Water Quality

Ambient Water Quality Guidelines for Organic Carbon

Overview Report

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Environment Management Act, 1981

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Summary

This document is one in a series which establishes ambient water quality guidelines, formerly known as criteria, for British Columbia. It is based on a report submitted by The Cadmus Group, Inc. of Ottawa under contract to the Water Management Branch in June, 1998. The contract was funded by Forest Renewal BC. The guidelines are safe conditions or levels of a variable which have province-wide application and are set to protect various water uses. This report sets guidelines for organic carbon to protect drinking water, freshwater and marine aquatic life, and wildlife. Guidelines for recreational, irrigation, livestock watering, and industrial water uses were not set due to the lack of pertinent information on effects of organic carbon on these water uses. The guidelines are summarized in Table 1.

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 standing.

Tables

Water Use	Organic carbon	Recommended Guidelines
Drinking Water Supply - with chlorination	TOC	4 mg/L source water
Drinking Water Supply - other disinfection	—	Not recommended
Aquatic Life - fresh water	TOC	30-day median ± 20% of the median background concentration
Aquatic Life - fresh water	DOC	30-day median ± 20% of the median background concentration
Wildlife	TOC	30-day median ± 20% of the median background concentration
Wildlife	DOC	30-day median ± 20% of the median background concentration
Industrial Water Supply	—	None recommended
Irrigation	—	None recommended
Recreation and Aesthetics	—	None recommended
Livestock Watering	—	None recommended

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
2. to provide guidelines for the establishment of site-specific ambient water quality objectives

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 Environmental Quality 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, 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, 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.

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.

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.

Recommended Guidelines

These guidelines are based on information presented in a technical appendix and are summarized in Table 1. Neither the Canadian Council of Ministers of the Environment (CCME) nor Health Canada recommended guidelines for organic carbon for any of the water uses given here.

1. RAW DRINKING WATER SUPPLY

In this document, the organic carbon guideline for raw drinking water considers issues related to the production of haloforms due to chlorination. The production of haloforms in drinking water as a result of the reaction between organic carbon compounds and hypochlorous acid is a serious drinking water quality issue. A study with drinking water supplies in the US has shown that the probability of exceeding the trihalomethane concentration of 100 micrograms/L (which is also a Health Canada guideline), following chlorination, is minimal for the finished drinking water containing total organic carbon level of less than or equal to 2 mg/L. The recently issued ***Disinfectants and Disinfection By-Products Rule*** by the US Environmental Protection Agency specifies maximum total organic carbon levels of 2 mg/L in treated water and 4 mg/L in source water to ensure acceptable levels of disinfection byproducts.

Health Canada has not established a drinking water quality guideline for dissolved or total organic carbon. However, it has recommended guidelines for parameters that are related to dissolved and total organic carbon. Many drinking water quality issues associated with high levels of organic carbon may be addressed through the Health Canada guidelines for true colour (aesthetic objective:15 TCU), total dissolved solids (aesthetic objective: 500 mg/L), turbidity (maximum acceptable concentration: 1 NTU), and trihalomethanes (interim maximum: 100 micrograms/L). A guideline for organic carbon will be an another avenue to protect water quality.

It is recommended that the total organic carbon (TOC) in raw drinking water or source water should not exceed 4 mg/L at any time. For systems that do not disinfect or which use other methods for disinfection (e.g., ozonation), the guidelines do not apply.

2. AQUATIC LIFE (FRESH WATER)

The aquatic life guidelines are expressed in terms of the total (TOC) and the dissolved (DOC) organic carbon concentrations. Changes in the concentrations of TOC and DOC can cause reductions in primary productivity, system metabolism, while increasing susceptibility to toxic metals and acidification. Increases in organic carbon concentrations can increase bacterial metabolism to the point of causing anoxia. Several studies suggested that a relatively small change in the average organic levels above or below the background concentrations can have measurable adverse impacts on aquatic systems.

2.1 Total Organic Carbon (TOC)

To protect freshwater aquatic systems, it is recommended that the 30-day 50th percentile TOC shall be within ±20% of seasonally-adjusted median background levels as measured historically or at appropriate reference sites. The 30-day 50th percentile calculation should be based on a minimum of five weekly samples taken over a period of 30 days.

2.2 Dissolved Organic Carbon (DOC)

To protect freshwater aquatic systems, it is recommended that the 30-day 50th percentile DOC shall be within ±20% of seasonally-adjusted median background levels as measured historically or at appropriate reference sites. The 30-day 50th percentile calculation should be based on a minimum of five weekly samples taken over a period of 30 days.

3. WILDLIFE

Wildlife can be directly or indirectly affected by changes in organic carbon levels in aquatic systems. For instance, abundance of loons, which require clear water to sight their prey, have been negatively correlated with TOC and DOC levels which render aquatic systems highly coloured. Indirect effects arise because organic carbon plays an important role in the productivity of aquatic systems and response of the aquatic systems to factors such as acid inputs. A study in the literature showed that addition of organic matter to man-made waterbodies caused an increase in macroinvertebrate predators (e.g., Hirudinea), an important food source for diving ducks. This increase in the predatory macroinvertebrates, however, depressed the existing population of detritivorous invertebrate groups (e.g., Asselus and chironomidae) which are important food sources for dabbling ducks.

The recommended guidelines for wildlife, dependent on aquatic systems for sustenance and reproduction, are the same as the aquatic life guidelines specified in Sections 2.1 and 2.2.

4. OTHER WATER USES (Recreation and Aesthetics, Livestock Watering, Irrigation and Industrial Water Uses)

Organic carbon guidelines for recreation and aesthetics, livestock, Irrigation, and Industrial water uses are not recommended due to the lack of pertinent information in the literature.

Application of Guidelines

1. MEASUREMENT OF ORGANIC CARBON

Total organic carbon consists of two fractions: dissolved organic carbon and particulate organic carbon. The DOC levels are determined in samples passed through a filter approximately 0.4 to 0.7 micrometers in diameter. No filtration of the sample is required to determine the total organic carbon.

There are several analytical methods available for determining organic carbon depending upon the type of samples. Methods are based on the principle of oxidation of the carbon in the sample to carbon dioxide (e.g., combustion, chemical reaction, ultraviolet radiation), which is then measured by one of several methods. Wet oxidation methods (e.g., UV persulphate) have been shown to underestimate total combustion by 15 to 30%, most likely because of incomplete oxidation of organic carbon in the sample.

BC Environment measures TOC by converting it to CO_2 via catalytic combustion or wet oxidation, and then measuring the CO_2 formed by infrared detector or converted to methane and measured by flame ionization. The detection limit for TOC in drinking, surface, and waste waters is 1 mg/L. All samples are stored in cool (4°C), dark conditions in sealed containers. As with other jurisdictions, unpreserved samples must be analyzed within 72 hours. Preserved samples (i.e., pH adjusted to less than 2) must be analyzed within 28 days. Environment Canada (1995) uses a somewhat different approach to determining TOC and DOC levels in water. The analysis is comprised of two phases, the determination of total carbon or dissolved carbon and the determination of total inorganic carbon or dissolved inorganic carbon. TOC and DOC levels are then calculated by difference. To do this, each sample is split into two. Total and dissolved carbon are determined by combusting the one split sample in the presence of a platinum catalyst at an elevated temperature with an oxygen gas carrier. Total and dissolved organic carbon are determined in the other split sample by combustion in a phosphoric acid solution through which the carrier gas is bubbled. An infrared detector is used to determine the CO_2 formed. The normal detection limit is 0.5 mg/L. Note that with this methodology, sample preservation by acidification to pH less than 2 is not recommended because it will result in the partial loss of the inorganic components.

2. ASSESSMENT OF EXISTING WATER QUALITY

The water quality guidelines recommended in this document are primarily based on potential indirect effects of organic carbon in aquatic environments: (a) potential formation of trihalomethanes in raw drinking waters upon chlorination, and (b) potential for altering the characteristics of an aquatic environment which may prove to be harmful to biota dependent upon it. The presence of organic carbon can, in fact, modify an aquatic environment in a variety of ways. For instance, organic carbon forms complexes with some metals (e.g., cadmium, copper, etc.), thus reducing their availability and toxicity to aquatic organisms. Conversely, mercury availability, bioaccumulation in fish and hence toxicity tend to increase in the presence of organic carbon. Studies have also shown that total organic carbon is strongly correlated with water colour.

Appropriate considerations must be given to these aspects when the existing water quality is assessed in an aquatic environment. Effects of organic carbon content in the aquatic environment should be assessed together with actual production of trihalomethanes after chlorination in drinking water, metal concentrations and their bioavailability, and compliance with related water quality guidelines (e.g., THM, colour, turbidity, etc. in drinking and ambient waters).

3. SETTING WATER QUALITY OBJECTIVES

The data in the literature show evidence of considerable temporal variations in the organic carbon concentration in aquatic environments. The data also indicate that median total and dissolved organic carbon concentrations in ambient waters in British Columbia are generally less than 5 mg/L. However, this concentration will be exceeded in ambient waters that are influenced by sources naturally high in organ carbon content. For instance, the median total organic carbon concentrations in Delta's Burns Bog ranged from 26 to 105 mg/L. Obviously, these natural variations will influence setting the site-specific water quality objectives. In some cases, socio-economic or other factors may justify objectives which are less stringent than the recommended options. Site-specific impact studies would be required in such cases.