till) and loam, and two crop types (tame hay, cereal, and pasture crops and other crops). The overall irrigation guideline is the lowest of these four guidelines (8.4 mg/L). The species maximum acceptable toxicant concentration (SMATC) for cereals, tame hays, and pasture crops was 95 mg/L (loam), and 42 mg/L (poor soil). For other crops the SMATC was 38 mg/L (loam), and 8.4 mg/L (poor soil). These guidelines were based on the acceptable soil concentrations calculated from a 10-fold uncertainty factor and the NOEC and LOEC. The acceptable soil concentrations were: 58 mg/kg for cereals, tame hays, and pasture crops grown in loam, based on the biomass endpoint for timothy; 26 mg/kg for cereals, tame hays, and pasture crops grown in poor soil, based on the root length endpoint for alfalfa in till; 233 mg/kg for other crops grown in loam, based on the root length endpoint for lettuce and carrot; and 51 mg/kg for other crops grown in poor soil, based on the root length endpoint for lettuce in till.

6. LIVESTOCK WATERING

The maximum concentration of sulfolane should not exceed 14 mg/L to protect livestock drinking water supplies. The Canadian Council of Ministers of the Environment (CCME) does not have a guideline to protect livestock from adverse effects of sulfolane in drinking water.

Rationale

Toxicological data were not sufficient to meet Canadian Council of Ministers of the Environment requirements for this water use. However, the quality of the toxicological data was determined to be satisfactory to develop a preliminary guideline. The recommended guideline is based on Canadian Council of Ministers of the Environment protocols with the application of additional safety factors. The tolerable daily intake (TDI) was calculated by applying a 700-fold safety factor to the mean of acute toxicity data for laboratory animals (1,540 mg/kg bw/day). The 700-fold safety factor was based on a factor of 70 to extrapolate from acute to chronic data, and a factor of 10 to extrapolate from rodent and lagomorph data to livestock. The recommended guideline was based on dairy cattle, which have a high water consumption to body weight ratio.

· Top

Application of the Guidelines for Aquatic Life

The water quality guidelines recommended in this document are primarily based on controlled, laboratory bioassays that do not account for factors that may modify the toxicity of sulfolane in the field. These factors should be considered when the guidelines are applied to assess the environmental impacts of sulfolane. There may be situations where sulfolane concentrations in the environment are fluctuating or are continuously renewed (*e.g.*, discharge from an industrial operation). Such environmental conditions may also modify the effects of sulfolane on its surroundings. In these types of situations, a site-specific study should be undertaken and appropriate site-specific water quality objectives developed based on the species present and actual sulfolane persistence and concentrations.

In many cases, water quality objectives will be the same as the guidelines. When concentrations of sulfolane in developed waterbodies are constantly maintained due to a continuous source or an environmental condition that prevents its degradation, then water quality objectives that are more stringent than the recommended guidelines may be justified. In some cases, socio-economic or other factors may justify objectives which are less stringent than the guidelines. Site-specific impact studies would be required in such cases.

Methods (*e.g.*, water effects ratio[3], resident species toxicity in the field, etc.) are available to adapt the recommended guidelines to a given site by considering these factors. Where necessary, these methods can be employed to set site-specific water quality objectives. Because these approaches are costly and time consuming, they are seldom used.

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[3]See BC Ministry of Water, Land and Air Protection publication *Methods for Deriving Site-Specific Water Quality Objectives in British Columbia and Yukon*

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