SCIENCE AND INFORMATION BRANCH

WATER STEWARDSHIP DIVISION

MINISTRY OF ENVIRONMENT

Ambient Aquatic Life Guidelines for Toluene

Overview Report

First Update

Prepared pursuant to Section 5(e) of the

Environmental Management Act 2003

Approved: _October 3, 2007_ ____Fern Schultz_____

Date Director, Science and Information Branch

Water Stewardship Division

Library and Archives Canada Cataloguing in Publication Data

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Ambient aquatic life guidelines for Toluene : overview report, first update [electronic resource]

Available on the Internet.

Report by: Narender K. Nagpal. Cf. p.

This overview is an update to a previous report originally published in 2000 that in turn was based on a technical report prepared for the Canadian Council of Ministers of Environment (CCME) in July 1995. This update assesses the freshwater aquatic life guideline based on more recent information generated by Kennedy at Simon Fraser University and a review by BWP Consulting, both under contract to the B.C. Ministry of Environment. Cf. Summary.

ISBN 978-0-7726-5874-6

1. Toluene – Environmental aspects - British Columbia. 2. Water quality – Standards - British Columbia. 3. Aquatic organisms – Effect of water pollution on - British Columbia. I. British Columbia. Ministry of Environment. Water Stewardship Division. Science and Information Branch. II. Title. III. Title: Water quality guidelines for Toluene.

TD227.B7N33 2007   363.739’46209711   C2007-960224-X

SUMMARY

This document is one in a series that establishes ambient water quality guidelines for British Columbia. It is an update to a previous report originally published in 2000 that in turn was based on a technical report prepared for the Canadian Council of Ministers of Environment (CCME) in July 1995. This update assesses the freshwater aquatic life guideline based on more recent information generated by Kennedy at Simon Fraser University and a review by BWP Consulting, both under contract to the B.C. Ministry of Environment, and makes amendments to suit B.C. conditions. The guidelines are safe conditions or levels that have province-wide application.

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 as a basis for evaluating contaminated sites and determining remediation requirements.

The water quality guideline to protect freshwater aquatic life in British Columbia was recommended to be 0.5 µg/L toluene.

PREFACE

The B.C. Ministry of Environment 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:

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

The definition adopted for a guideline is as follows:

> A maximum and/or a minimum value for a physical, chemical or biological characteristic of water, sediment or biota, which should not be exceeded to prevent specified detrimental effects from occurring to a water use, including aquatic life, 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 processing
- Aquatic life and wildlife
- Agriculture (livestock watering and irrigation)
- Recreation and aesthetics
- 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.

Ambient water quality objectives for specific waterbodies will be 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.

The site-specific water quality objectives are, in many 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 thus setting 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.

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.

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

INTRODUCTION

Toluene is a colourless liquid at room temperature with a gasoline-like aroma. It occurs naturally in coal and crude oil and is found in consumer products such as paints, cosmetics, upholstery, carpet cleaners, cigarette smoke, pesticides and gasoline. In Canada, toluene is used in the production of benzene and as an octane enhancer instead of lead in gasoline refining.

Toluene can enter aquatic environments during production, usage, storage, transportation and spills. Toluene has been detected throughout North America in effluents from municipalities, industries, industrialized river basins, ground water, sediments, soil and water. It is released into the air from burning oil, gas and coal. Physical, biological and chemical processes remove toluene from all media so there is little tendency for it to accumulate in environmental compartments. Toluene can be removed from water by volatilization and biodegradation, but does not tend to hydrolyze or adsorb to sediments. It may leach into ground water if released to land. Toluene is volatile with a half-life of up to two weeks in water. The log octanol-water partition coefficient, Kow, is 2.7.

The CCME considers data produced through primary studies to be more relevant than data from secondary studies. Table 1 lists primary toxicity data (lowest value shown) obtained from the literature that was assessed for this document (along with the recent information generated by the Ministry of Environment in Section 1.1).

The most sensitive freshwater species to toluene was rainbow trout, *Oncorhynchus mykiss*, with a 27-d LC_{50} of 20 µg/L. Coho salmon, *Oncorhynchus kisutch*, exhibited a weight loss after 40-d exposure to 2,800 and 5,000 µg/L of toluene. The leopard frog, *Rana pipiens*, had a 9.5-d LC_{50} of 390 µg/L, while the salamander, *Ambystoma gracile*, had a 9.5-d LC_{50} of 0.850 µg/L. *Daphnia magna* had a 24-hr EC_{50} of 7,000 µg/L for immobilization.

Table 1. Freshwater Toxicity Tests

Species	Exposure Duration	Age/Size	Response	Toxicity µg/L	References
Rainbow Trout *Oncorhynchus mykiss*	Chronic	Hatch	27-d LC_{50}	20	Black *et al.* 1982
Rainbow Trout *Oncorhynchus mykiss*	Chronic	4-d post-hatch	23-d LC_{50}	30	Black *et al.* 1982
Rainbow Trout *Oncorhynchus mykiss*	Acute	—	96-h LC_{50}	5,800	Galassi *et al.* 1982
Leopard Frog *Rana pipiens*	Chronic	4-d post-hatch	9-d LC_{50}	390	Black *et al.* 1982
Leopard Frog *Rana pipiens*	Chronic	fertilization to hatch	5-d LC_{50}	5,100	Black *et al.* 1982
Salamander *Ambystoma gracile*	Chronic	4-d post-hatch	9.5-d LC_{50}	850	Black *et al.* 1982
Salamander *Ambystoma gracile*	Chronic	fertilization to hatch	5.5-d LC_{50}	1,100	Black *et al.* 1982
Coho Salmon *Oncorhynchus kisutch*	Chronic	Fry	40-d EC_{50}	2,800 – 5,000	Moles 1981
Coho Salmon *Oncorhynchus kisutch*	Acute	0.3 g	96-h LC_{50}	5,460	Moles 1981
Water Flea *Daphnia magna*	Acute	24 hours	24-h EC_{50} (immobility}	7,000	Galassi *et al.* 1988
Goldfish *Carassius auratus*	Chronic	1-1.5 years	30-d LC_{50}	14,600	Brenniman *et al.* 1976
Goldfish *Carassius auratus*	Acute	1-1.5 years	96-h LC_{50}	22,800	Brenniman *et al.* 1976
Goldfish *Carassius auratus*	Acute	13-20 cm	72-hd LC_{50}	25,300	Brenniman *et al.* 1976
Goldfish *Carassius auratus*	Acute	20-80 g	48-h LC_{50}	27,600	Brenniman *et al.* 1976

Species	Exposure Duration	Age/Size	Response	Toxicity µg/L	References
Guppy *Lebistes reticulatus*	Acute	—	96-h LC_{50}	28,200	Galassi *et al.* 1988
Fathead minnow *Pimphales promelas*	Chronic	30-35 days	8-d LC_{50}	44,100	Hall *et al.* 1984, 1989
Fathead minnow *Pimphales promelas*	Acute	30 days	96-h LC_{50}	18,000 – 31,000	Devlin *et al.* 1982
Fathead minnow *Pimphales promelas*	Acute	protolarvae	96-h LC_{50}	25,000 – 36,000	Devlin *et al.* 1982
Fathead minnow *Pimphales promelas*	Acute	embryo	96-h LC_{50}	55,000 – 72,000	Devlin *et al.* 1982

B.C. Ministry of Environment Freshwater Testing

Many of the studies mentioned above have not adequately dealt with the fact that toluene is very volatile, and therefore it is difficult to maintain stable concentrations to conduct toxicity tests, especially for longer-term studies. Additionally, the study upon which the existing water quality guideline is based (Black *et al.* 1982, Table 1) showed LC_{50} values considerably lower than those reported in other studies. While the study by Black *et al.* (1982) was considered to be primary based on the flow-through methodology used, it was felt that confirmation of the results was necessary to ensure that a guideline based on these results was valid. A study was undertaken by Kennedy (2006) at Simon Fraser University in British Columbia under contract to the B.C. Ministry of Environment to address the problem of volatility to validate results found in the literature. Specifically, a special intermittent flow-through bioassay system was developed to ensure that toluene concentrations remained constant for the duration of the testing period.

Three trials were conducted on rainbow trout (*Oncorhynchus mykiss*) eggs which were fertilized not more than one hour prior to their exposure to the toluene solution. In each trial, 100 eggs were exposed to toluene at concentrations of 0, 5, 10, 50, 100, 200 and 500 µg/L. Trout from the egg stage to button-up fry were examined a minimum of three times daily, and percent survival of eggs, hatching success and survival of fry at several stages were recorded. Finally, dead fish as well as those surviving to the end of the test were examined by light microscopy for deformities and teratogenic effects. The EC_{50} for survival for toluene was found to be 16 µg/L with a 95% confidence interval of 12 – 20 µg/L; the EC_{20} from the same data was determined to be 5 ug/L. Teratogenic deformities were seen in <1% of all fry examined. The EC_{50} values in this study were comparable to those found in the literature (Black *et al.*, 1982) for the same species. Most of the toxicity occurred following hatch.

RECOMMENDED GUIDELINES

To protect freshwater aquatic life, the maximum concentration of toluene should not exceed 0.5 ug/L.

RATIONALE

The freshwater aquatic life guideline is based on a review of the CCME (1995) technical background information, recent information from the literature, and the recent study by the Ministry of Environment (Kennedy, 2006). The lowest observed effect level (EC20) from the Ministry of Environment study was used with a safety factor of 10 to derive the guideline.

The recommended level is four times lower than the CCME guideline of 2 µg/L, but is considered justified. The resulted from the use of EC_{20} as the lowest observed effect level (LOEL) in this document instead of EC_{50} value used by the CCME as the LOEL for their guideline. The use of EC_{20} as the LOEL in this document is consistent with the CCME protocol. The EC_{20} value was not available at the time the CCME guideline for toluene was derived.

APPLICATION OF THE GUIDELINES

Toluene is a very volatile substance. The water quality guidelines recommended in this document are based primarily on controlled, laboratory bioassays that do not account for factors that may modify the toxicity of toluene in the field.

SETTING WATER QUALITY OBJECTIVES

Care must be exercised when the water quality guidelines are applied to assess environmental impacts of toluene, since there will be situations where toluene concentrations are continuously renewed, e.g., discharge from an industrial operation, or with the potential for only a minimal amount of volatilization e.g., under ice cover. In these types of situations, a site-specific study should be undertaken and appropriate site-specific water quality objectives developed based on species present and actual toluene persistence and concentrations.

In many cases, water quality objectives will be the same as the guidelines. In some cases, socioeconomic or other factors may justify objectives that are less stringent than the guidelines. Site-specific impact studies would be required in such cases.

Methods (*e.g.*, water effects ratio, resident species toxicity in the field, etc.) are available to adapt the recommended guidelines to a given site. 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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