

**Springer Series on Environmental  
Management**

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**Robert S. DeSanto, Series Editor**

# Heavy Metals in Natural Waters

Applied Monitoring and Impact Assessment

With a Contribution by E.E. Ballantyne

With 48 Figures



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## Series Preface

This series is dedicated to serving the growing community of scholars and practitioners concerned with the principles and applications of environmental management. Each volume is a thorough treatment of a specific topic of importance for proper management practices. A fundamental objective of these books is to help the reader discern and implement man's stewardship of our environment and the world's renewable resources. For we must strive to understand the relationship between man and nature, act to bring harmony to it, and nurture an environment that is both stable and productive.

These objectives have often eluded us because the pursuit of other individual and societal goals has diverted us from a course of living in balance with the environment. At times, therefore, the environmental manager may have to exert restrictive control, which is usually best applied to man, not nature. Attempts to alter or harness nature have often failed or backfired, as exemplified by the results of imprudent use of herbicides, fertilizers, water, and other agents.

Each book in this series will shed light on the fundamental and applied aspects of environmental management. It is hoped that each will help solve a practical and serious environmental problem.

Robert S. DeSanto  
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# Preface

A biological monitoring system, which had the potential to save lives, was developed over one hundred years ago. The capital investment in this program amounted to a few pounds (in 1880 pounds) and operating costs were negligible, even by 19th century standards. The early coal mines of Great Britain became a safer place to work because canaries could be used to detect dangerous levels of carbon monoxide. Although biological monitoring in this form had a number of drawbacks, such as poor detection limits at low CO concentrations, it did produce reproducible results at toxic levels. Consequently, the bird-CO system survived with minimal modifications well into the 20th century. Parakeets for example saw action in World War II submarines. It therefore comes as a shock to realize that this cost-effective program has no aquatic counterpart. Today, capital and operating costs of biological monitoring programs may be very high. Yet, economic and political factors together with intrinsic weaknesses in study design and methods may significantly reduce the effectiveness of the recommendations generated by such investigations. Hence the simplicity and cost-effectiveness of the bird-CO system is perhaps a utopian example which aquatic toxicologists cannot duplicate.

Biological monitoring and impact assessments have been carried out in lakes, rivers, and estuaries since the early part of this century and are now common features of most environmental programs. In most instances, the methods involved in both types of study are similar. In general terms, biological monitoring should occur before, during, and after environmental disturbances in order to avoid significant environmental impacts. Biological assessments on the other hand measure the extent of potentially major impacts which have already occurred.

Those knowledgeable in the field might well wonder why we need another review on monitoring and impact assessment. The literature on chemical and physical disturbances is already bulging with site specific studies and several major review articles have been published in recent years. Our response to the question is that we have emphasized an interdisciplinary approach to monitoring and impact assessments in this book. There are lengthy reviews on environmental chemistry, the pollution-ecology of algae, invertebrates and fish, and on aquatic toxicology, genetic toxicology, and the pathology of fishes and invertebrates in relation to heavy metals. Such an approach has the potential of overcoming intrinsic weaknesses in conventional programs which emphasize species diversity and community structure analysis. In the final chapters, we review biological, chemical, and political criteria which should be considered in the development of monitoring and impact assessment programs.

Because the book is written for managers and scientists with broad environmental interests, some topics such as pharmaco-kinetics and toxic mechanisms are not covered in great depth. Such information falls within the domain of the specialist and cannot be put to immediate use by agencies involved in monitoring and impact assessment. In addition, although every effort has been made to give a balanced review of the literature, we have possibly omitted relevant papers from our citations. This was done to improve the flow of the text and shorten the reference lists.

We would like to acknowledge the assistance of staff from the Alberta Environmental Centre in the preparation of this volume. We relied heavily on Sita Ramamoorthy and Joan O'Brien for the compilation and indexing of the literature. Sita Ramamoorthy and Jim Bradley also proofread the various drafts. The library staff, Mrs. Diana Lee and Harriet Judge, handled all of our literature requests, Mrs. Arhlene Hrynyk coordinated typing of the drafts, and Mr. Terry Zenith was responsible for figure preparation. Ann Wheatley collated data on the genetic toxicology of metals. Finally we would like to acknowledge Dr. R.S. Weaver, Executive Director, Alberta Environmental Centre, and Dr. L.E. Lillie, Head, Animal Sciences Wing, for their support and encouragement during this project.

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