Water Quality

Ambient Water Quality Guidelines for Cobalt

Overview Report

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Summary

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This document is one in a series that establishes ambient water quality guidelines (Table 1). This document is mainly based on a report prepared by Golder Associates for the Ministry of Water, Land and Air Protection. It sets guidelines for cobalt (Co) to protect aquatic life in the freshwater environment. A water quality guideline for other water uses viz., marine aquatic life, wildlife and agricultural water uses were not set because of lack of sufficient data.

Table 1: Recommended guidelines for Cobalt

Water Use	Guideline (Total Co; µg/L)
Aquatic Life: Freshwater Maximum 30-d average	 110 4
Aquatic Life: Marine	Not Recommended
Wildlife	Not Recommended
Irrigation	Not Recommended
Livestock Watering	Not Recommended

Guidelines were also not set for raw drinking water and recreational and industrial water uses, since relevant Co toxicity data for these uses were not available in the literature.

Preface

The Ministry of Water, Land and Air Protection develops ambient water quality guidelines for British Columbia. This work has two goals:

- to provide guidance for the evaluation of data on water, sediment and biota, and
- to provide basis for setting site-specific ambient water quality objectives.

The guidelines represent safe conditions or safe levels of a substance in water. Guideline is defined as "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 detrimental effects from occurring to a water use under given environmental conditions."

The guidelines are applied province-wide, but they are use-specific, and are being developed for these water uses:

- raw drinking water, public water supply and food processing [1]
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics [2]
- industrial water supplies

[1] The guidelines apply to an ambient raw water source before it is diverted or treated for domestic use. The Ministry of Health Services regulates the quality of water for domestic use after it is treated and delivered by a water purveyor.

[2] Guidelines relating to public health at bathing beaches will be the same as those developed by the Ministry of Health Services, which regulates the recreation and aesthetic water use.

The guidelines are established after considering the scientific literature, existing guidelines from other jurisdictions, and environmental conditions in British Columbia. The scientific literature provides information about the persistence of toxicants in the environment and their effect on various life forms. This information is not always conclusive because it is usually based on laboratory work that, at best, only approximates field conditions. To compensate for this uncertainty, and applying the "precautionary principle," the guidelines have built-in safety factors that are conservative, but reflect the natural background levels.

The guidelines are used to set ambient site-specific water quality objectives for waterbodies. In setting the objectives, considerations are given to present and future water uses, waste discharges, hydrology, limnology, oceanography, and existing background water quality.

In most cases, the objectives are the same as the guidelines. However, when natural background levels exceed the guidelines, the objectives could be less stringent than the guidelines. In rare instances — for example, if the resource is unusually valuable or of special provincial significance — the safety factor could be increased, enabling objectives to be more stringent than the guidelines. Another approach would be to develop site-specific objectives by conducting toxicity experiments in the field. However, because this approach is costly and time consuming, it is seldom used.

Neither the guidelines nor the objectives derived from them have any legal standing. However, objectives can be used to calculate waste discharge limits for contaminants. These limits are outlined in waste management permits, orders and approvals, all of which have legal standing. Objectives are not usually incorporated as conditions of a permit.

Introduction

Cobalt is a naturally occurring hard silver-grey metal that belongs to group 9 of the periodic table. It is a relatively rare element of the earth's crust with concentration around 25 mg/kg. As an integral part of the vitamin B_{12} complex, cobalt is essential in trace amounts for humans and animal life. The essentiality of cobalt has also been demonstrated in the environment elsewhere: (a) as a micronutrient for some blue-green algae, (b) required for nitrogen-fixation in legumes, (c) in growth of many marine algal species, including diatoms, chrysophytes and dinoflagellates, and (d) in growth enhancement of some terrestrial plants at low concentrations. However, in higher concentrations, cobalt is toxic to humans and to terrestrial and aquatic animals and plants.

Most cobalt resources are present in nickel-bearing laterite deposits, with remainder occurring primarily in nickel-copper sulphide deposits present in mafic and ultramafic rocks and sedimentary copper deposits. The largest cobalt deposits are found in Australia, Canada, Russia, Congo and Zambia. Canada began commercially producing cobalt in 1905 and contributes approximately 20% of the total world production of cobalt.

Currently, cobalt is mainly used in some types of steel and in a variety of alloys, including high-temperature steel alloys, magnetic alloys, and abrasion-resistant hard-facing alloys. Cobalt is used in magnets to increase the saturation of magnetization of iron. It is also used as a pigment in glass, ceramics, and paints; as paint drier; as a catalyst for the petroleum industry; and in batteries. Many fertilizers are enriched with cobalt, generally in the range of 1 mg/kg to 12 mg/kg, in order to amend cobalt-deficient agricultural soils.

The concentration of total cobalt in freshwaters is generally low ($\leq$1 µg/L). Higher concentrations are generally associated with industrialized or mining areas. Concentrations of cobalt ranging from non-detectable (detection limit 0.1 µg/L) to 27,000 µg/L have been measured; the total and dissolved in ambient, uncontaminated environments are, however, generally below 5 µg/L. Cobalt is also found in low concentration in marine waters.

Municipal and industrial wastes and effluents are primary sources of anthropogenic cobalt in the environment. Anthropogenic emissions, largely the burning of fossil fuels, account for 55% of all cobalt in the air. Windborne soil particles and sea salt spray are primary natural sources of cobalt to the atmosphere.

Canada is one of the countries that contain largest deposits of cobalt. It was estimated that Canada contributes 20% of the total world production of cobalt.

Recommended Guidelines

1 Drinking Water

Drinking water quality guideline for cobalt was not recommended due to lack of data in the literature.

Rationale:

In general, the province of British Columbia adopts the Canadian drinking water quality guideline for a given substance available from Health Canada. Currently, Health Canada has not recommended a drinking water quality guideline for cobalt. Cobalt is generally not detected in finished drinking water, reflecting its low concentration in surface waters and the removal of particular metal during the water treatment process.

2 Aquatic Life

Freshwater:

It is recommended that the interim maximum concentration of total cobalt should not exceed 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.

It is also recommended that the interim 30-day average concentration to total cobalt (based on five weekly samples) should not exceed 4 µg/L to protect aquatic life from chronic effects of cobalt.

Rationale:

The recommended interim maximum guideline is based on the lowest observed effect level (LOEC) causing 50% mortality in *Daphnia magna* exposed to 1110 µg/L cobalt for 48 hours and a safety factor of 0.1. The safety factor was selected to protect from possible delayed mortality of the organisms exposed to the metal and is consistent with the British Columbia protocols for the guideline development.

Invertebrates, *Daphnia magna* and *Ceriodaphnia dubia*, also exhibit chronic effects when exposed to low concentrations of cobalt. A lowest observed effect concentration (geometric mean - LOEC) of about 8 µg /L total cobalt was determined to cause reproductive effects in these organisms. The 30-day average concentration to protect aquatic life from chronic effects of cobalt was obtained by applying a safety factor of 2 to the LOEC. A lower (than 10 as above) safety factor was justified because cobalt is essential in the synthesis of vitamin B_{12} which is necessary for animal and human nutrition.

Marine water:

A water quality guideline to protect marine aquatic life from adverse effects of cobalt is not recommended at this time due to the lack of data.

3 Wildlife

A water quality guideline for the protection of wildlife from adverse effects of cobalt is not recommended at this time due to insufficient data.

4 Irrigation

A water quality guideline for the protected of irrigated crops from adverse effects of cobalt is not recommended at this time due lack of sufficient data.

Rationale:

The CCME has recommended a cobalt guideline for irrigation water in 1987. This guideline, resourced from another jurisdiction, is based on old and scant data. There is not sufficient data available in the literature to develop an irrigation water quality guideline based on the current CCME (1993) protocol for the purpose. Hence, the irrigation water guideline was not developed in this document.

5 Livestock Watering

A water quality guideline for the protection of livestock from adverse effects of cobalt in their drinking water is not recommended due to insufficient data.

Rationale:

The CCME has recommended a cobalt guideline for livestock watering in 1987. This guideline, resourced from another jurisdiction, is based on old and scant data. There is not sufficient data available in the literature to develop an irrigation water quality guideline based on the current CCME (1993) protocol for the purpose. Hence, the livestock watering guideline was not developed in this document.

Application of Guidelines for Aquatic Life

Cobalt is ubiquitous in the environment. Its impact on the environment depends on several factors related to the source and environmental variability. The water quality guidelines recommended in this document are primarily based on controlled, laboratory bioassays in which organisms are exposed to cobalt only. In the environment, however, cobalt toxicity may be modified by local conditions (e.g., hardness, presence of other synergistic or antagonistic contaminants, etc.). To adjust the guideline recommended here to take local conditions into consideration, the B.C. Ministry of Water, Land and Air Protection publication, "*Methods for Deriving Site-Specific Water Quality Objectives in British Columbia and Yukon*" is recommended.

Other methods to adjust the water quality guideline may include one or more assessment techniques such as measuring the complexing capacity, cobalt speciation methods, and population studies on biota. These methods are complex and costly and should be reserved for water bodies with fisheries values threatened by controllable cobalt input.

Water quality guidelines are an integral part of the exercise of setting site-specific water quality objectives. In most cases, water quality objectives will be same as guidelines. When concentration of cobalt in undeveloped waterbodies are less than the recommended guidelines, then more stringent values, if justified, could apply. In some cases, socioeconomic or other factors (e.g., higher background levels) may justify site-specific objectives that are less stringent than the guidelines. Site-specific impact studies would be required in such cases. Where ambient cobalt concentrations exceed the guideline, it is recommended that degradation of existing water quality should be avoided to protect aquatic life.