Ambient Aquatic Life Guidelines for Iron

Overview Report

Water Stewardship Division
Ministry of Environment
Province of British Columbia

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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 1993. This update assesses the freshwater aquatic life guideline for use in British Columbia, assesses more recent information and makes amendments to suit B.C. conditions. The guidelines are safe conditions or levels that have province-wide application. The report consists of two parts: this, an overview report, and a technical document upon which this overview summary is based.

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.

To protect freshwater aquatic life, the short-term maximum guideline for total iron is 1 mg/L and for dissolved iron is 0.35 mg/L.

Water quality guidelines to protect marine life and other water uses such as wildlife, agriculture (i.e., livestock watering and irrigation), drinking water and recreational were not recommended because relevant data were not available from the literature.

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
- 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 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, 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.

1.0 RECOMMENDED GUIDELINES

The freshwater aquatic life guideline is based on Technical Appendix titled 'Ambient Water Quality Guidelines for Iron' by Burke Phippen, Cheryl Horvath, Rick Nordin, and Narender Nagpal, February 2008. The technical report is based on new information on the subject from the literature and the toxicity data developed by the Ministry of Environment.

The maximum concentration should not exceed 1.0 mg/L total iron and 0.35 mg/L dissolved iron to protect freshwater aquatic life from adverse effects of iron.

Water quality guidelines for Iron were not recommended for other water uses for the lack of data.

1.1 RATIONALE

1.1.1 Dissolved Iron

The guideline recommended in this document is based primarily on the lowest 96-hour LC_{50} value reported in the testing conducted by the B.C. Ministry of Environment. This value (3.5 mg/L for *Hyalella* in soft water, supported by the LC_{50} value of 3.6 mg/L for *Selenastrum, deemed to be a chronic test*) was divided by a safety factor of 10 to arrive at the recommended guideline.

There are a number of studies that also support a proposed guideline in the relative range suggested above. Milam and Farris (1998) suggested on the basis of their bioassays with clams, that a no effect level of 0.4 mg/L (as Fe^{2+}) would be appropriate. They cite a recommendation from AEPSC (1983 – cited in Milam and Farris, 1998) for a criterion of 0.37 mg/L. There seem to be a number of field studies that indicate that negative environmental impacts occur at lower concentrations than are shown by laboratory bioassays (Vouri 1995). Interaction of other factors and mixtures of contaminants is a possible reason for this difference. Warnick and Bell (1969) suggested a protective guideline of 0.32 mg/L. Wang (1986) suggested 0.37 mg/L was appropriate to protect aquatic plants. Warnick and Bell (1969) based on their fish bioassays, suggested 0.32

mg/L. A study by Linton *et al*. (2007) suggests a water quality criterion of 0.21 mg/L is necessary to protect sensitive species (mayflies) in Ohio waters. Their criterion is expressed as total iron but uses the response of biological communities as an indicator and so may be more functionally equivalent to dissolved iron.

Due to the arbitrary nature of the term "dissolved" (usually designating any material that passes through a 0.45 μm membrane), this guideline designation becomes slightly more complicated since colloidal iron is capable of passing through such a membrane. However, this serves only to increase the sensitivity (and therefore decrease the risk) of the dissolved iron guideline.

1.1.2 Total Iron

In light of the contradictory data, the recommendation is to use what seems to be the most recent and best field-based research of Linton *et al*. (2007) as the basis of a guideline for total iron. Linton *et al*. used two benchmarks of change in community structure to establish guidelines. The first (0.21 mg/L) corresponds to no or minimal changes in aquatic community structure and function. A second benchmark that allowed for a slight to moderate changes in community population structure because of loss of some rare species and/or replacement of sensitive ubiquitous taxa with more tolerant taxa generated a guideline of 1.74 mg/L. In the context of environmental protection whether some change in sensitive species is acceptable is an open question. In the spirit of the precautionary principle, a lower concentration seems appropriate and the existing if poorly justifiable 1.0 mg/L seems to be an acceptable value to end up at. This is possible that, as discussed earlier, the 1 mg/L may be overly protective but with the present data, it is difficult to rationalize. Other recent research, for example Randall *et al*. 1999 have coincidentally recommended 1.7 mg/L.

2.0 APPLICATION OF THE GUIDELINES

Iron is required for all forms of life. For the protection of aquatic life, water quality guidelines for both total and dissolved fractions of iron are recommended in this document.

With guidelines for both dissolved and total iron proposed, there needs to be some discussion of the how the two guidelines are to be applied. The guideline for dissolved iron is of primary importance and if monitoring for iron toxicity is appropriate, dissolved iron should be sampled and analyzed and should be the focus of any evaluation. If measurements for both dissolved and total are taken, the possibility exists that one guideline might be met and the other exceeded. In this case, if the dissolved is exceeded and the total is below the limit, there would be more reason for concern than if the opposite (total iron guideline exceeded and dissolved iron guideline met) were to occur. There is value in the two guidelines when sampling and when it is obvious that iron precipitation is occurring, the dissolved iron concentration should be of primary importance.
In certain circumstance, total iron concentration in water may exceed the recommended guideline of 1.0 mg/L due to natural cases (This may be true for total iron but not for dissolved iron.). This is often caused by high load of suspended material in water during high flow conditions and the association of total iron content with the suspended materials. In such cases, it is suggested that the background total iron concentration be used as a guideline. This is consistent with anti-degradation policy of the CCME where substance/contaminant concentration is naturally high and the background procedure employed by B.C. Ministry of Environment for setting water quality objectives.

2.1 SETTING WATER QUALITY OBJECTIVES

Care must be exercised when the water quality guidelines are applied to assess environmental impacts of iron, since iron solubility is significantly influenced by pH and anoxic conditions of the aquatic environment. In these types of situations, a site-specific

study should be undertaken and appropriate site-specific water quality objectives developed based on environmental conditions.

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 or more 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 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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