# Aquatic Toxicology and Hazard Assessment

## Seventh Symposium

**Cardwell/Purdy/Bahner**
editors

**ASTM STP 854**

# AQUATIC TOXICOLOGY AND HAZARD ASSESSMENT: SEVENTH SYMPOSIUM

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sponsored by
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on Biological Effects and
Environmental Fate
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# Foreword

The papers in this publication, *Aquatic Toxicology and Hazard Assessment: Seventh Symposium*, are taken from the seventh in a series of annual symposia on Aquatic Toxicology sponsored by ASTM. This seventh symposium, held 17–19 April 1983 in Milwaukee, Wisconsin, was, like its immediate predecessor, sponsored by ASTM Committee E-47 on Biological Effects and Environmental Fate. The first five symposia in this series were sponsored by ASTM Committee E-35 on Pesticides.

Chairing this symposium were Rick D. Cardwell, Envirosphere Company, Rich Purdy, 3M Company, and Rita Comotto Bahner, Association of Official Analytical Chemists, all of whom also served as editors of this publication.

# Related ASTM Publications

Aquatic Toxicology and Hazard Assessment (Sixth Symposium), STP 802 (1983), 04-802000-16

Aquatic Toxicology and Hazard Assessment (Fifth Symposium), STP 766 (1982), 04-766000-16

Aquatic Toxicology and Hazard Assessment (Fourth Symposium), STP 737 (1981), 04-737000-16

Aquatic Toxicology (Third Symposium), STP 707 (1980), 04-707000-16

Aquatic Toxicology (Second Symposium), STP 667 (1979), 04-667000-16

Aquatic Toxicology and Hazard Evaluation (First Symposium), STP 634 (1977), 04-634000-16

Ecological Assessments of Effluent Impacts on Communities of Indigenous Aquatic Organisms, STP 730 (1981), 04-730000-16

Analysis of Waters Associated with Alternative Fuel Production, STP 720 (1981), 04-720000-16

Aquatic Invertebrate Bioassays, STP 715 (1980), 04-715000-16

# A Note of Appreciation to Reviewers

The quality of the papers that appear in this publication reflects not only the obvious efforts of the authors but also the unheralded, though essential, work of the reviewers. On behalf of ASTM we acknowledge with appreciation their dedication to high professional standards and their sacrifice of time and effort.

*ASTM Committee on Publications*

# ASTM Editorial Staff

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BIOAVAILABILITY

# Introduction

The theme for this seventh ASTM-sponsored symposium on aquatic toxicology and hazard evaluation might be casually entitled "ecological relevance." Over the past several years there has been a pronounced shift in emphasis in aquatic toxicological research. From the areas of method development and data acquisition (e.g., information to support water quality criteria derivation) the emphasis has shifted to the fundamental question of whether generic water quality criteria and standards as well as permits for such things as the discharge of effluents and application of pesticides are providing a socially acceptable level of protection to aquatic communities. The transition can be seen in the chronicles of the previous ASTM symposia of this series [*ASTM STP 634* (1977), *STP 667* (1979), *STP 707* (1980), *STP 737* (1981), *STP 766* (1982), and *STP 802* (1983)].

The papers in this volume have been divided into five sections. The first addresses the area of foremost ASTM emphasis, methods development and validation. Results of single-species tests are presented; the greatest emphasis is on several species of daphnids (class Crustacea, order Cladocera), the main toxicological invertebrate test species in freshwater.

The remaining four sessions implicitly or explicitly address the theme of ecological relevance. There is much research interest concerning the potential toxicity of chemicals that are bound to particulates, whether natural particulates (e.g., detritus and clay), sewage sludge, or wastewaters. This area has traditionally received much less emphasis than aquatic hazard assessments of dissolved chemicals in the water column. The section on Evaluation of Chemicals and Chemical Wastes consists of papers addressing this area in terms of methods for assessing and interpreting toxicity and hazard evaluation data.

The third section, Assessing Impacts of Wastes on Aquatic Ecosystems, addresses the complex issue of whether effects of chemicals and chemical wastes, determined by laboratory testing, can be predicted or in fact occur in the environment. The issue is addressed from several vantage points, which will provide the reader a perspective on the issue's complexity.

Why chemicals, wastes, and sediments do or do not kill or undergo assimilation by aquatic life is the subject of the section on Bioavailability. The reader perplexed by the questions posed in the third section will here find insights concerning some of the mechanisms governing toxicity and assimilation. For example, failure to observe effects of metals in the natural environment may be due in part to the *in vivo* detoxification mechanism discussed by

Brown et al. The papers by Breteler and Saksa, Harrison, and O'Donnel et al demonstrate why certain metal compounds may never be assimilated by certain organisms under specific water quality conditions that control biological availability.

Much of the work in aquatic toxicology is driven by regulatory agency decisions; thus it is appropriate that the last section in this volume addresses water quality criteria. Some of the papers will likely influence future water quality criteria. The session was initially developed to debate the merits of the U.S. Environmental Protection Agency's paper "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Life and Its Uses." Stephan argued its merits, while Seegert et al and Wang took exceptions to certain of its aspects. Kimerle et al believe that the data base requirements of the criteria were much greater than necessary; tests with a few key fish, invertebrate, and algal species would, the authors feel, provide the same degree of protection. Papers by Hedtke and Arthur and by Jaworski and Mount address different aspects of water quality criteria rather than the Guidelines explicitly.

The symposium chairmen are especially indebted to Dr. Charles Coutant, Mr. Carlos Fetterolf, Dr. Charles Gibson, Dr. Alan Mearns, Dr. Del Nimmo, and Dr. Rich Purdy for convening sessions, and to Ms. Anne McKlindon, Ms. Kathy Greene, and the ASTM staff for organizing the symposium and supervising the publication of this volume.

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Association of Official Analytical Chemists, Washington, D.C.; symposium chairman and editor

# Methods Development, Refinement, and Evaluation

*R. C. Bailey*[1] *and P. M. Stokes*[1]

# Evaluation of Filamentous Algae as Biomonitors of Metal Accumulation in Softwater Lakes: A Multivariate Approach

**REFERENCE:** Bailey, R. C. and Stokes, P. M., **"Evaluation of Filamentous Algae as Biomonitors of Metal Accumulation in Softwater Lakes: A Multivariate Approach,"** *Aquatic Toxicology and Hazard Assessment: Seventh Symposium, ASTM STP 854*, R. D. Cardwell, R. Purdy, and R. C. Bahner, Eds., American Society for Testing and Materials, Philadelphia, 1985, pp. 5–26.

**ABSTRACT:** Algae from artificial substrates were collected from 36 softwater lakes in four geographic areas of central Canada. Determination of aluminum, manganese, cadmium, copper, nickel, lead, and zinc were made on the algae, water, and sediment. Sediment nutrients, water pH, alkalinity, and conductivity were also measured.

One objective of the study was to evaluate algae as biomonitors of metals. Another was to determine the levels of metals in water and sediments as they related to other environmental variables. A multivariate approach was used to analyze the data statistically.

As pH decreased, metal concentration in water and algae increased. Sediment metals were unrelated to water pH, but were positively related to sediment organic level and algal metals. Sediment metals were approximately ×1000 the metal concentrations in water, whereas algal metals were 1000 to ×10 000 greater than water levels.

An evaluation is made of algae as biomonitors of acid-stressed lakes. Their role in metal cycling in aquatic systems is identified as an area for future research.

**KEY WORDS:** algal biomonitors, metal bioaccumulation, aquatic metal cycling, lake acidification, multivariate analysis

Acidic precipitation has the potential to influence the biogeochemical cycling of metals in aquatic ecosystems. Some metals (e.g., aluminum) are leached by acidic precipitation from soils, sediments, or parent geological material and can thus be considered as "internally generated" by the lake ecosystem. For some metals (e.g., lead), deposition from the atmosphere onto

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the watershed and the lake is increased. This increased deposition is likely to be correlated with the pH of the precipitation, but very few direct measurements of metal deposition resulting from long-range transport of air pollutants (LRTAP) are available [*1*].

If spatial and temporal studies or theoretical considerations indicate an increase in the concentration of a potentially toxic metal in water or sediment in a manner which is related to acidification, it is still necessary to assess whether or not the levels and the forms of the metal are such that the aquatic biota are at risk. It is already clear that aluminum toxicity to fish is related to pH depressions [*2*]. There are several independent studies on mercury in fish which show a negative correlation between pH and mercury levels in fish [*3-5*]. The cycling of several other metals is likely to be changed by acidification. Seven metals (aluminum, manganese, cadmium, copper, nickel, lead, and zinc) are considered in the present study. All except nickel have been found to be worthy of concern in acid-stressed lakes [*6*]. Nickel was included to examine the distribution of a metal which was known to be important in one of the study areas (Sudbury).

Figure 1 shows some of the factors expected to influence the transfer of a metal through an aquatic system to the first trophic level. One direct measure of bioavailability of metals in an aquatic system is to use a biological receptor-accumulator (monitor) to provide information on the availability of metals to the biota. In theory, the biological monitor integrates the effects of all the environmental factors which combine to influence the bioavailability (and thus potential toxicity) of the contaminant. It will also integrate doses over time. If the monitor works in a practical sense, it should obviate the need for much of the chemical analyses usually carried out. Filamentous algae, which occur naturally in softwater lakes, may be ideal candidates for such a monitor. The community is loosely attached and large amounts of material can be collected from artificial substrates after a few weeks. Although a large number of species are often found, a small number of filamentous Chlorophyta (*Mougeotia*, *Spirogyra*, *Oedogonium*, and *Bulbochaete*) are usually dominant.

Stokes et al [*7*] have shown mercury bioconcentration by algae of 10 000 fold over that of the water and have proposed the use of the attached filamentous algal community as a biological monitor of mercury in acid-stressed lakes. In the present study, the same algal community was evaluated as a biomonitor of other metals important in acid-stressed lakes.

Although it is clear that a biomonitoring system can be useful without detailed knowledge of the specific mechanisms involved, some critical evaluation of the monitor is necessary. Certain empirical relationships and practical considerations can be established to test the validity of a biomonitor of metals. These include:

1. Concentration of the metal in biota correlated with concentrations in water but at higher levels, so that analytical detection limits are improved.