Water Quality

Ambient Water Quality Criteria for Polycyclic Aromatic Hydrocarbons (PAHs)

Overview Report

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

Original signed by J. O'Riordan
Assistant Deputy Minister
Ministry of Environment, Lands and Parks
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Summary

This report is one in a series that establishes ambient water quality criteria for British Columbia. It includes an overview which is followed by the main body of the report. This document sets criteria for polycyclic aromatic hydrocarbons (PAHs) to protect drinking water, freshwater and marine aquatic life, recreational waters and food-processing industries.

Criteria for wildlife, irrigation and livestock use were not set in this document because pertinent information about the effects of PAHs on these water uses is lacking. There are no CCME (Canadian Council of Ministers of the Environment) guidelines for any of the water uses for which we have set PAH criteria.

Aquatic life is the most sensitive water use affected by polycyclic hydrocarbons. In particular, aquatic organisms are very vulnerable to the phototoxic effects of PAHs that accumulate in their tissues. The criteria for PAHs are summarized in Table 2. and Table 3. A more detailed discussion of the criteria is presented in the main body of the report.

Tables

Table 1: Maximum Allowable Concentrations of B[a]P in Fish and Shellfish

B[a]P Concentration in the Edible Portion of Fish / Shellfish	Safe Quantity for Weekly* Consumption on a Regular Basis

Ministry of Environment Water Protection and Sustainability Branch
Environmental Sustainability
and Strategic Policy Division
Mailing Address:
PO Box 9362
Stn Prov Govt
Victoria BC V8W 9M2
Telephone: 250 387-9481
Facsimile: 250 356-1202
Website: www.gov.bc.ca/water

(µg B[a]P/kg Wet Weight)	(g Wet Weight)
4	50
2	100
1	200

**** Low and moderate consumption levels, according to the State of Washington, are: 45 g/week (or 6.5 g/day) and 140 g/week (or 20 g/day), respectively***

Table 2: Summary of Criteria for Polycyclic Aromatic Hydrocarbons (PAHs)

Water Use	PAHs	Recommended Concentration
Drinking Water Supply	B[a]P	0.01 µg/L
Wildlife Water Supply	—	None proposed
Livestock Water Supply	—	None proposed
Irrigation Water Supply	—	None proposed
Fish and/or Shellfish (edible tissue for human consumption) - low consumption of 50 g/week	B[a]P	4 µg/kg wet weight
Fish and/or Shellfish (edible tissue for human consumption) - moderate consumption of 100 g/week	B[a]P	2 µg/kg wet weight
Fish and/or Shellfish (Edible Tissue for Human Consumption) - Heavy Consumption of 200 g/Week	B[a]P	1 µg/kg wet weight
Primary Contact Recreation	—	None proposed
Food Processing Industries	B[a]P	0.01 µg/L

Table 3: Summary of Aquatic Life and Sediment Criteria for Polycyclic Aromatic Hydrocarbons (PAHs)

PAH	Fresh Water (chronic)	Fresh Water (phototoxic)	Marine Water	Sediments (Fresh Water)	Sediments (Marine)
Naphthalene	1 µg/L	NR	1 µg/L	0.01 µg/g	0.01 µg/g
Methylated naphthalene	NR	NR	1 µg/L	NR	NR
Acenaphthene	6 µg/L	NR	6 µg/L	0.15 µg/g	0.15 µg/g
Fluorene	12 µg/L	NR	12 µg/L	0.2 µg/g	0.2 µg/g
Anthracene	4 µg/L	0.1 µg/L	NR	0.6 µg/g	NR
Phenanthrene	0.3 µg/L	NR	NR	0.04 µg/g	NR
Acridene	3 µg/L	0.05 µg/L	NR	1 µg/g	NR
Fluoranthene	4 µg/L	0.2 µg/L	NR	2 µg/g	NR
Pyrene	NR	0.02 µg/L	NR	NR	NR
Chrysene	NR	NR	0.1 µg/L	NR	0.2 µg/g
Benz[a]anthracene	0.1 µg/L	0.1 µg/L	NR	0.2 µg/g	NR
Benzo[a]pyrene	0.01 µg/g	NR	0.01 µg/g	0.06 µg/g	0.06 µg/g

NR - not recommended due to insufficient data
****sediment containing 1% organic carbon***

Table 4: B[a]P Concentration in Smoked Fish and Shellfish

Organism	B[a]P (wet weight)	Organism	B[a]P (wet weight)	Organism	B[a]P (wet weight)
Haddock[a]	up to 0.05 µg/g	Saithe[b]	less than 0.10 µg/g	Oyster[b]	3.9 µg/g
Cod[a]	up to 0.05 µg/g	Mussell[b]	1.0 µg/g	Oyster[b]	0.4 µg/g
Herring[a]	up to 0.05 µg/g	Mussell[b]	3.9 µg/g	Oyster	2.8 µg/g

Arctic Char[a]	up to 0.05 µg/g	Mussell[b]	0.8 µg/g	Oyster	2.3 µg/g
Digby Chix[a]	up to 0.05 µg/g	Mussell (average)	1.5 µg/g	Oyster	13.3 µg/g
Sardine[b]	0.5 µg/g	Oyster[b]	7.7 µg/g	Oyster (average)	2.9 µg/g
Kippers[b]	less than 0.10 µg/g	Oyster[b]	1.6 µg/g	—	—

a - fresh smoked fish
b - canned smoked fish / shellfish
Source: Health and Welfare Canada

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 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.

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

Polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) are organic compounds composed of two or more benzene rings fused together. Theoretically, a large number of compounds can belong in the PAH category. The environmentally significant PAHs, however, are those molecules containing two to seven benzene rings. Naphthalene (molecular weight, 128.16 g) is an example of a PAH molecule having two benzene rings; coronene (molecular weight, 300.34 g) is an example having seven.

Several factors determine the physical, chemical and biological characteristics of PAHs. The low molecular weight PAHs-those containing two to three benzene rings, for example, naphthalenes, fluorenes, phenanthrenes and anthracenes are acutely toxic to aquatic organisms, whereas the high molecular weight PAHs-those containing four to seven rings-are not. However, several high molecular weight PAHs are known to be carcinogenic (e.g., B[a]P).

Among the large number of PAHs, only a few are manufactured in Canada and the USA. Forest fires and prairie fires, agricultural burning, and fossil-fuels are the major contributors of PAHs to the environment.

Recommended Guidelines

The following criteria are based on information presented in the main body of the report, and are summarized in Table 2 and Table 3 at the end of this overview. The Canadian Council of Ministers of the Environment (CCME) did not recommend PAH guidelines for any of the water uses given here.

RAW DRINKING WATER

In this document, PAH criteria for raw drinking water are given for benzo[a]pyrene, B[a]P.

> ***It is recommended that the B[a]P concentration in raw drinking water should not exceed 0.01 µg/L.***

This is the current Canadian / British Columbia drinking water guideline.

AQUATIC LIFE

Water

> ***To protect freshwater aquatic life from phototoxic and long-term effects, and to protect marine aquatic life from long-term effects, it is recommended that PAH concentrations in water should not exceed those in***

Table 2.

FISH AND SHELLFISH

To protect consumers of fish and shellfish, it is recommended that B[a]P concentrations in edible tissue should not exceed the values in Table 1.

The criteria in Table 1 are interim criteria. They will be superseded by criteria from Canadian or British Columbia health authorities.

SEDIMENT

To protect aquatic life from the harmful effects of PAHs in sediment, it is recommended that PAH concentrations in freshwater and marine sediments containing 1.0% organic carbon should not exceed those shown in Table 3. For a sediment with an organic carbon content other than 1.0%, an appropriate criterion can be obtained by multiplying the recommended criterion by the actual organic carbon content of the sediment (e.g. if the sediment had 5% organic carbon you would multiply the sediment guideline value in Table 3 by 5) .

WILDLIFE

PAH criteria for wildlife are not recommended in this document due to the lack of pertinent information in the literature.

LIVESTOCK

PAH criteria for livestock watering are not recommended in this document due to the lack of pertinent information in the literature.

IRRIGATION

PAH criteria for irrigation waters are not recommended in this document due to the lack of pertinent information in the literature.

RECREATION AND AESTHETICS

PAH criteria for recreational water uses are not recommended in this document due to the lack of pertinent information in the literature.

INDUSTRIAL WATER USES

PAH criteria for food-processing and beverage industries are the same as the drinking water criteria. It is recommended that B[a]P concentrations in water supplies used for food processing and related industries should not exceed 0.01 µg/L.

Application of the Guidelines

PHOTOTOXIC vs LONG-TERM CRITERIA

The ecological significance of photo-induced toxicity of PAHs on aquatic environments has not been fully explored. However, it is evident from data presented in the literature that phototoxicity is relatively more severe and hazardous to aquatic organisms in clear shallow waters than are long-term effects in the absence of solar UV radiation. Juveniles of most fish are found in shallow areas of the littoral zone or on the surface as pelagic larvae, and would be extremely vulnerable.

Therefore, we recommend that the criteria developed to protect freshwater aquatic life from phototoxic effects, if available, should take precedence over the criteria to protect against long-term effects. If PAH levels in a specific waterbody exceed the phototoxic criteria, but the aquatic life does not show adverse effects of PAHs introduced by human activities, the long-term criteria should be applied to manage and control further deterioration of water quality.

ASSESSMENT OF EXISTING WATER QUALITY

The water quality criteria we recommend in this document are based primarily on controlled, laboratory bioassays in which the toxic effects on organisms were measured in terms of PAH levels in water. However, the PAH body burden of aquatic organisms in their natural environments is the result of exposure to both water and food sources. PAHs associated with the sediment fraction are also available to the organisms under favourable environmental conditions.

Thus, PAH concentrations in water alone should not be taken as a true reflection of the potential PAH problem in a given waterbody. Other assessment techniques are required, which include the measurement of PAH concentrations in fish and/or sediment, and long-term bioassays with resident species using local water.

The guidelines for PAHs in fish and sediment can be used as parameters for the assessment of existing water quality. Long-term bioassays are complex and costly. They are likely to be undertaken for waterbodies with high resource values, which are threatened by a controllable point-source of PAH pollution.

SETTING WATER QUALITY OBJECTIVES

PAHs can be produced naturally in the environment. When concentrations of PAHs in undeveloped waterbodies are less than the criteria levels, then the criteria-or more stringent values, if justified-should apply. In some cases, socioeconomic or other factors may justify objectives that are less stringent than the criteria. Such cases would require site-specific impact studies.

PAH LEVELS IN SMOKED FISH

There is often a concern that PAH concentrations-for example, B[a]P concentrations-in smoked fish and shellfish may exceed the criteria recommended under the section Fish and Shellfish. As shown in Table 4, in most cases these criteria will protect consumers from the harmful effects of B[a]P in smoked fish and shellfish.

There may be an exception for those consuming smoked oysters, which show a considerable variability in B[a]P concentrations, with some values exceeding the recommended criteria (Table 4). The high variability in the B[a]P values in oysters may be attributed, in part, to sampling and analytical problems. Nevertheless, the average (geometric mean) B[a]P concentration in oysters will not harm those consumers who eat small amounts of fish and shellfish. B[a]P concentration in canned smoked oysters might be problematic for consumers who eat moderate to high amounts of fish and shellfish. But this is unlikely. The consumption of these foods, on average, may fall short of the amounts indicated in the Fish and Shellfish section due to the availability of other food sources that are more common, less expensive and relatively uncontaminated with B[a]P. Obviously, more data are required on B[a]P levels and human consumption patterns to assess the potential toxicity of PAH in smoked oysters. Currently, Health and Welfare Canada does not consider B[a]P in smoked foods to be a health hazard.