Water Quality

Water Quality Criteria for Microbiological Indicators

Overview Report

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Environment Management Act, 1981

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Summary

This report is part of a series establishing water quality criteria for British Columbia. It sets criteria for microbiological indicators, which are bacteria indicating the risk of disease from pathogenic bacteria. The criteria are set to protect drinking water, shellfish harvesting, livestock watering, irrigation, recreation and industry from bacterial but not from viral pathogens. Fecal coliforms have historically been the indicator of choice, but their presence does not always correlate well with the incidence of disease. Coliforms are therefore now being supplanted by more specific indicators. These include *Escherichia* coli and enterococci which are good indicators of gastrointestinal disease, and *Pseudomonas aeruginosa* which correlates well with ear and skin infections. Criteria are set in this report for these three other indicators as well as for fecal coliforms. Although the fecal coliform criteria are the only ones that apply now, they will be phased out in the future as the change to other organisms occurs. No criteria are set for viruses since an adequate routine monitoring technique is not yet available. The Canadian Water Quality Guidelines published by the CCREM in 1987 deal only with coliform bacteria for drinking water, recreation and irrigation. They are consistent with our criteria except for irrigation which we address in more detail.

Tables

Table 1. Summary of Water Quality Criteria for Microbiological Indicators

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

Water Use	Escherichia coli	Enterococci	Pseudomonas aeruginosa	Fecal coliforms
Raw Drinking Water - no treatment	0/100 mL	0/100 mL	0/100 mL	0/100 mL
Raw Drinking Water - disinfection only	less than or equal to 10/100 mL 90th percentile	less than or equal to 3/100 mL 90th percentile	None applicable	less than or equal to 10/100 mL 90th percentile
Raw Drinking Water - partial treatment	less than or equal to 100/100 mL 90th percentile	less than or equal to 25/100 mL 90th percentile	None applicable	less than or equal to 100/100 mL 90th percentile
Raw Drinking Water - complete treatment	None applicable	None applicable	None applicable	None applicable
Aquatic Life - shellfish harvesting	less than or equal to 43/100 mL 90th percentile	less than or equal to 11/100 mL 90th percentile	None applicable	less than or equal to 43/100 mL 90th percentile
Aquatic Life - shellfish harvesting	less than or equal to 14/100 mL median	less than or equal to 4/100 mL median	None applicable	less than or equal to 14/100 mL median
Wildlife	None applicable	None applicable	None applicable	None applicable
Livestock - free range animals	None applicable	None applicable	None applicable	None applicable
Livestock - general livestock use	200/100 mL maximum	50/100 mL maximum	None applicable	200/100 mL maximum
Livestock - closely confined (no treatment)	0/100 mL maximum	0/100 mL maximum	None applicable	0/100 mL maximum
Livestock - closely confined (disinfection only)	less than or equal to 10/100 mL 90th percentile	less than or equal to 3/100 mL 90th percentile	None applicable	less than or equal to 10/100 mL 90th percentile

Livestock - closely confined (partial treatment)	less than or equal to 100/100 mL 90th percentile	less than or equal to 25/100 mL 90th percentile	None applicable	less than or equal to 100/100 mL 90th percentile
Livestock - closely confined (complete treatment)	None applicable	None applicable	None applicable	None applicable
Irrigation - crops eaten raw	less than or equal to 77/100 mL geometric mean	less than or equal to 20/100 mL geometric mean	None applicable	less than or equal to 200/100 mL geometric mean
Irrigation - public access - livestock access	less than or equal to 385/100 mL geometric mean	less than or equal to 100/100 mL geometric mean	less than or equal to 10/100 mL 75th percentile	None applicable
Irrigation - general irrigation	less than or equal to 1000/100 mL geometric mean	less than or equal to 250/100 mL geometric mean	None applicable	less than or equal to 1000/100 mL geometric mean
Recreation - aesthetics - non contact	None applicable	None applicable	None applicable	None applicable
Recreation - secondary contact - crustacean harvesting	less than or equal to 385/100 mL geometric mean	less than or equal to 100/100 mL geometric mean	less than or equal to 10/100 mL 75th percentile	None applicable
Recreation - primary contact	less than or equal to 77/100 mL geometric mean	less than or equal to 20/100 mL geometric mean	less than or equal to 2/100 mL 75th percentile	less than or equal to 200/100 mL geometric mean
Industrial Water (dairy, food processing) - no treatment	0/100 mL	0/100 mL	None applicable	0/100 mL
Industrial Water (dairy, food processing) - disinfection only	less than or equal to 10/100 mL 90th percentile	less than or equal to 3/100 mL 90th percentile	None applicable	less than or equal to 10/100 mL 90th percentile

Industrial Water (dairy, food processing) - partial treatment	less than or equal to 100/100 mL 90th percentile	less than or equal to 25/100 mL 90th percentile	None applicable	less than or equal to 100/100 mL 90th percentile
Industrial Water (dairy, food processing) - complete treatment	None applicable	None applicable	None applicable	None applicable
Industrial Water - other industries	less than or equal to 385/100 mL geometric mean	less than or equal to 100/100 mL geometric mean	less than or equal to 10/100 mL 75th percentile	None applicable

1. Fecal coliform criteria which presently exist will apply on an interim basis until use of the other preferred indicators is adopted.

2. For the dairy industry there is an additional criterion of less than or equal to 5/100 mL lipolytic and/or proteolytic bacteria.

3. Medians and geometric means are calculated from at least 5 samples in a 30-day period. Ten samples are required for 90th percentiles.

4. These recreation and shellfish harvesting criteria are applicable to fresh and marine waters, except the E. coli criteria, which apply only to fresh water.

5. Only a few salad greens which cannot be adequately washed to remove adhering or trapped pathogens are of concern under the crops eaten raw section of irrigation. Examples include lettuce, cabbage, broccoli, cauliflower and similar crops.

6. These primary contact recreation criteria may be subject to revision depending upon the future results of a federal/provincial study group on Canadian recreational water quality.

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

Contaminated water has always been an important agent in the spread of disease. Ingestion may cause gastrointestinal diseases, and skin diseases may be caused by immersion. Water treatment and disinfection have markedly reduced the incidence of many diseases, but the need for constant vigilance and enforcement of standards is highlighted by the occasional water-borne disease epidemic. Microbiological criteria are presently undergoing re-evaluation throughout the world, and the historical dependence upon total and fecal coliforms is being supplanted by more specific, epidemiologically-derived indicators of water quality. Eventually, each use of the water and source of contamination should have a representative specific indicator associated with a regression equation so that disease risks can be quantified. Once this occurs, the costs of achieving a given water quality could be directly compared with the savings in health care costs resulting from this level of water quality.

Organisms which are pathogenic to humans are rarely capable of survival as free-living organisms for very long. Virtually all the water-borne diseases affecting humans are a result of poor waste treatment and disposal practices; the disposal of disease organisms carrying resistance to antibiotic drugs is of particular concern. The harvesting of shellfish for human consumption is particularly sensitive to water quality since these organisms filter out and concentrate pathogens found in the water at relatively low levels. Contaminated shellfish have been responsible for many disease epidemics, but due to the rigorous sanitary surveys carried out before shellfish harvesting areas are opened, no sewage-contaminated shellfish have caused a disease outbreak in British Columbia.

Since the direct monitoring of all possible pathogens would be too slow and uneconomical for routine water quality control, microbiological water quality is commonly estimated or monitored using a single or a few indicator organisms. The validity and usefulness of the indicator concept depends upon the existence of a constant quantitative relationship between the indicator organism and the pathogens it is monitoring. Establishing such relationships is a complex process, and several indicators are necessary if acceptable health risks are to be assigned to all pathogens in an economical manner. This indicator-to-pathogen ratio may change when an epidemic occurs or if changes take place in the quality of health care and treatment.

Pseudomonas aeruginosa is a common opportunistic pathogen of man which causes ear infections and other non-gastrointestinal infections when present in recreational waters. These include hot tubs, whirl pools and swimming pools. It is not adequately monitored by such gastrointestinal indicators as the coliforms and needs to be monitored directly. Enterococci are better indicators than fecal coliforms and most closely approach the ideal characteristics of an indicator for gastrointestinal diseases. They are the best indicators for recreational uses, especially in marine waters where E. coli do not survive as well. They are not as useful in water with high organic wastes from vegetable processing, but are good in assessing reservoir quality, sewage-contaminated water supplies and chlorinated water high in organics. *Escherichia coli* is a better indicator than fecal coliforms since *Klebsiella* is not enumerated in the *E. coli* test. *Klebsiella* may multiply in water containing pulp mill effluent and other organics, which is not contaminated by human sewage, and thus gives false positives for fecal contamination. These indicators have higher correlations with specific types of disease under specified conditions than does the fecal coliform test, and are recommended as replacements for fecal coliforms.

Both employees and the general public may be subjected to pathogens in aerosols formed in several industrial processes. For example, *Klebsiella* pneumonia builds up in pulp mill process water and *Legionella pneumophila* multiplies in cooling towers, humidifiers and air conditioning systems. These problems can not be controlled by ambient water quality control since contamination and multiplication often occur subsequent to delivery of the water to the plant. These are waste-water management problems or process control problems.

The criteria are based on bacteria present in human and animal feces as distinct from other bacteria which may be found in sewage. These indicators are meant to be fecal indicators as opposed to sewage indicators. While these terms may, in some circumstances be synonymous, they are not necessarily so and some conditions will be found where different indicators are best for quantifying sewage contamination. The fecal bacteria from animals indicate less risk of disease to people than do those from humans. Since ambient water can contain a mix of human and animal fecal contamination, the criteria may be over-protective if all the indicator organisms came from animals or under-protective if all the indicator organisms came from humans.

There are no routine monitoring techniques for viruses, hence no criteria for viruses have been set. The risk of viral disease is not always known when using criteria based on bacteria. However, given the usual uses of ambient water in the province, the criteria presented here are expected to provide a high degree of protection.

A summary of the Water Quality Criteria for Microbiological Indicators is given in Table 1. The criteria for fecal coliforms are the only ones that apply now. They will be phased out as a change to the other indicator organisms occurs. A summary of non-criteria 'Other Recommendations' is included.

Recommended Guidelines

The criteria are based on detailed analyses given in a technical document.

Raw Drinking Water

Most surface waters should be treated before distribution to the consumer. The BC Ministry of Health recommends that all supplies derived from surface water and shallow ground water sources receive disinfection as a minimum treatment. The degree of treatment needed is a function of the quality of the raw water. Protection of surface water to a degree that would eliminate health risks without treatment of the raw water is impractical in most cases. The criteria describe the raw water quality necessary for a given level of water treatment. If prevention fails to maintain raw water quality, then additional treatments or location of alternate water supplies with their added costs, become necessary. The intent of the treatment processes is to deliver water to the consumer's tap which is free of potentially harmful microorganisms, is aesthetically acceptable to the user and otherwise meets drinking water quality standards.

Most water treatments reduce viruses to a certain extent, but none except disinfection can do a complete job. Both chlorine and ozone are effective in clear water. Generally speaking [at pH's below 8.0, turbidities below 1 NTU, temperatures above 40 degrees celcius, and a free chlorine residual above 0.5 mg/L] 30 minutes exposure is required to achieve virus-free water. However, there are exceptions and viral monitoring must take place to determine the effectiveness of the treatment.

Most existing criteria were set using fecal coliform bacteria as the indicator and may need to be adjusted to reflect the use of *Escherichia coli*, as the indicator of choice in this report. If, as is the case for shellfish harvesting sites, testing shows that most of the fecal coliforms are *E. coli*, then the *E. coli* criteria may be numerically identical to those of the present fecal coliform criteria. Fecal coliform criteria are also given and are intended as interim criteria. while the change to *E. coli* is taking place. Until testing is carried out and the correct ratio of *E. coli* to fecal coliforms is determined on a site-specific basis, *E. coli* criteria will be recommended as the numerical equivalent of the fecal coliform criteria. Regression equations developed by the EPA show a 4:1 ratio between the criteria for *E. coli* and the criteria for enterococcus, at the recommended risk level of 8/1000. This same ratio is used in the criteria below.

Raw Water Without Treatment

The following criteria are recommended to provide guidance in those cases where raw drinking water does not receive any treatment prior to use. This occurs in wilderness camping areas; some campgrounds, particularly at higher elevations; and in some smaller or remote communities.

- Escherichia coli should not be present in any 100 mL sample of raw drinking water.

- Enterococci should not be present in any 100 mL sample of raw drinking water.

- Pseudomonas aeruginosa should not be present in any 100 mL sample of raw drinking water.

- Fecal coliforms should not be present in any 100 mL sample of raw drinking water.

Raw Water Receiving Disinfection Only

- Escherichia coli should not exceed 10/100 mL in at least 90% of the raw water samples taken in a 30-day period.

- Enterococci should not exceed 3/100 mL in at least 90% of the raw water samples taken in a 30-day period.

- Fecal coliforms should not exceed 10/100 mL in at least 90% of the raw water samples taken in a 30-day period.

Raw Water Receiving Partial Treatment Consisting of Filtration or Sedimentation, and Disinfection

- Escherichia coli should not exceed 100/100 mL in at least 90% of the raw water samples taken in a 30-day period.

- Enterococci should not exceed 25/100 mL in at least 90% of the raw water samples taken in a 30-day period.

- Fecal coliforms should not exceed 100/100 mL in at least 90% of the raw water samples taken in a 30-day period.

Raw Water Receiving Complete Treatment Consisting of Coagulation, Flocculation, Sedimentation, Filtration, Adsorption or Other Forms of Advanced Treatment and Disinfection

When the *Escherichia coli* or fecal coliform criterion for raw drinking water receiving disinfection and partial treatment is exceeded, complete treatment is necessary. There are no upper limits to *E. coli*, enterococci, or fecal coliform levels in raw water receiving complete treatment.

Application of Raw Drinking Water Criteria

While they are not specifically recommended as indicators, *Salmonella*, *Campylobacter*, *Vibrio*, *Klebsiella pneumoniae*, *Aeromonas hydrophila, Giardia lamblia*, *Shigella*, *Yersinia enterocolitica*, *Clostridium perfringens*, *Mycobacterium tuberculosis*, enteric viruses and *Proteus* should be monitored occasionally since they can not always be quantitatively predicted by the recommended indicators. A health hazard may exist if they are found in any 100 mL sample of raw or treated water.

The recommended criteria for raw water are not meant to be necessarily sufficient, but only represent minimum guides. After treatment, the finished water must meet the British Columbia Drinking Water Quality Standards (1982) at the consumer's tap. If the indicated raw water treatment cannot produce water of the required quality from the raw water supply, then either better quality raw water must be sought or more advanced treatment used. The interim fecal coliform criteria are the same as the CCREM Guidelines.

Aquatic Life

There are insufficient data to set criteria for the protection of the health of aquatic organisms. The criteria below are for fresh or marine waters used for the growth and harvesting of shellfish for human consumption where the shellfish may be eaten raw and are used directly without a cleansing period prior to killing. Since *Salmonella* and coliforms may survive in the shell liquor up to 60 days after harvest, and viruses may remain viable for up to 6 weeks in shellfish, a cleansing period of up to ten weeks in clean water should be the minimum when shellfish are harvested from waters not known to be free of bacterial or viral pathogens. Current practice shows that two weeks is an adequate cleansing period but this procedure has not been used when shellfish were grown in grossly contaminated water.

> *- The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.*
>
> *- The enterococci density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 4/1 00 mL, and at least 90% of the samples in a 30-day period should not exceed 11/100 mL.*
>
> *- The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.*

> *In addition to the above water quality criteria, the meat of shellfish must meet a maximum criterion of 230 E. coli or fecal coliforms/100 g wet weight.*

If shellfish grown in water which meets the above water criteria do not meet the meat criterion, then higher quality growing water must be sought or a cleansing period must precede harvest and marketing. A sanitary survey of the processing plant may also be in order to determine if the shellfish are being contaminated after harvesting during processing. No CCREM Guideline is given for this use of the water.

Wildlife

No criteria are recommended for this use of fresh and marine waters due to a lack of epidemiological or other objective data. No CCREM Guideline is given for this use of the water.

Livestock

Three distinct types of livestock operations are recognized based upon animal density and thus the risk of a disease epidemic.

For unconfined or free-ranging animals no criteria are recommended.

For closely confined animals, battery, feedlot and other high density operations, the raw drinking water criteria are recommended.

> *- Escherichia coli should not be present in any 100 mL sample of raw drinking water*
>
> *- Enterococci should not be present in any 100 mL sample of raw drinking water*
>
> *- Pseudomonas aeruginosa should not be present in any 100 mL sample of raw drinking water*
>
> *- Fecal coliforms should not be present in any 100 mL sample of raw drinking water*

For general livestock use on farms, where neither of the two previously mentioned animal density extremes occurs, the recommended criteria are based on those of Manitoba in 1979.

> *- The fecal coliform density in fresh waters used by livestock should not exceed a maximum of 200/100 mL*
>
> *- The E. coli density in fresh waters used by livestock should not exceed a maximum of 200/100 mL*
>
> *- The enterococci density in fresh waters used by livestock should not exceed a maximum of 50/100 mL*

There is no specific CCREM Guideline for livestock water. CCREM recommends that high-quality water be given to livestock in high density operations, and that the water supply of free-range livestock be monitored for pathogens and chlorinated if necessary.

Irrigation

These criteria are designed to protect the ultimate consumers of the crop, grazing animals, farm workers, and in the case of non-farm irrigation, the general public. The criteria depend upon the method of applying the irrigation water, the type of crop grown, and the way the crop is used.

Water Used to Irrigate Crops Eaten Raw

Water used for the sub-surface, surface or spray irrigation of produce which may be eaten raw, can not be adequately washed, or is not processed sufficiently to kill pathogens, should ideally meet the drinking

water criteria for raw water without treatment except that the Pseudomonas aeruginosa criterion does not apply. Examples of such crops include strawberries, cauliflower, lettuce, cabbage and broccoli, and uses include aerial spraying of vineyards, market gardens and orchards. However, until epidemiological evidence becomes available we propose using the primary-contact recreation criteria.

> *- The fecal coliform level for the irrigation of crops eaten raw should not exceed 200/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.*
>
> *- The E. coli level for the irrigation of crops eaten raw should not exceed 77/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.*
>
> *- The enterococci level for the irrigation of crops eaten raw should not exceed 20/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.*

Water Used to Irrigate Areas Open to the Public or to Livestock

Water used for the irrigation of parks, playgrounds, and school yards, or where there is public or livestock access to the recently irrigated area, or to the aerosols during irrigation, should meet the following secondary-contact recreation criteria.

> *- The Escherichia coli level should not exceed 385/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.*
>
> *- The Enterococci level should not exceed 100/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.*
>
> *- The Pseudomonas aeruginosa level should not exceed 10/100 mL in at least 75% of the samples. There should be at least 5 samples in a 30-day period.*

Water Used to Irrigate Areas where there is no Public or Livestock Access and the Crops are not Eaten Raw

Water used for all other uses where there is no public or grazing access and the crops are not eaten raw by humans should meet the following Alberta, Saskatchewan and Manitoba criteria.

- The fecal coliform level should not exceed 1000/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.

- The Escherichia coli level should not exceed 1000/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.

- The enterococci level should not exceed 250/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.

The CCREM tentative guideline is a maximum of 100/100 mL of fecal coliforms and 1000/100 mL of total coliforms in all irrigation water from a surface or ground water source. We believe that the CCREM guideline is too stringent for general irrigation use. Different uses of irrigation water require different criteria depending upon the health risk perceived for each use. Epidemiological studies are needed to determine the proper criteria for crops irrigated with contaminated water then eaten raw.

Recreation

Existing recreation criteria are presently designed to protect people who swallow water. While these criteria are related to the quantitative risk of gastrointestinal tract infection, they do not address the major non-gastrointestinal infections associated with water-contact recreation. Drinking water indicators are used for swimming pool and hot tub criteria, but these indicators are neither specific nor quantitative for those organisms causing non-gastrointestinal infections.

The secondary-contact recreation criteria should be considered tentative and hopefully conservative. They should afford adequate protection against the risk of disease from such recreational use of water until complete epidemiological studies can provide statistically defensible, permanent criteria in the form of regression equations, as has been done for primary-contact recreation.

Water Used Solely for Aesthetic Non-Contact Recreation

No criteria for any water-borne pathogens are recommended for this water use. Criteria may be required for concomitant aquatic life or wildlife uses. No CCREM Guideline is given for this use of the water.

Water Used for the Recreational Harvest of Shellfish or other Filter Feeders

The shellfish criteria are recommended.

> *- The Escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.*
>
> *- The Enterococci density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 4/1 00 mL, and at least 90% of the samples in a 30-day period should not exceed 11/100 mL.*
>
> *- The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.*

No CCREM Guideline is given for this use of the water.

Water Used for Secondary-Contact Recreation and for the Recreational Harvest of Crustaceans and other non-Filter Feeders

Secondary-contact recreation is defined as an activity where a person would have very limited direct contact with the water, usually only the feet and hands, and little risk of complete immersion. Some examples of activities include boating, fishing, flat water kayaking, canoeing and rafting,. etc. See primary-contact recreation below. No CCREM Guideline is given for this use of the water.

Gastrointestinal Disease Criteria

No fecal coliform criteria are recommended for secondary-contact recreation in fresh and marine waters due to a lack of information or existing guidelines.

> *- The Escherichia coli level for secondary-contact recreation in fresh water should not exceed a geometric mean of 385/100 mL. There should be at least 5 samples in a 30-day period.*
>
> *- The Enterococci level for secondary-contact recreation in fresh and marine waters should not exceed a geometric mean of 100/100 mL. There should be at least 5 samples in a 30-day period.*

Ear and Skin Infection Criteria

> *- The level of Pseudomonas aeruginosa in fresh and marine waters used for secondary-contact recreation should not exceed 10/100 mL in at least 75% of the samples. There should be at least 5 samples in a 30-day period.*

Water Used for Primary Contact Recreation

Primary-contact recreation is defined as an activity where a person would have direct contact with water over most of the body's surface, to the point of complete submergence, or where there is substantial risk of ingestion or intimate contact with eyes, ears, nose, mouth or groin.

Some examples of activities include swimming, diving, wading, SCUBA, and water sports where dunking is commonly expected such as white water canoeing, kayaking and rafting, board and windsurfing, water skiing, log birling, snorkeling, etc. See secondary-contact recreation above. Some specific activities could go in either primary-contact recreation or secondary-contact recreation, depending upon the conditions and skill of the participant. For example, experienced windsurfers and kayakers are unlikely to get dunked except under adverse conditions, whereas novices will likely get dunked under ideal conditions. The above activities were placed in the primary-contact category to provide protection to novices and to experienced people during adverse conditions.

These primary contact recreation criteria may be subject to revision depending upon the future results of a federal-provincial study group on Canadian recreational water quality.

Gastrointestinal Disease Criteria

> *- The fecal coliform level for primary-contact recreation in fresh and marine waters should not exceed a geometric mean of 200/100 mL in 5 samples taken in a 30-day period. This is the CCREM Guideline.*
>
> *- The Escherichia coli level for primary-contact recreation in fresh water should not exceed a geometric mean of 77/100 mL. There should be at least 5 samples in a 30-day period.*
>
> *- The Enterocci level for primary-contact recreation in fresh and marine waters should not exceed 20/100 mL as a geometric mean. There should be at least 5 samples in a 30-day period.*

Ear and Skin Infections

- The level of Pseudomonas aeruginosa in fresh and marine waters used for primary-contact recreation should not exceed 2/100 mL in at least 75% of the samples. There should be at least 5 samples in a 30-day period.

Application of Recreation Criteria

While no specific criteria are set, a health hazard exists if the following organisms are routinely isolated from bathing waters: *Candida albicans, Shigella, Mycobacterium tuberculosis, Clostridium perfringens*, enteric viruses, *Vibrio parahaemolyticus, Salmonella,* and *Staphylococcus aureus*. These organisms are not quantitatively associated with the recommended indicators and must be monitored separately.

The fecal coliform criterion for primary-contact recreation recommended by CCREM is a geometric mean of 200/100 mL in 5 samples taken in a 30-day period. Re-sampling is recommended when any sample exceeds 400/100 mL. This criterion should be used during the transition to the *E. coli,* enterococci, and *Pseudomonas aeruginosa* criteria given below. The fecal coliform criterion is empirical and the other criteria are derived from regression equations.

The CCREM guideline is a temporary one which recognizes that ultimately *E. coli,* enterococci and *Pseudomonas aeruginosa* will become the indicators of choice as they have already become, or are in the process of becoming, in some US States and Canadian Provinces, for the International Joint-Commission and the US Environmental Protection Agency. We recommend that these new indicators be phased in as soon as possible.

Industrial

The criteria levels here are somewhat industry specific, but generally if water meeting secondary-contact recreation criteria is supplied the industries can finish processing it in-house to their desired standards. CCREM does not give specific recommendations for industrial uses of water. For most uses acceptable quality is the guideline and in some sectors of the food and beverage industry potable water is the recommendation. There is no conflict between the CCREM general statements and the criteria recommended in this report.

Food Processing, Dairy, Garment, Bedding, Laundry and Tanning Industries

The water should meet the drinking water criteria for raw water without treatment.

> *- Escherichia coli should not be present in any 100 mL sample of raw drinking water*
>
> *- Enterococci should not be present in any 100 mL sample of raw drinking water*
>
> *- Pseudomonas aeruginosa should not be present in any 100 mL sample of raw drinking water*
>
> *- Fecal coliforms should not be present in any 100 mL sample of raw drinking water*

> *- For the dairy industry, the additional criterion of a maximum of 5/100 mL lipolytic acid proteolytic bacteria is recommended for raw water without treatment.*

Industries where there is Contact with the Water by the Employees Either Directly or as Aerosols

The water should meet the secondary-contact recreation criteria.

> *- The Escherichia coli level for secondary-contact recreation in fresh water should not exceed a geometric mean of 385/100 mL. There should be at least 5 samples in a 30-day period.*
>
> *- The Enterocci level for secondary-contact recreation in fresh and marine waters should not exceed a geometric mean of 100/100 mL. There should be at least 5 samples in a 30-day period.*

Other Industries where Bacterial Slimes and Deposits have an Adverse Effect Upon the Product Quality or Process Equipment

The secondary-contact recreation criteria are the minimum acceptable.

- The Escherichia coli level for secondary-contact recreation in fresh water should not exceed a geometric mean of 385/100 mL. There should be at least 5 samples in a 30-day period.

- The Enterocci level for secondary-contact recreation in fresh and marine waters should not exceed a geometric mean of 100/100 mL. There should be at least 5 samples in a 30-day period.

Other Recommendations

The following are non-criteria recommendations arising from the process of establishing the criteria.

In drinking water supplies the following pathogens should be monitored specifically at intervals, especially when any changes are made to supplies, distribution or treatment of drinking water, since they are not always quantitatively monitored by the recommended indicators. A health hazard exists if they are found in any 100 mL sample of raw or treated drinking water. The pathogens are: *Salmonella spp., Campylobacter spp., Vibrio spp., Klebsiella pneumoniae, Aeromonas hydrophila, Giardia lamblia, Shigella spp., Yersinia enterocolitica, Clostridium perfringens, Mycobacterium tuberculosis, Candida albicans, Staphylococcus aureus, enteric viruses* and *Proteus spp*. They should also be monitored occasionally in recreational waters.

Waste discharges of any type which ultimately end up in the environment should not contain any viable bacteria which possess transferable drug-resistance. While such quality may not be practical for all discharges, high risk discharges, such as those from hospitals, may need special supplementary treatment before being added to the general waste stream.

Epidemiological studies need to be carried out for all uses of water in order to establish regression equations linking disease risk with the concentration of indicator species for both gastrointestinal and skin diseases. This would allow health and environment agencies to set defensible criteria for any use with a known level of risk. The costs of achieving certain water quality criteria could then be directly compared with the savings in health care costs which would ensue. The first priority is for a study of the irrigation of crops that are eaten raw.

Research is required in virology in order to determine health risks and develop an economical, practical, routine virus screening test to assess viral disease risk.