BOOK REVIEWS

Assessing the TMDL Approach to Water Quality Management

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NATIONAL RESEARCH COUNCIL
National Academy Press, Washington, D.C., xii + 109 pp., ISBN 0-309-07579-3, 2001, $28.25.

Every human being on Earth is a stakeholder in water quality management. And so, for that matter, is every animal, domesticated or wild, though they have no constituency. Water quality includes not only considerations of water composition for multiple human uses such as drinking and irrigation, but also in terms of its capacity to support systems of aquatic biota in general. This is so because we now realize that our well-being is inseparable from the well-being of, say, the aquatic biota. If frogs were dying, we would be next in line!

The U.S. Clean Water Act of 1972 envisioned waters in the United States to be in "fishable and swimmable" condition. This was to be achieved through pollution reduction by making the dischargers comply with effluent-based standards for criteria pollutants. Subsequently, habitat destruction, changes in flow regimes, and the introduction of exotic species, etc., necessitated a shift in the focus of water quality management from effluent-based to ambient-based water quality standards. The new focus is to be effected through the Total Maximum Daily Load (TMDL) approach, which is based on various chemical, physical, and biological criteria.

At the request of the U.S. Congress, the U.S. National Research Council composed a committee of experts to assess the scientific basis of the TMDL approach to water pollution reduction. *Assessing the TMDL Approach to Water Quality Management* is a committee effort and was prepared in the record time of just four months, including the time taken for hearings. The book has five chapters: Introduction; Conceptual Foundations for Water Quality Management; Water Body Assessment: Listing and Delisting; Modeling to Support the TMDL Process; and Adaptive Implementation for Impaired Waters. The end of each chapter provides eminently practical suggestions, as well as the latest references. The book is not recommended for bedtime reading; the text is concentrated stuff, packed with solid science.

More than 4000 TMDLs are required to address pollution reduction in about 21,000 polluted river segments, lakes, and estuaries equaling over 300,000 river and shore miles and 5 million acres. The magnitude of the effort involved is so stupendous that only the United States can afford to implement it.

I recall an anecdote, probably apocryphal, attributed to Sir Harold Jeffrys of Cambridge University. It appears the Burmah-Shell Oil Company (BOC) had particularly intractable problems in regard to an oil property. They requested Jeffrys to help them. For 2 days, the geophysicists and engineers of BOC gave detailed presentations. Jeffrys took copious notes and asked searching questions. On the third day, all the top brass of BOC attended the final session, expecting words of wisdom from the great man. Jeffrys got up and said, "Thank God, the problem is yours, and not mine. Good day, gentlemen," and walked out!

The recommendations made by the NRC Committee in the volume under review for implementation in the United States are of great relevance, not only to industrialized countries, but also to developing countries. The recommendations are as follows.

(i) As biocriteria integrate the effects of multiple stressors over time and space, reliable conclusions can still be drawn, even though the number of samples may be limited. Determining the Index of Biological Integrity (IBI) of a water body is a lot cheaper than measuring some trace chemical constituents, which can be very expensive.

(ii) Human activities may have altered the biosystem in some situations so radically that the attainment of pre-disturbance condition may well nigh be impossible. For instance, planning for the restoration of salmon to every Pacific Northwest stream is unrealistic, but yet a restoration goal that includes viable population of cutthroat trout is reasonable.

(iii) Simple, commonsense explanations of impairment must first be attempted before applying complex models. For instance, many farm fields straddle small streams, with cows freely grazing in and around the stream. It is perfectly possible that an observed impairment of water quality downstream may be rectifiable by the simple expedient of restricting the access of the cows to the riparian corridor.

(iv) Use Attainability Analysis (UAA) should be done invariably. This is so because the impairment in some cases may have been caused by natural contaminants, non-removable physical condition, legacy pollutants, or natural conditions about which nothing can be done.

(v) The Bayesian approach holds particular promise for adaptive implementation for impaired waters.

Water quality assessment is a continuous process. The NRC Committee provides practical guidelines to be implemented by the Environmental Protection Agency (EPA) and Congress to make the TMDL process an effective instrument for identifying impaired waters and for the design of optimal methods for their remediation. For instance, EPA has been advised to promote the development of models that link the environmental stressors to biological responses. The Committee is assuring the Congress that adaptive implementation of the TMDL process would, in fact, be an application of scientific method to decision-making.

Apart from water managers, for whom this book is required reading, it could be used as a supplementary text for senior undergraduate students and graduate students taking courses in environmental studies, hydrology, geography, civil engineering, and water engineering.

Reviewer

U. Aswathanarayana
Somajiguda, Hyderabad-500 482, India

The Benthic Boundary Layer: Transport Processes and Biogeochemistry

PAGES 658–659

BERNARD P. BOUDREAU AND BO BARKER JØRGENSEN (EDITORS)
Oxford University Press, New York, 404 pp., ISBN 0-19-511881-2, 2001, $79.95.

Interdisciplinary research is certainly one of the current buzzwords that needs to be incorporated in virtually every grant proposal. The idea that integration of different scientific fields is a prerequisite for progress in Earth sciences is now well recognized. The benthic boundary layer (BBL) is one area of research in which physicists, chemists, biologists, geologists, and engineers have worked in close and fruitful cooperation for several decades. The BBL comprises the near-bottom layer of water, the sediment-water interface, and the top layer of sediment that is directly influenced by the overlying water. In 1974, a BBL conference in France resulted in a book titled *The Benthic Boundary Layer* edited by I. N. McCave. This publication contained contributions from scientists from a wide range of disciplines and gave an overview of the state-of-the-art of BBL research. However, science has moved on in the past 25 years. Significant conceptual and technological progress has been made, and it is definitely time for an update.

The Benthic Boundary Layer, a worthy successor to McCave's publication, contains contributions from 20 scientists, including McCave, from a variety of different fields. It covers theory, modeling, and measurement of water flow above and below the sediment-water interface, suspended particle transport in BBL and fine scale texture of sediment, biogeochemical sensors, microbial mats, early diagenesis, in situ technologies, and macrobiological organisms living in the BBL. The book excels not only in the integration of different disciplines, but also in integrating in situ field observations, laboratory experiments, modeling, and theory, while a good balance is achieved between these different approaches.

In general, the book is very well organized. The introductory chapter clearly marks the subject area covered, cross-referencing among the chapters is very good, and an extensive index is provided, something that is surprisingly often lacking in such multi-author volumes. Scientific disciplines have different habits and conventions. This is one of the great stumbling blocks of interdisciplinary work. The editors have thankfully paid special attention to a uniform system of notation of variables and parameters, and there is a list of symbols common to all the chapters.

The chapters that focus on theoretical background of boundary layer hydrodynamics, particle transport, and solute transport are admirably comprehensive, yet very concise. Although clearly written, the extremely high information density may make the subjects less accessible to those who are rather new to this field. In particular, biologists with little background in hydrodynamics or biogeochemistry seeking a quick introduction into BBL research will find these texts valuable, but very hard work indeed. For those who do have some background in this field these chapters will provide very useful reference material.

The proverb, "Never judge a book by its cover," is true for this book. All of the effort has been devoted to the contents, and hardly any attention seems to have been paid to its outward appearance; the austere dark gray cover does little to attract the reader. Unfortunately, the lack of attention to appearance also extends to the contents of the book. The large number of spelling errors, particularly in the names of the authors and in the Greek symbols, suggests sloppy editing.

A book on a subject that deals with so many disciplines and different approaches cannot, of course, be fully comprehensive. Certain choices had to be made concerning which topics to deal with and what to leave out. Biogeochemistry and microbiology, both in relation to small-scale hydrodynamics, are the focus of attention in this volume. This bias is almost certainly a reflection of the editors' backgrounds. In view of the large amount of attention paid to solute transport and biogeochemical fluxes, a background chapter on organic chemistry of the BBL would have been a useful addition. Another topic that has received relatively little attention is the role of macro-organisms in the BBL. Although chapter 13 is devoted to this topic, treatment is limited to a few examples of how boundary layer hydrodynamics influences the biota. The reverse—ecosystem engineering by macro-organisms—receives hardly any attention.

Several chapters deal with the advances that have been made in the past few decades in the field of small-scale observation techniques for flow and solutes as well as in situ techniques for biogeochemical transport processes. One conclusion that might be drawn from this overview is that techniques concerned with small-scale transport of solids, particularly within sediments, are somewhat underdeveloped. This appears to be an area where technological innovation is particularly needed for future research.

This leads to interesting but dangerous speculation: 25 years from now, what will be the focus of *The Benthic Boundary Layer III*? We can safely assume that the profitable lines of research presented in the current will be continued. In particular, work on dynamic environments with permeable beds allowing subsurface water advection, not only driven by unidirectional currents but also oscillatory wave motion, will yield very interesting results in the coming years. The question of how organisms respond to advective flow through sediment also needs to be addressed. Our theoretical knowledge is also insufficient for predictive modeling in the area of particle deposition and erosion. At present, we know that biology has a large effect on particle dynamics, but we lack the ability to model these effects quantitatively. The direct effects of biogenic structures on hydrodynamics and particle dynamics in general should receive a lot more attention in the near future. A final issue that has theoretical as well as practical implications is the problem of scale: how do small-scale phenomena affect large-scale processes? This will definitely need to be tackled in years to come.

The Benthic Boundary Layer is a landmark publication that will become a standard reference work for aquatic scientists in the near future. At nearly US$80, this information-packed book is very good value for the money.

Reviewers

Luca A. van Duren and Jack J. Middelburg, Netherlands Institute of Ecology, Yerseke, The Netherlands

In Brief

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Earthquakes and ancient civilizations
The possible role of earthquakes in the destruction of ancient civilizations received an airing on December 13 at the 2001 AGU Fall Meeting in San Francisco, California. Amos Nur, professor of Earth sciences and geophysics at Stanford University, presented evidence that earthquakes and related tsunamis were responsible for leveling cities such as Megiddo, or Armageddon, and also have played a significant role in bringing down some ancient civilizations.

Others presenting findings of earthquake destruction included Bernabe Garcia, a former graduate student at Stanford's Center for Latin American Studies, who assisted Stanford geophysics professor Robert Kovach in piecing together evidence of earthquakes in Meso-America that could have played a role in the collapse of the Mayan classic period in the ninth century. Manika Prasad, research associate in Stanford's Rock Physics Laboratory, presented findings of his research with Nur that earthquakes may have contributed to the collapse of the Harappan civilization in South Asia around 1900 BC.

Iain Stewart, a geologist at Brunel University in Uxbridge, England, presented a talk that questioned the role of earthquakes and tsunamis in bringing critical damage to some ancient civilizations. Stewart noted that signs of ancient seismicity are generally indistinguishable from some non-seismic mechanisms of destruction, including landslides and human activity. "A number of arguments about the role of earthquakes in the destruction of ancient civilization presuppose that we can recognize earthquakes," he said, adding that there is a question of how to separate the role of earthquakes from other factors.

Cotton in a warming climate Summertime, and the cotton is...higher. That could be the future theme song for "King Cotton" in the southeastern United States, according to two climate change scenarios analyzed by researchers at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado.

While elevated carbon dioxide levels in the atmosphere could cause a number of significant concerns, it appears that increased cotton yields in the U.S. southeast could be a plus, if farmers can adapt to climate changes. The study was presented on December 10 at the AGU Fall Meeting in San Francisco.

Co-authors Linda Mearns and Ruth Doherty, who are researchers with NCAR's environmental and societal impacts group, utilized global and regional climate to determine that cotton yields could increase 5–36% under different scenarios. Some scenarios included a doubling of CO_2 and planting crops earlier in the season to take advantage of longer growing seasons. Doherty noted that the climate scenarios used were simplistic, such as assuming an instantaneous doubling of CO_2, rather than a gradual doubling, which could lead to different growth outcomes.

Mearns noted that the study was the first to investigate the impacts of climate change on cotton production at a regional scale. The research, funded by NASA and the U.S. Environmental Protection Agency, is part of a larger project examining climate change impacts on various crops, including corn, wheat, and soybeans.

New technique maps bioremediation Before researchers can effectively harness microbial populations for bioremediation, they first need to understand why some microbes are attracted to specific minerals.

A new tool for studying the feasibility of in situ bioremediation has now been shown to be able to map mineral crystals and bacterial growth on basalt, according to Mary Kauffman, a geo-microbiologist with the U.S. Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL) in Idaho Falls. Kauffman described her research on December 11 at the 2001 AGU Fall Meeting.

Using a customized laser imaging Fourier transform mass spectrometer, Kauffman and project lead researcher Jill Scott, also of INEEL,