

9007

**AMBIENT WATER QUALITY CRITERIA  
FOR AMMONIA TO PROTECT  
MARINE AQUATIC LIFE**



**Province of  
British Columbia**

**Ministry of  
Environment**

**WATER  
MANAGEMENT  
BRANCH**

WATER MANAGEMENT BRANCH  
MINISTRY OF ENVIRONMENT  
PROVINCE OF BRITISH COLUMBIA

AMBIENT WATER QUALITY CRITERIA  
FOR AMMONIA TO PROTECT  
MARINE AQUATIC LIFE

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

Approved: October 11/90  
Date

J. E. Richardson.  
Assistant Deputy Minister

## SUMMARY

This report is one in a series which establishes ambient water quality criteria for British Columbia. The criteria are safe conditions or levels of contaminants, applicable province-wide, which are set to protect various water uses. This report sets criteria for ammonia to protect aquatic life in marine or saltwater ecosystems. The criteria update those for ammonia in marine waters issued in 1986 and are summarized in tables at the back of the report.

The criteria to protect marine life are set for either continuous exposure to ammonia or for maximum acceptable concentrations. For continuous exposure, values are tabulated to take into account the effect on toxicity of pH, temperature, and salinity. Maximum acceptable concentrations are similarly presented in tabular form with the same three variables. These criteria are more flexible and detailed than the criteria for ammonia in marine waters of a previous Ministry criteria document (Nordin and Pommen, 1986). The CCREM (now known as CCME) Canadian Water Quality Guidelines (1987) do not consider marine water quality.

A major use of the criteria is to set ambient water quality objectives. The objectives are the criteria modified or adopted to protect the most sensitive water use in a particular body of water. The objectives are used in the preparation of waste management permits, which are the only entity to have legal standing. The objectives, however, are not usually part of the permit.

## PREFACE

The Ministry of Environment is developing province-wide ambient water quality criteria for variables that are important in the surface waters of British Columbia. This work has the following goals:

- (i) to provide criteria for the evaluation of data on water, sediment and biota for water quality assessments;
- (ii) to provide criteria for the establishment of site-specific ambient water quality objectives.

The ambient water quality objectives for specific waterbodies will be based on the criteria as well as on 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 the Water Management Branch.

Neither criteria, nor objectives which are derived from them, have any legal standing. The objectives can be used in calculating the limits to be allowed in waste discharges. These limits are set out in waste management permits which do have legal standing. The objectives are not usually incorporated as conditions of the permit.

The definition adopted for criterion is:

"A maximum and/or a minimum value for a physical, chemical or biological characteristic of water, sediment or biota, applicable province-wide, which should not be exceeded to prevent specified detrimental effects from occurring to a water use, including aquatic life, under specified environmental conditions".

The criteria are province-wide in application, but use-specific, and are being developed for the following water uses:

- Drinking, public water supply and food processing\*
- Aquatic life and wildlife
- Agriculture (livestock watering and irrigation)
- Recreation and aesthetics\*\*
- Industrial (water supplies)

The criteria are set after considering the scientific literature, criteria 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 rarely totally conclusive because it is usually based on laboratory work which only approximates actual field conditions. To compensate for this uncertainty, criteria have built-in safety factors. We use safety factors which are conservative but reflect natural background conditions in the province.

Given this procedure for setting criteria, the objectives will, in most cases, be the same as criteria. However, in some cases, such as when natural background levels exceed the criteria, the objectives could be less stringent than the criteria. In relatively rare instances, for example if the resource is unusually valuable or of special provincial significance, we could increase the safety factor by using objectives which are more stringent than the criteria. Another approach in such special cases would be to develop site-specific criteria by carrying out toxicity experiments in the field. This approach is costly and time-consuming and therefore not often used.

The criteria will be subject to review and revision as new knowledge becomes available, or as other circumstances dictate.

---

\* The criteria 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.

\*\*Criteria relating to public health at bathing beaches will be the same as those used by the Ministry of Health which regulates their use.

## BACKGROUND

Because the fields of environmental toxicology and the setting of quantitative values (criteria) to protect specific water uses are relatively new, it should be expected that the generation of new knowledge might require changes in criteria over even relatively short time periods.

The purpose of this short report is to update one portion of a previous criteria document on inorganic nitrogen compounds (nitrate, nitrite and ammonia), issued in 1986. In 1986, the Ministry published a criteria document for inorganic nitrogen compounds (nitrate, nitrite and ammonia) (Nordin and Pommen, 1986). In that document criteria were proposed for a variety of water uses for each of these nitrogen compounds. One particular area where few data were available was for ammonia toxicity to aquatic life in saltwater. Criteria were proposed based primarily on the review by Haywood (1983) of ammonia toxicity to marine fish. The criteria proposed were an average of less than 1.0 mg/L and a maximum of 2.5 mg/L, based on total ammonia nitrogen. In 1985, the U.S. Environmental Protection Agency (E.P.A.) had reviewed the existing data for toxicity with regard to aquatic life and concluded that there was insufficient information to set criteria for the marine (saltwater) environment.

By 1989 the E.P.A. had again attempted to assess the data that were available in the literature. This time the agency determined that sufficient information existed in the scientific literature for both acute and chronic toxicity to a variety of marine species (fish, crustaceans, and molluscs) and that criteria could be established. The report which was issued (United States Environmental Protection Agency, 1989) set new criteria for ammonia in salt water.

The approach taken in that report is similar to the approach taken in their 1985 criteria report for ammonia in freshwater. One difference was that in the earlier report the criteria values were primarily keyed to the un-ionized form of ammonia. For the 1986 Ministry of Environment report, the un-ionized values were converted to total ammonia so they would be more readily compared to analytical results. In the 1989 E.P.A. marine ammonia criteria

document, this use of total ammonia for the criteria values was also made. In reviewing the 1989 E.P.A. criteria document, the technical basis was examined and appeared to be sound. Rather than re-examining all the references cited by E.P.A. a number were reviewed to verify the procedure and interpretation. The E.P.A. report was then updated by a literature search to locate applicable published data from 1987-89 (the most recent E.P.A. citations are for 1986); on the basis of this work, it was determined that minor modification and adoption of the E.P.A. criteria would be the best course of action. The purpose of this document is to update and improve the 1986 Ministry of Environment criteria document.

Although the E.P.A. approach is a reasonable one, it is not without weaknesses. The E.P.A. criteria (for a wide range of water quality characteristics) are designed to protect only 95% of the species tested and a caveat is usually included which notes that some local sensitive species may not be adequately protected. If these criteria values are used in setting site specific water quality objectives, this information has to be taken into account. In the compilation of toxicity data there is a distinct bias in terms of the amount of data for Atlantic marine species (U.S. and Europe) in contrast to Pacific (and specifically British Columbia) species. Ideally, toxicity data for a wide range of B.C. species should be the basis for provincial criteria; however, in the absence of such data, the E.P.A. data base and the approach taken serves as an interim but satisfactory solution. The criteria proposed here were considered because they represent an improvement over the previous approach. The E.P.A. criteria tables provide the advantages of considering both acute and chronic effect and are far more specific than the previous Ministry criteria since they take into account temperatures, salinity and pH. The criteria are particularly needed in British Columbia at the present time because of the large number of aquaculture operations which exist or are proposed and the concern over the environmental effects of these operations. Ammonia is a particular item of interest in this regard.

The levels proposed in the 1986 Ministry criteria document were 1.0 mg/L average and 2.5 mg/L maximum total ammonia nitrogen. In comparison to the E.P.A. criteria table values, both 2.5 mg/L and 1.0 would best be described as mid-range values in the context of the newer criteria tables. In the new table for maximum values (Table 1), 2.5 mg/L is obtained at a temperature of 15°C and a pH of 8.6. For conditions of lower pH and lower temperatures (in general) the 2.5 mg/L value would be overprotective. Also for pH greater

than 8.6 or temperatures of greater than 10 or 15°, the 2.5 mg/L would be underprotective. Similarly, the previous average criterion of 1.0 mg/L corresponds to approximately pH 8.2 and 15°C in the new table (Table 2) and would have been either overprotective or underprotective at other pH, temperature or salinity combinations. It is clear that the new E.P.A. tables (adapted here) are a significant improvement on the 1986 Ministry criteria.

There are several considerations in using the tables. They are not applicable to inland saltwater lakes as the criteria values are based on toxicity to marine organisms. As such the tables only apply to salinities >10 g/kg (parts per thousand). For salinities <10 g/kg, the freshwater criteria should be used. For the range of values in the tables, intermediate values of pH, temperature or salinity should be interpolated linearly.

For calculation of acceptable average concentrations at a particular site over a period of time (Table 2) a series of samples is usually taken (e.g., 5 samples in 30 days). To compare the field result to the value in the table, the five field temperature values should be averaged, as should the field pH and salinity data. Using the average pH, temperature and salinity values, the criterion value can then be obtained from Table 2 and compared to the average ammonia result.

One area which requires more work is the toxicity thresholds for organisms in the brackish water salinity range, say between 500 mg/L (0.5 g/kg) and 10 g/kg. Although at higher pH the toxicities are comparable to freshwater data, at lower pH there is considerable difference between the freshwater and marine criteria. Apparently, the paucity of data at lower salinities ( $\leq 10$  g/kg) is the reason for this. In the absence of sufficient data to generate a separate criteria table for brackish water, the more protective freshwater criteria for ammonia should apply.

## RECOMMENDED CRITERIA

The criteria for ammonia in saltwater are consistent with the approach taken in the Canadian Water Quality Guidelines issued by the Canadian Council of Resource and Environment Ministers (1987) except as noted (the CCREM is now known as the CCME, or Canadian Council of Ministers of the Environment). However, the CCREM Guidelines consider only freshwater applications. These criteria apply exclusively and specifically to the single water use of protection of marine aquatic life.

### 1. Maximum Concentrations

The criteria provided in Table 1 are maximum values, which should not be exceeded at any time. The values listed are related to data for acute toxicity.

### 2. Average Concentrations

The criteria provided in Table 2 are designed to provide protection for aquatic life over the long term. The values in this table are related to data for chronic toxicity. To evaluate whether conditions meet these numerical limits, it is necessary to take samples over a period of not less than 5 days nor more than 30 days. A minimum of 5 samples, equally spaced in time, should be used to calculate the average. The criterion value is obtained by entering the mean pH, temperature and salinity values into the Table. The criterion can then be compared to the average of the measured concentrations.

Coincident with the analytical measurement of ammonia, accurate measurement of field pH, field temperature and salinity are necessary to provide the basis of comparison to criteria values.

Intermediate values of pH, temperature or salinity should be interpolated (linearly) from the table. The criteria given here apply only to locations where salinity is equal to or greater than 10 g/kg. The freshwater criteria (1986) apply at salinities less than 10 g/kg.

The data in both Tables 1 and 2 have been adopted from the U.S. Environmental Protection Agency report: "Ambient Water Quality Criteria for Ammonia (Saltwater) (1989)".

---

R.N. Nordin, Ph.D., R.P.Bio  
Resource Quality Section  
Water Management Branch

**REFERENCES**

- Haywood, G.P. 1983. Ammonia toxicity in teleost fishes: a review. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1177.
- Nordin, R.N. and L.W. Pommen. 1986. Water Quality Criteria for nitrogen (nitrate, nitrite, and ammonia). Ministry of Environment and Parks, Province of British Columbia, Victoria, B. C. Technical Appendix 83 p. Summary Document. 11 p.
- United States Environmental Protection Agency. 1985. Ambient Water Quality Criteria for Ammonia - 1984. Washington, D.C. EPA 440/5-85-001. Also Published by the NTIS as Pb85-227114.
- United States Environmental Protection Agency. 1989. Ambient Water Quality Criteria for Ammonia (Saltwater) - 1989. Office of Research and Development, Environmental Research Laboratory, Narragansett, Rhode Island. EPA 440/5-88-004. 59 p.

**TABLE 1**  
**MAXIMUM CONCENTRATION OF TOTAL AMMONIA**  
**NITROGEN**  
**FOR PROTECTION OF SALTWATER AQUATIC LIFE**  
**(mg/L-N)**

pH	Temperature (°C)					
	0	5	10	15	20	25
-----						
	Salinity = 10 g/kg					
7.0	270	191	131	92	62	44
7.2	175	121	83	58	40	27
7.4	110	77	52	35	25	17
7.6	69	48	33	23	16	11
7.8	44	31	21	15	10	7.1
8.0	27	19	13	9.4	6.4	4.6
8.2	18	12	8.5	5.8	4.2	2.9
8.4	11	7.9	5.4	3.7	2.7	1.9
8.6	7.3	5.0	3.5	2.5	1.8	1.3
8.8	4.6	3.3	2.3	1.7	1.2	0.92
9.0	2.9	2.1	1.5	1.1	0.85	0.67
Salinity = 20 g/kg						
7.0	291	200	137	96	64	44
7.2	183	125	87	60	42	29
7.4	116	79	54	37	27	18
7.6	73	50	35	23	17	11
7.8	46	31	23	15	11	7.5
8.0	29	20	14	9.8	6.7	4.8
8.2	19	13	8.9	6.2	4.4	3.1
8.4	12	8.1	5.6	4.0	2.9	2.0
8.6	7.5	5.2	3.7	2.7	1.9	1.4
8.8	4.8	3.3	2.5	1.7	1.3	0.94
9.0	3.1	2.3	1.6	1.2	0.87	0.69
Salinity = 30 g/kg						
7.0	312	208	148	102	71	48
7.2	196	135	94	64	44	31
7.4	125	85	58	40	27	19
7.6	79	54	37	25	21	12
7.8	50	33	23	16	11	7.9
8.0	31	21	15	10	7.3	5.0
8.2	20	14	9.6	6.7	4.6	3.3
8.4	12.7	8.7	6.0	4.2	2.9	2.1
8.6	8.1	5.6	4.0	2.7	2.0	1.4
8.8	5.2	3.5	2.5	1.8	1.3	1.0
9.0	3.3	2.3	1.7	1.2	0.94	0.71

g/kg salinity is equivalent to parts per thousand (ppt or  $\frac{0}{00}$ )

**AVERAGE 5 TO 30-DAY CONCENTRATION OF TOTAL  
AMMONIA NITROGEN  
FOR PROTECTION OF SALTWATER AQUATIC LIFE  
(mg/L-N)**

pH	Temperature (°C)					
	0	5	10	15	20	25
Salinity = 10 g/kg						
7.0	41	29	20	14	9.4	6.6
7.2	26	18	12	8.7	5.9	4.1
7.4	17	12	7.8	5.3	3.7	2.6
7.6	10	7.2	5.0	3.4	2.4	1.7
7.8	6.6	4.7	3.1	2.2	1.5	1.1
8.0	4.1	2.9	2.0	1.40	0.97	0.69
8.2	2.7	1.8	1.3	0.87	0.62	0.44
8.4	1.7	1.2	0.81	0.56	0.41	0.29
8.6	1.1	0.75	0.53	0.37	0.27	0.20
8.8	0.69	0.50	0.34	0.25	0.18	0.14
9.0	0.44	0.31	0.23	0.17	0.13	0.10
Salinity = 20 g/kg						
7.0	44	30	21	14	9.7	6.6
7.2	27	19	13	9.0	6.2	4.4
7.4	18	12	8.1	5.6	4.1	2.7
7.6	11	7.5	5.3	3.4	2.5	1.7
7.8	6.9	4.7	3.4	2.3	1.6	1.1
8.0	4.4	3.0	2.1	1.5	1.0	0.72
8.2	2.8	1.9	1.3	0.94	0.66	0.47
8.4	1.8	1.2	0.84	0.59	0.44	0.30
8.6	1.1	0.78	0.56	0.41	0.28	0.20
8.8	0.72	0.50	0.37	0.26	0.19	0.14
9.0	0.47	0.34	0.24	0.18	0.13	0.10
Salinity = 30 g/kg						
7.0	47	31	22	15	11.	7.2
7.2	29	20	14	9.7	6.6	4.7
7.4	19	13	8.7	5.9	4.1	2.9
7.6	12	8.1	5.6	3.7	3.1	1.8
7.8	7.5	5.0	3.4	2.4	1.7	1.2
8.0	4.7	3.1	2.2	1.6	1.1	0.75
8.2	3.0	2.1	1.4	1.0	0.69	0.50
8.4	1.9	1.3	0.90	0.62	0.44	0.31
8.6	1.2	0.84	0.59	0.41	0.30	0.22
8.8	0.78	0.53	0.37	0.27	0.20	0.15
9.0	0.50	0.34	0.26	0.19	0.14	0.11

The criterion value is obtained by using the average pH, temperature and salinity field values, and is compared to the mean of the measured ammonia concentrations.

