



Water Quality

Ambient Water Quality Guidelines for Mercury

Overview Report — First Update

Prepared pursuant to Section 2(e) of the
Environment Management Act, 1981

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Summary

This report is one in a series that establishes ambient water quality guidelines for British Columbia. The guidelines are safe conditions or levels of contaminants, applicable province-wide, which are set to protect various water uses.

This report updates the 1989 BC Environment guidelines for total mercury (THg) by providing revised water quality guidelines to protect aquatic life from chronic effects of mercury. This was deemed to be necessary since the Canadian Council of Ministers of the Environment (CCME) have recently developed guidelines for mercury in the water column to protect aquatic life and in the flesh of aquatic life to protect wildlife. The report also outlines water quality guidelines to protect avian wildlife feeding on aquatic organisms. The updated guidelines are consistent with the CCME tissue residue guideline to protect wildlife from methyl mercury (MeHg) in their diet. The guidelines for livestock, irrigation and recreation, are unchanged from in the 1989 report. The guidelines are summarized in Table 1, Table 2, and Table 3.

Table 1: Summary of Water Quality Guidelines for Mercury

Water Use	30-d av. Conc.* (µg/L THg)	Maximum Conc. (µg/L THg)
Source Drinking Water	See Source Drinking Water Quality Guidelines: https://www2.gov.bc.ca/assets/download/1F11ABD2CBD24EB09A70B89AB50CE6B0	
Wildlife and Aquatic Life (Freshwater Estuarine and Marine)+		None proposed
When MeHg = 0.5% of THg	0.02	
When MeHg = 1.0% of THg	0.01	
When MeHg = 8.0% of THg	0.00125	
Irrigation Water Supplies	None proposed	2.0
Livestock Water	None proposed	3.0

* The 30-day average is based on five weekly samples taken in a period of 30 days.

+ If natural levels exceed the guidelines for aquatic life, then any increase allowed above the natural levels should be based on site-specific data.

Table 2: Tissue Residue Guidelines to Protect Wildlife from Mercury Toxicity

The concentration of methyl Hg in fish or shellfish consumed by wildlife should not exceed 0.033 µg/g wet weight.

Preface

THE MINISTRY OF ENVIRONMENT, LANDS AND PARKS (now called 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

The definition of a guideline is:

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:

- Raw drinking and public water supply
- Aquatic life
- Wildlife
- Agriculture (livestock watering and irrigation)
- Recreation and aesthetics

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.

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

The guidelines apply to the ambient raw water source before it is diverted or treated for domestic use.

The Ministry of Health regulates the quality of water for domestic use after it is treated and delivered by a water purveyor.

Guidelines relating to public health at bathing beaches are the same as those used by the Ministry of Health which regulates the recreation and aesthetic use.

Introduction

Mercury is a non-essential element for plants and animals. However, metallic mercury is widely used in industry for the manufacture of chemicals, electrical equipment, power generation, dental amalgams and metallurgical gold. The mercurial compounds have found applications in paints, drywall compounds, scientific supplies, pharmaceuticals, fungicides and bactericides.

Mercury is found naturally in the earth crust, rocks, minerals, and coal and base metal deposits. Areas of high mercury content associated with zones of instability and volcanic and thermal activity have been found over the globe.

Many natural and anthropogenic sources contribute to environmental mercury loading. In the environment, mercury can exist in both organic and inorganic forms. Methyl mercury (MeHg), the most toxic form of mercury, tends to bioaccumulate and biomagnify in the aquatic food chain. Piscivorous mammals, fish and birds accumulate most of their body burden through diet.

Mercury is known to damage renal, nervous, reproductive, and developmental systems. The chemical form of mercury and route of entry are important determinants of its toxicity. Ingestion of inorganic mercury is primarily responsible for erosion of intestinal tracts and kidney damage in both animals and humans. Methyl mercury and short-chain organic mercurials destroy neuronal cells in areas of central nervous systems concerned with sensory and co-ordination functions.

In British Columbia, economic grade deposits of mercury are commonly associated with sedimentary rocks such as limestone and sandstone of the Palaeozoic to Recent age. The province's richest mercury deposits are in the Pinchi Lake fault zone which extends from Fort St. James northwest to the Omineca River. Other major areas of mercury mineralization in British Columbia include Kamloops Lake, Bridge River, and Yalakom River.

The concentration of mercury in natural waters is generally low. However, elevated concentrations of mercury have been reported in British Columbia in areas contaminated by the industrial activity (e.g., Squamish) and where extensive mercury mineralization has occurred.

Historical mercury concentrations should be viewed with caution. Results from cleaner laboratory analytical methods with lower detection limits show that background mercury concentrations are lower than previously thought. Older high values may be the artifacts of high detection limits and artificial contamination during measurement.

Recommended Guidelines

Table 1 summarizes all guideline values including those that have been updated. This was deemed to be necessary since the Canadian Council of Ministers of the Environment (CCME) have recently developed guidelines for mercury in the water column to protect aquatic life and in the flesh of aquatic life to protect wildlife. There is obviously a need to reconcile all these guideline values in one document for the benefit of resource managers.

1. SOURCE DRINKING WATER

See the Source Drinking Water Quality Guidelines: Guideline Summary Document

<https://www2.gov.bc.ca/assets/download/1F11ABD2CBD24EB09A70B89AB50CE6B0>

2. AQUATIC LIFE (FRESHWATER, ESTUARINE AND MARINE)

These guidelines replace the 1989 BC Environment guidelines for fresh, marine and estuarine waters.

(a) The 30-day average guidelines for marine, estuarine and fresh waters are the same, due to the facts that:

- the bioaccumulation potential of mercury in marine and freshwater food chain is similar; and
- both are based on the 1999 CCME recommended tissue residue guideline to protect the most sensitive consumers of aquatic life (e.g., avian species).

The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 ug/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 3 below. The rationale for the graduated guideline is the fact that MeHg concentrations may vary in the environment. For example if the percent of MeHg is 11% the guideline would be calculated by the following equation:

$$\begin{aligned} 0.1\text{ng MeHg/L (WQGwl see below in rationale section)} \div 0.11 \text{ (i.e. the \% MeHg)} \\ = 0.9 \text{ (guideline ng/L total Hg)} \end{aligned}$$

Table 3: The Total Hg Guideline as a Function of the Percentage of Methyl Mercury

% MeHg (of total Hg)	Guideline (ng/L total Hg)
0.5	20.0 ng/L
1.0	10.0 ng/L
2.5	4.0 ng/L
5.0	2.0 ng/L

These levels will protect freshwater aquatic life from chronic effects of mercury. They will also prevent undesirable accumulation of mercury from water to the food chain that may harm the most sensitive consumers (e.g., avian species) of aquatic life.

Rationale:

The following assumptions were made to update the 30-day average guideline to protect from mercury bioaccumulation in fish to a level that may harm wildlife consuming the mercury-contaminated fish:

All mercury in fish tissue is in the methylated form. This conclusion is consistent with observations made by researchers in the literature.

The MeHg bioaccumulation factor at a higher trophic level (level 3 or fish consumed by avian species) is 320,000 on wet-weight (BAF_{3ww}) basis or 1,600,000 on dry-weight (BAF_{3dw}) basis. This BAF is consistent with the US EPA recommended value and values observed in Squamish, British Columbia.

Based on recommended level of methyl mercury at 33 µg/kg wet-weight (diet) and the methyl mercury BAF_{3ww} of 320,000, the acceptable concentration in water for the protection of wildlife consuming fish can be estimated as follows:

$$WQGwl = (33 \mu\text{g MeHg kg}^{-1} \times 1000 \text{ mg}/\mu\text{g}) / 320,000 = 0.1 \text{ ng MeHg/L}$$

(where WQGwl is the water quality guideline to protect wildlife)

Table 5 below expresses WQGwl in terms of the comparable THg levels for various percentages of MeHg as a function of THg.

Table 5. WQGwl In Terms of the Comparable THg Levels for Various Percentages of MeHg as a Function of THg

% MeHg (of total Hg)	WQGwl (ng/L total Hg)
0.5	20.0 ng/L
1.0	10.0 ng/L
2.5	4.0 ng/L
8.0	1.25 ng/L

This analysis suggests that the 1989 BC Environment's 30-day average guideline of 0.02 mg/L (or 20 ng/L) total mercury is valid as long as MeHg is less than or equal to 0.5% of the total mercury concentration. Appropriate water quality guidelines for MeHg concentrations other than those specified in the above table can be determined using a linear relationship between WQGwl and MeHg (%).

It should be noted that the CCME (2000) in developing guidelines for fresh and marine waters did not consider bioaccumulation effects per se, but based their guidelines on chronic toxicity. They caution that the guidelines that they have developed 'may not protect wildlife that consume aquatic life'. As well, they considered marine and fresh waters separately, even though there is no reason to suspect that the chemistry of each affects mercury or its bioaccumulation in fish and avian wildlife and do not provide a guideline for MeHg in marine water.

(b) The 1989 BC Environment guidelines for a maximum mercury concentration in either fresh or marine waters has been deleted due to the bioaccumulative nature of mercury which is the most important consideration in developing guidelines. Direct toxic effects that a maximum concentration is meant to protect against are seldom encountered and will be accounted for in bioaccumulation in most cases.

3. WILDLIFE

The 30-day average concentration of total mercury in water to protect wildlife should not exceed levels shown in Section 2 above. These guidelines are based on the tissue residue guideline recommended by the CCME (2000), and will protect the most sensitive avian life feeding on aquatic organisms that may accumulate undesirable levels of mercury in their tissues. This guideline replaces the 1989 BC Environment guideline of 3.0 mg THg/L that had been based on livestock sensitivity to mercury since there were insufficient data on mercury toxicity to avian wildlife. The CCME (2000) did not recommend mercury guidelines for wildlife.

Additionally, the methyl mercury concentration should not exceed 0.033 µg/g wet weight in the diet of wildlife. This guideline is consistent with the CCME (2000) tissue guidelines to protect avian wildlife feeding on fish and shellfish containing mercury.

4. LIVESTOCK WATER SUPPLY

The concentration of total mercury in livestock water supply should not exceed 3.0 µg/L at any time. This is consistent with the 1989 BC Environment and the CCME (1999) guidelines.

5. IRRIGATION

The maximum concentration of total mercury in irrigation water should not exceed 2.0 µg/L. This is consistent with the 1989 BC Environment guideline. The CCME (1999) did not recommend mercury guidelines for water used for irrigation.

Application of the Guidelines

1. FORMS OF MERCURY

Toxicity of mercury has been expressed in terms of both total and methyl forms of mercury. However, total mercury is recommended for setting water quality objectives for a given waterbody. The advantages of expressing toxicity on the basis of total mercury concentrations are:

- i. all the mercury that may potentially be toxic is included in the measurement; if the total mercury concentration in water is within the guideline limits, then it is safe to conclude that no mercury pollution exists;
- ii. for comparison purposes, there is a considerable amount of historical information available for total mercury; and
- iii. total mercury measurements are routine and relatively inexpensive.

Mercury in aquatic organisms (e.g., fish) is predominantly in the methyl form and should also be measured when investigating mercury contamination problems in aquatic systems. The CCME recommended tissue residue guideline (0.033 micrograms MeHg/g wet weight-diet) should apply to protect wildlife consumers of fish.

The main disadvantage of using total mercury to assess water quality is that a large fraction of mercury may become biologically unavailable by forming complexes with the organic and suspended solids fractions of water. Nevertheless, given favourable environmental conditions, mercury complexed in such a manner will be released into the environment in readily available forms, becoming part of the food chain.

2. ASSESSMENT OF EXISTING WATER QUALITY

The guidelines recommended in this document are primarily based on laboratory bioassays that usually are performed with soluble forms of mercury under controlled conditions. Aquatic organisms in a natural environment, however, obtain their mercury burden from both water and food. Mercury from sediments

could become available to the organisms under certain environmental conditions. Thus measuring total mercury in water alone cannot be taken as a true measure of a mercury problem in a given waterbody.

Other assessment techniques include measurements of mercury in fish, and long-term bioassays with resident species using local water. The guidelines for mercury in fish can be used for to assess existing water quality. Long-term bioassays are complex and costly, and should be used for waterbodies with high fisheries values that are threatened by a controllable source.