

**SCIENCE AND INFORMATION BRANCH  
WATER STEWARDSHIP DIVISION  
MINISTRY OF ENVIRONMENT**

**Ambient Water Quality Guidelines for Xylene**

**Overview Report**

Prepared pursuant to Section 5 (e) of the  
*Environmental Management Act, 2003.*

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## **SUMMARY**

This document is one in a series that establishes ambient water quality guidelines for British Columbia. This overview report is based on the technical report which was prepared by BWP Consulting under contract to the B.C. Ministry of Environment. To develop freshwater aquatic life guideline for use in British Columbia, the technical report assessed the recent literature, and new information generated by Kennedy at the Simon Fraser University under contract to the B.C. Ministry of Environment . 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 for xylene is set at 0.03 mg/L for the protection of freshwater aquatic life.

## 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 to protect 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 information from 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 the Water Stewardship Division.

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 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 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.

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

## INTRODUCTION

Xylene is an aromatic hydrocarbon with a characteristic sweetish odour, existing as a colourless liquid at room temperature. Xylene ( $C_6H_4(CH_3)_2$ ) consists of a benzene ring with two methyl groups, and occurs as three isomers: *ortho* (*o*-xylene, or 1,2-dimethylbenzene); *meta* (*m*-xylene, or 1,3-dimethylbenzene); and *para* (*p*-xylene, or 1,4-dimethylbenzene). Its solubility in water is about 200 mg/L at room temperature. The widespread use of xylene as both a solvent and as an additive to gasoline necessitates the production of very large amounts of this chemical every year. In 1995, 9.37 billion pounds (4.25 billion kilograms) of xylene were produced in the U.S., making it 23<sup>rd</sup> on the list of overall chemical production (American Chemical Society, 1996). World production of free xylenes is estimated to be over one million cubic meters per year (Jori *et al.*, 1986).

The majority of xylene releases into the environment occur either during some stage of its production (principally from catalytic reformat) or through its end-use (solvent losses) (Fishbein, 1985). Globally, a total of approximately  $3.2 \times 10^6$  tons of xylenes are introduced into the environment every year (Fishbein, 1985). Of this,  $0.6 \times 10^6$  tons are lost into the sea,  $1.5 \times 10^6$  tons are lost from refineries directly into the air,  $0.02 \times 10^6$  tons are lost through evaporation of gasoline,  $0.5 \times 10^6$  tons are released through automobile exhaust,  $0.5 \times 10^6$  tons are lost through solvent losses, and  $0.05 \times 10^6$  tons are lost from the chemical industry (Merian and Zander, 1982 cited in Fishbein, 1985).

The CCME assigns a ranking of either primary or secondary to toxicity studies used to develop water quality guidelines. A primary study (or the study of primary importance) is one in which tests are carried out in a flow-through environment and the contaminant concentration is measured during the test period. In a study classified as secondary, tests are conducted in a static environment and/or concentration is not measured during the experiment. Primary and secondary data classifications apply to both freshwater and marine data sets. Data produced through primary studies are considered to be more relevant than data from secondary studies. The following toxicity tests (acute toxicity in Table 1, chronic toxicity in Table 2) from the literature were deemed as primary:

**Table 1. Acute toxicity of xylene to various species of freshwater aquatic organisms (concentrations in mg/L).**

Species	Compound	24-hr LC <sub>50</sub>	48-hr LC <sub>50</sub>	72-hr LC <sub>50</sub>	96-hr LC <sub>50</sub>	Reference
<i>Daphnia magna</i>	o-xylene	1.0 (IC <sub>50</sub> )				Galassi <i>et al.</i> 1988
Rainbow trout	p-xylene				2.6	Galassi <i>et al.</i> 1988
<i>Selenastrum capricornutum</i>	p-xylene			3.2		Galassi <i>et al.</i> 1988
<i>Daphnia magna</i>	p-xylene	3.6 (IC <sub>50</sub> )				Galassi <i>et al.</i> 1988
<i>Daphnia magna</i>	m-xylene	4.7 (IC <sub>50</sub> )				Galassi <i>et al.</i> 1988
<i>Selenastrum capricornutum</i>	o-xylene			4.7		Galassi <i>et al.</i> 1988
<i>Selenastrum capricornutum</i>	m-xylene			4.9		Galassi <i>et al.</i> 1988
Rainbow trout	o-xylene				7.6	Galassi <i>et al.</i> 1988
Rainbow trout	m-xylene				8.4	Galassi <i>et al.</i> 1988
Guppies	p-xylene				8.8	Galassi <i>et al.</i> 1988
Guppies	o-xylene				12.0	Galassi <i>et al.</i> 1988
Guppies	m-xylene				12.9	Galassi <i>et al.</i> 1988
Goldfish	o-xylene	13				Bridié <i>et al.</i>
Goldfish	m-xylene	16				Bridié <i>et al.</i>
Goldfish	p-xylene	18				Bridié <i>et al.</i>
Goldfish	xylene	30.55	25.10	20.72	16.94	Brenniman <i>et al.</i> 1975

**Table 2. Chronic toxicity of xylene to various species of freshwater aquatic organisms (concentrations in mg/L).**

Species	Compound	8-day LC <sub>50</sub>	30-day LC <sub>50</sub>	LC <sub>50</sub> to hatch	Reference
<i>Selenastrum capricornutum</i>	m-xylene	3.9			Herman <i>et al.</i> , 1990
<i>Selenastrum capricornutum</i>	o-xylene	4.2			Herman <i>et al.</i> , 1990
<i>Selenastrum capricornutum</i>	p-xylene	4.4			Herman <i>et al.</i> , 1990
Rainbow trout	m-xylene			5.95	Black <i>et al.</i> , 1992
<i>R. pipiens</i>	m-xylene			4.06	Black <i>et al.</i> , 1992
<i>R. pipiens</i>	m-xylene			2.3	Kennedy, 2006
<i>R. pipiens</i>	m-xylene			0.31 (EC <sub>20</sub> )	Kennedy, 2006
Goldfish	xylene		14.58		Weber <i>et al.</i> (1974) cited in Buikema and Hendricks, 1980.

The most sensitive freshwater species to xylene was *Daphnia magna*, with 24-hr IC<sub>50</sub> (immobilization concentration, *i.e.*, that concentration at which movement of the organism ceases, generally taken to indicate death) of 1.0 mg/L o-xylene. Xylene concentrations, in this study, were measured before and after the test, and did not change considerably. Rainbow trout (*Oncorhynchus mykiss*) and *Rana pipiens* also show relatively high sensitivity, with a 96-hr LC<sub>50</sub> of 2.6 mg/L p-xylene for rainbow trout and a 28-day LC<sub>50</sub> of 2.3 mg/L m-xylene for *R. pipiens*.

#### **B.C. MINISTRY OF ENVIRONMENT FRESHWATER TESTING**

Many studies with xylene have not adequately dealt with the fact that xylene is very volatile and difficult to maintain at stable concentrations in static toxicity testing environments. A study was undertaken by the Simon Fraser University under contract to the B.C. Ministry of Environment to address the problem of the substance volatility (Kennedy, 2006). Specifically, a special intermittent flow-through bioassay system was developed to ensure that xylene concentrations remained constant for the duration of the testing period (28 days). Water samples were collected at 0.5, 1, 3, 5, 7, 12, 17, 22 and 28 day and analyzed for m-xylene concentrations. The mean m-xylene concentration for those samples was 29.1±1.1 µg/L, or 97% of expected results.

Trials were conducted on the amphibians *Rana pipiens* and *Xenopus laevis*. Eggs of *R. pipiens* were fertilized within one day prior to exposure to the xylene solution, while *X. laevis* larvae were fertilized less than 30 minutes prior to exposure. For each test, either 30 to 40 *X. laevis* eggs or 100 to 105 *R. pipiens* eggs were exposed to m-xylene at concentrations of 0, 0.05, 0.10, 1.5, 3.0, and 35 mg/L. Eggs were examined up to four days post hatching, and the percent survival/hatch was recorded.

Toxicity tests showed limited mortality in *X. laevis* exposed to xylene; hence, no EC<sub>50</sub> was calculated. Triplicate trials with *R. pipiens* eggs, yielded an EC<sub>50</sub> for m-xylene of 2.3 mg/L with a 95% confidence interval of 1.11 to 4.69 mg/L, and the EC<sub>20</sub> was 0.31 mg/L.



## RECOMMENDED GUIDELINES

The freshwater aquatic life guideline is 0.03 mg/L xylene. The guideline applies to all xylene fractions (m-, p- and o-xylene). The guideline was derived by applying a safety factor of 10:1 to the EC<sub>20</sub> value of 0.31 mg/L measured by Kennedy (2006).

### RATIONALE

There are relatively few chronic toxicity studies involving xylene reported in the literature. This is probably due to the transient nature of xylene in the aquatic environment: unless there is a continuous discharge of xylene into water, it evaporates in a relatively short period of time. The lowest chronic value reported was a 28-day EC<sub>20</sub> of 0.31 mg/L m-xylene for *Rana pipiens* by SFU for the Ministry of Environment (Kennedy, 2006). This value is about three times lower than the lowest acute toxicity (24-hour LC<sub>50</sub>) of 1.0 mg/L o-xylene for *Daphnia magna* (Galassi *et al.*, 1988).

The proposed guideline states that the maximum total concentration of xylene occurring in freshwater should not exceed 0.03 mg/L. This value is based on the 28-day EC<sub>20</sub> value of 0.31 mg/L for m-xylene. The guideline incorporates a safety factor of 10; to ensure that organisms are not adversely affected by xylene in the aquatic environment. This safety factor is considered appropriate because the study was chronic (28 days), and xylene has a low bioaccumulation potential and would not be expected to remain in the environment for prolonged periods of time. The safety factor is consistent with the CCME protocol and also supported by the fact that rainbow trout fry tend to avoid xylene in concentrations as low as 0.1 mg/L (Folmar, 1976).

## **APPLICATION OF THE GUIDELINES**

Xylene 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 xylene in the field.

### **SETTING WATER QUALITY OBJECTIVES**

Care must be exercised when the water quality guidelines are applied to assess environmental impacts of xylene, since there will be situations where xylene 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 xylene persistence and concentrations.

In many cases, water quality objectives will be the same as the guidelines. When concentrations of xylene 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, 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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