Water Quality

Ambient Water Quality Guidelines for Chlorophenols — First Update

Overview Report

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Summary

This document is one in a series that establishes ambient water quality guidelines for British Columbia. It includes a short report and a technical appendix. This document sets guidelines for chlorophenols, chlorinated hydroxylated monocyclic aromatic hydrocarbons, to protect drinking water, freshwater and marine aquatic life, recreational waters, food-processing industries, and wildlife and livestock drinking water.

Guidelines were not set for crop irrigation or other industries. Suitable data documenting the effects of chlorophenols for these uses is lacking. The CCME (Canadian Council of Ministers of the Environment) has set guidelines for all water uses and all chlorophenols for which we have set guidelines.

Toxicity to aquatic life and the generation of an unpleasant taste in fish and shellfish that live in chlorophenol-contaminated waters are effects that occur at the lowest chlorophenol concentrations. The guidelines for chlorophenols are summarized in three tables at the end of the short report. A more detailed discussion of the guidelines is presented in the technical appendix. The guidelines for aquatic life and livestock drinking water have been recalculated since the first edition of this document, printed in August, 1993. New data became available and some old data were considered unreliable; the new criteria are less stringent than the old criteria for aquatic life and livestock drinking water. Other criteria are unchanged from the previous document.

Tables

Table 1. Summary of Water Quality Guidelines for Chlorophenols

WATER USE	GUIDELINES (maximum)
Raw Drinking Water - Aesthetics (taste and odour)	MCPs: 0.1 µg/L DCPs: 0.3 µg/L TCPs: 2.0 µg/L TTCPs: 1.0 µg/L PCP: 30.0 µg/L
Raw Drinking Water - Toxicity	2,4-DCP: 900 µg/L 2,4,6-TCP: 5 µg/L 2,3,4,6-TTCP: 100 µg/L PCP: 60 µg/L
Livestock and Wildlife Drinking Water - Aesthetics	MCPs: 0.1 µg/L DCPs: 0.3 µg/L TCPs: 2.0 µg/L TTCPs: 1.0 µg/L PCP: 30.0 µg/L
Livestock and Wildlife Drinking Water - Toxicity for Lactating Animals (high temperatures and high water intake rates)	MCPs: 185 mg/L DCPs: 46 mg/L TCPs: 21 mg/L TTCPs: 41 mg/L PCP: 17.5 mg/L
Livestock and Wildlife Drinking Water - Toxicity for Non-lactating Animals (normal temperatures and low water intake rates)	MCPs: 1854 mg/L DCPs: 460 mg/L TCPs: 210 mg/L TTCPs: 410 mg/L PCP: 175 mg/L
Aquatic Life (fresh, marine and estuarine waters) - Flavour impairment guidelines for water (when harvesting fish, crustaceans and shellfish)	MCPs: 0.1 µg/L DCPs: 0.2 µg/L TCPs: use Table 3 TTCPs: use Table 3 PCP: use Table 3
Aquatic Life (fresh, marine and estuarine waters) - Toxicity guidelines for aquatic life	all CPs: use Table 3
Recreation - Primary contact	MCPs: 0.1 µg/L DCPs: 0.3 µg/L TCPs: 2.0 µg/L TTCPs: 1.0 µg/L PCP: 30.0 µg/L

Irrigation	No criterion set
Industrial - Food processing	MCPs: 0.1 µg/L DCPs: 0.3 µg/L TCPs: 2.0 µg/L TTCPs: 1.0 µg/L PCP: 30.0 µg/L
Industrial - Other uses	No criterion set

Table 3. Aquatic Life Toxicity Guidelines

Chlorophenol Congeners	pH 5.7	pH 6.2	pH 6.7	pH 7.2	pH 7.7	pH 8.2	pH 8.7	pH 9.2
2-MCP	3.9	6.4	11	17	29	48	79	130
3-MCP	3.4	5.6	9.3	15	25	42	70	115
4-MCP	1.7	2.9	4.8	7.8	13	22	36	59
2,3-DCP	1.1	1.8	3.1	5.1	8.3	14	23	38
2,4-DCP	0.6	1.0	1.6	2.6	4.3	7.2	12	20
2,5-DCP	0.5	0.8	1.4	2.3	3.7	6.3	10	17
2,6-DCP	2.0	3.3	5.5	9.1	15	25	41	68
3,4-DCP	0.6	1.0	1.6	2.7	4.4	7.4	12	20
3,5-DCP	0.59	0.7	1.2	2.0	3.4	5.6	9.2	15
2,3,4-TCP	0.5	0.8	1.3	2.2	3.6	6.0	9.9	16
2,3,5-TCP	0.5	0.8	1.3	2.2	3.7	6.1	10	17
2,3,6-TCP	1.6	2.6	4.4	7.2	12	20	33	54
2,4,5-TCP	0.5	0.7	1.2	2.0	3.3	5.6	9.2	15
2,4,6-TCP	1.2	1.9	3.2	5.3	8.8	15	24	40
3,4,5-TCP	0.2	0.3	0.5	0.9	1.4	2.4	3.9	6.4
2,3,4,5-TTCP	0.4	0.6	1.0	1.7	2.8	4.7	7.8	13
2,3,4,6-TTCP	1.1	1.84	2.9	4.9	8.0	13	22	36
2,3,5,6-TTCP	0.5	0.8	1.3	2.2	3.6	6.1	10	17

2,3,4,5,6-PCP	0.2	0.3	0.5	0.7	1.2	2.0	3.4	5.5

1. Multiply the table values by 2 at 0 degrees C and by 0.5 at 20 degrees C.

2. These are maximum values in µg/L.

3. These are final guidelines for PCP and interim guidelines for the other chlorophenol congeners.

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 goal:

- To provide guidelines for the evaluation of data on water, sediment, and biota

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:

- Drinking water
- 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

Only 8 of the 19 chlorophenols are in commercial use. The other 11 are produced incidentally when organic material is chlorinated, as in sewage treatment plants. Chlorophenols are used world-wide as broad spectrum biocides; residues and breakdown products are ubiquitous in air, water, sediments and organisms. Their major use, particularly pentachlorophenol, PCP and tetrachlorophenols, TTCPs, has been as anti-sapstain fungicides in the cut lumber industry. Chlorophenols affect the respiration and energy storage processes common to all higher organisms; the energy stored in food is wasted and is not available for growth and reproduction. Toxicity levels in different organisms are not identical due to differing efficiencies of chlorophenol uptake and elimination. Chlorophenols are notorious for causing taste and odour problems in water, at levels below those which are toxic.

For most organisms there are abundant data on the effects of PCP but few data about the effects of the other chlorophenols. Therefore, the ratios of the toxicities of each chlorophenol to PCP, as determined in several experiments, are applied to the best PCP data to determine guidelines for the other chlorophenols. In mammals chlorophenols are not accumulated to high levels in fat due to rapid excretion, thus keeping bioconcentration factors low. In most mammals the dose of PCP needed to kill one half of the test animals is fairly uniform at about 150 µg/g of body weight.

The environmental half-lives of most chlorophenols are short, rarely as long as a month. Once discharge ceases, levels drop rapidly due to bacterial breakdown. The half-life of chlorophenols in fish is less than

one day and chlorophenols do not accumulate. Hence the existence of high levels in fish tissues indicates chronic or current exposure. Micro-organisms will alter their metabolic processes to utilize chlorophenols. If they have not previously been exposed there will be an initial adaptation period until a large microbial population has been established; any subsequent additions of chlorophenols will be quickly degraded.

Recommended Guidelines

The following guidelines are based on information presented in the technical appendix, and are summarized in the tables at the end of this short report. The Canadian Council of Ministers of the Environment (CCME) has set guidelines for all water uses and all chlorophenols for which we have set guidelines.

RAW DRINKING WATER

We recommend adoption of the existing Canadian Drinking Water Quality Guidelines for Chlorophenols, which have been adopted by the BC Ministry of Health, with the addition of a monochlorophenol criterion of 0.1 µg/L.

The existing Canadian guidelines specify specific isomers and omit any mention of others. We have set aesthetic guidelines based on the total concentration of all the isomers for each group of chlorophenols. The toxicity guidelines are specific for certain congeners in each isomer group.

Aesthetic

For taste and odour, it is recommended that combined concentrations of all the monochlorophenols (MCPs), dichlorophenols (DCPs), trichlorophenols (TCPs) and tetrachlorophenols (TTCPs) should not exceed 0.1 µg/L, 0.3 µg/L, 2 µg/L and 1 µg/L, respectively. The concentration of pentachlorophenol (PCP) should not exceed 30 µg/L. Table 1 under Raw Drinking Water.

Toxicity

It is recommended that the concentrations of 2,4-dichlorophenol, 2,4,6-trichlorophenol and 2,3,4,6-tetrachlorophenol should not exceed 900 µg/L, 5 µg/L and 100 µg/L, respectively. The concentration of pentachlorophenol should not exceed 60 µg/L. Table 1 under Raw Drinking Water.

LIVESTOCK AND WILDLIFE

Aesthetic

The recommended guidelines based on organoleptic effects are the same as the raw drinking water aesthetic guidelines.

Toxicity

The following guidelines, based on toxicity calculations, are recommended with the proviso that such levels, while not toxic, may prove unpalatable to some species. This unpalatability may cause them to restrict their water intake or to search for alternate sources of drinking water. Under some conditions, such as drought, these toxicity-based guidelines may be appropriate, but generally the raw drinking water aesthetic guidelines are recommended.

For lactating animals at high temperatures with high water intake rates (up to 200 mL/kg), it is recommended that the combined concentrations of all the monochlorophenols (MCPs), dichlorophenols (DCPs), trichlorophenols (TCPs) and tetrachlorophenols (TTCPs) should not exceed 185 mg/L, 46 mg/L, 21 mg/L and 41 mg/L, respectively. The concentration of pentachlorophenol (PCP) should not exceed 17.5 mg/L.Table 1 under Livestock and Wildlife Drinking Water.

For non-lactating animals under normal temperatures and water intake rates (20 mL/kg), it is recommended that the combined concentrations of all the monochlorophenols (MCPs), dichlorophenols (DCPs), trichlorophenols (TCPs) and tetrachlorophenols

(TTCPs) should not exceed 1854 mg/L, 460 mg/L, 210 mg/L and 410 mg/L, respectively. The concentration of pentachlorophenol (PCP) should not exceed 175 mg/L.Table 1 under Livestock and Wildlife Drinking Water.

AQUATIC LIFE

Water

It is recommended that the levels of MCPs and DCPs in water containing fish should not exceed 0.1 µg/L and 0.2 µg/L, respectively. The levels of PCP, and of each TCP and TTCP isomer should not exceed the aquatic life toxicity guidelines in Table 3.

Toxicity

The recommended toxicity guidelines for the chlorophenols in Table 3. are in µg/L, calculated for 10 degrees C. The temperature conversion factor is 2 for every 10 degrees C change in temperature (the value would be multiplied by 2 at 0 degrees C and by 0.5 at 20 degrees C). Correction for different pH levels is more complex. A table of guidelines for pH values in the range pH 5.7 to pH 9.2 was calculated for the chlorophenols. Except for PCP, these should be considered interim guidelines until properly controlled experiments can provide a unified temperature and pH-dependent regression equation for each chlorophenol.

To protect aquatic life, chlorophenol levels in water should not exceed those in Table 3.

IRRIGATION

No data were found documenting the effects of chlorophenols on irrigation uses of water. Terrestrial plants are less sensitive to chlorophenols than are aquatic organisms; any effects found were in the mg/L range. Therefore, water suitable for aquatic life or drinking should also be suitable for irrigation. No guidelines were set for this use.

RECREATION

General

There are no data documenting the effects of chlorophenols on recreational uses of water. Human taste and odour thresholds for some chlorophenols in water are available, as are taste thresholds for some chlorophenols in fish meat. No published taste thresholds for crustacean or mollusc meat were found for the chlorophenols.

Primary-Contact

Since swimming involves contact of the face with the water, taste and odour thresholds for the chlorophenols should be met. These are the critical factors determining raw drinking water aesthetic guidelines, and should give adequate protection to waters used for swimming.

> ***Water used for primary-contact recreation should meet the drinking water aesthetic guidelines.***

AESTHETICS

For distant scenic and vista uses, no guidelines are necessary. For proximal uses, the odour thresholds in water are appropriate. These vary with water temperature and are a function of the molecular weight and volatility of the chlorophenol. The more chlorine atoms substituted, the lower the volatility and the higher the threshold concentration for odour detection.

> ***It is recommended that water designated for aesthetic use should not exceed 0.3 µg/L MCPs or DCPs, 11 µg/L TCPs, 600 µg/L TTCPs and 860 µg/L PCP.***

INDUSTRIAL

No data were found documenting the effects of chlorophenols on industrial uses of water.

> ***Due to taste and odour concerns, the food and beverage industries should use the raw drinking water aesthetic guidelines, and the aquaculture industry should meet the aquatic life toxicity and flavour impairment guidelines.***

A few other industries with a need for very high quality water would likely have to use point-of-use treatment to keep chlorophenols below acceptable levels, if the local supply was not adequate.

Application of Guidelines

There were seven pairs of data points, derived from experiments with fish, which indicated that an appropriate ratio of the no-observed-effect to LC_{50} response was 0.041. *Daphnia* data was used to derive the ratio of PCP response to that of the other chlorophenols but this data is only valid at one pH value. Some equations developed using guppies allow one to derive PCP guidelines for various pH levels. Comparison of these guppy ratios at the same pH as the *Daphnia* ratios shows good agreement. Trout and frogs are about 50 times more sensitive than *Daphnia* and guppies so the values derived using the more complete *Daphnia* and guppy data sets were adjusted to reflect this greater sensitivity.

The guidelines for chlorophenols are pH and temperature dependent since the effects are metabolic. Temperature correction is the well known factor-of-two change for a ten degree Celsius temperature change but pH correction is more complex and the criterion has to be recalculated for each pH value and for each chlorophenol. Water hardness does not seem to have a predictable effect on chlorophenol toxicity, however in natural waters pH and hardness would be well correlated. It does not seem to make much difference whether one uses literature no-observed-effect levels, applies a 0.1 safety factor to the lowest literature chronic effect levels or applies an acute-to-chronic effect ratio factor to the lowest LC_{50} data in the literature. Much the same guidelines result.

The assumptions used in deriving these guidelines are:

1. the ratio of the toxicity of any chlorophenol to that of PCP, as derived in guppies, is nearly the same in other species
2. the pH response curve found for guppies also holds for other species
3. the temperature dependence curve found for the fish *Notopterus notopterus* also holds true for other species.