

Book review

Hobbie, J.E. and P.J. LeB. Williams [Eds.] 1984. **Heterotrophic Activity in the Sea.** NATO Conf. Ser. IV Mar. Sci. V. 15. Plenum Press, New York and London. 569 pp. [Typewriter composition.] \$87.00.

This book is a collection of some of the papers presented at a NATO Advanced Research Institute held three years ago in Cascais, Portugal. I thought it would be difficult for a book to capture the enthusiasm and excitement most of us attending the conference felt in discussing some of the recent questions and controversies about microbial metabolism and the cycling of organic matter in the sea. Editors Hobbie and Williams truly succeeded and must be commended for their selection of authors and topics.

Pomeroy introduces the topic of microbial processes in the sea and reviews what we know and don't know about the role of microbes in the production and decomposition of organic matter. The next three papers discuss strategies of growth of microorganisms in the sea. Chapters by van Gernerden and Kuenen and by Morita particularly address the adaptations made by microorganisms to thrive in oligotrophic areas, while Wiebe discusses classical physiological and biochemical approaches to the study of growth.

In a chapter on inputs of organic matter into microbial food chains, Sharp discusses the relative roles of phytoplankton and zooplankton in producing dissolved organic matter. Next, Wright reviews recent experimental approaches to determining turnover of dissolved organic carbon. Two chapters specifically address particulate matter. Wangersky discusses the distribution and composition of particles in the ocean and how they might provide a habitat for bacteria. Hargrave summarizes some of the recent sediment trap work and discusses what we have learned about biological decomposition processes from this work.

One of the highlights of the book is a series of papers describing various new techniques of measuring bacterial growth in the sea. Azam and Fuhrman summarize most of the methods currently being used and discuss some of the factors affecting bacterial growth in the sea. Karl and Winn particularly address the theoretical principles in the application of ³H-adenine as a measure of microbial nucleic acid synthesis. Moriarty discusses his experience using the tritiated thymidine technique in both seawater and sediments. Hagström and Larsson investigated seasonal and diel cycles of bacterial growth by measuring the frequency of dividing cells (FDC). Riemann and Søndergaard make a comparison of several of these methods in their study of the relation between bacterial growth and phytoplankton release of organic carbon. Difficulties in measuring microbial biomass and growth in oligotrophic deep-sea environments are discussed by Jannasch and in sediments by Meyer-Reil. And, in a somewhat different vein, Brassell and Eglinton describe how lipid compounds in sediments can be used to infer microbial activity in the geologic past.

The effect of microbes on nutrient cycles is the primary topic of two chapters. Richards gives a very personal account of microbial effects on the cycles of carbon, nitrogen, and phosphorus in oxic and anoxic systems. Then, in one of my favorite chapters (the opinion of an unbiased nitrogen chemist), Billen summarizes his thoughts on the heterotrophic remineralization of organic nitrogen compounds.

Perhaps one of the more controversial topics covered is the measurement of respiration and its agreement or lack of agreement with ¹⁴C production measurements. Williams outlines the problem and explains some of the difficulties in measuring respiration by using oxygen consumption, carbon dioxide production, and electron transport system (ETS) activity as indicators of respiration. Jenkins then presents his method of estimating oxygen utilization rates by modeling the spatial distribution of measured oxygen concentration. He suggests that advection-diffusion models can be calibrated using a dynamic geostrophic balance or a steady state or transient tracer approach. Although potentially quite accurate as an in situ measure of oxygen consumption, this method can only be used for water masses where oxygen concentrations have been measured over a large scale. In another chapter, Davies discusses the potential use of large enclosures to study the experimental discrepancies between production and respiration measurements.

Two chapters specifically discuss grazing organisms. Sieburth summarizes much of what is known about marine protozoa and their effect on bacterial populations. Jørgensen discusses the metazoans and how their suspension feeding can reduce the concentration of particles and also perhaps dissolved species in seawater. In a final chapter, Peterson describes a model of carbon flow in the mixed layer with comments from participants.

With all of this at a cost of only 15 cents per page, how can anyone interested in microbes in the sea not have a copy?

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Book review

Morel, Francois M.M. 1983. **Principles of Aquatic Chemistry**. John Wiley & Sons, New York, USA. 446 pp.

In 1970 Stumm and Morgan introduced their now classic book, 'Aquatic Chemistry', which first unified the chemical principles controlling the composition of natural waters in a single text. In the 15 years since, more and more colleges and universities have introduced courses in aquatic chemistry. These courses are frequently offered in engineering departments, but are increasingly attended by students interested in a wide diversity of disciplines including ecology, limnology, oceanography, environmental science, biogeochemistry, and microbiology. The goal of Dr. Morel's new book is to provide a text suitable to the diverse backgrounds and interests of these students. In nearly all respects the book fulfills this goal. The book's heavy emphasis on geochemical cycles of elements and on biological processes makes it especially well suited for students and researchers interested in biogeochemistry.

The first chapter of the book is devoted to conservation principles. In this chapter Dr. Morel introduces the 'Tableau', a matrix representation of the relationship between components, species, formulae and mole balance equations. The use of this formal chemical accounting system is unique to Morel's book and once mastered, provides the student with a powerful method for organizing and solving equilibrium problems. Much of this chapter is used to define components, the fundamental chemical species around which the tableau is constructed. Several examples are used to show how the proper choice of components can simplify solving equilibrium problems. Rules for choosing components and setting up a tableau are clearly laid out.

In the next chapter on energetics and kinetics Dr. Morel attempts to provide the highlights of the thermodynamic principles used in aquatic chemistry without repeating the classical presentation of thermodynamics given in most text books. The principles on the energetics of chemical reactions are developed relying solely on the notion of molar free energy and are covered in less than twenty pages. Enthalpy and entropy are introduced quite a bit later in a discussion of the effects of temperature and pressure on equilibrium. The purpose of this organization was to provide an intuitive feeling for thermodynamics. The drawback is that some students, failing to see the somewhat familiar quantities of E , S and H which they learned from general chemistry, may get lost in the derivations without seeing the point. I think that students who have not taken physical chemistry will need some supplementary material to get the most out of this chapter. This, however, is the only place where the book falls short of its goal and a general chemistry background may not be sufficient to understand the material. The rest of the energetics section, on non-ideal effects, is very well done and quite readable. A short section on kinetics is included at the end of the chapter. The concepts of partial and pseudoequilibrium is introduced and illustrated.

Chapter three deals with the organization and solution of equilibrium problems. Here equilibrium problems are solved using the tableau and intelligent guessing. The usefulness of graphing out the problem is stressed and rules for including solids and gases in the calculations are laid out. The chapter ends with a short explanation of computer calculations for more complex problems.

These first three chapters form the core of the book and lay the groundwork for the rest of the subjects covered. Chapter 4, on acids and bases, focuses on the concept of alkalinity. It includes a well written section on the effects of biological process on pH and alkalinity in closed systems. Equilibrium with gas phases and buffering are also covered. The chapter ends with a discussion on the exchange of gases at the air–water interface. This section ties back in to the kinetic section in chapter 2 with a discussion of the kinetics of CO_2 equilibrium in a water column. The next chapter covers solid dissolution and precipitation beginning with a general discussion of weathering reactions. The method of determining if a particular solid is present at equilibrium is demonstrated using halite, ferric hydroxide and calcium carbonate as examples. These sections lead into a discussion on the control of alkalinity in fresh water and in the ocean.

Dr. Morel's research interests are well represented in a beautifully done chapter on complexation (Chapter 6). Sections on trace metal complexation by humates, the excretion of strong chelators by algae, and trace metals and microorganisms, supplement the more basic information on inorganic and organic complexation in natural waters. The chapter also includes a fairly extensive compilation of stability constants for the formation of complexes and solids from metals and ligands. Redox reactions are treated in chapter 7. The importance of microorganisms in mediating redox reactions is repeatedly stressed and a considerable portion of the chapter is devoted to the energetics of microbial processes. The short section on photochemistry is interesting and again focuses on one of Morel's research interests, the photoreduction of organically chelated trace metals. The final chapter on reactions on solid surfaces begins by treating the adsorption of metals and ligands on particles as a complexation problem. The classic models on electrostatic effects on adsorption are then introduced. An electrostatic term is then introduced into the surface complexation model. The results of these models are then compared to experimental data. All five of these chapters include some discussion of kinetic factors. All eight chapters end with a brief list of relevant references and extensive problem sets (unfortunately answers are not included).

I recently used this book for a tutorial on aquatic chemistry attended by graduate students in ecology and behavior who were interested in biogeochemistry and chemoreception. None of these students had taken advanced chemistry courses. I found the 'tableau' method to be an effective way for students to learn how to set up and solve equilibrium problems. However, it takes some time for students to gain the necessary chemical intuition to correctly set up the tableau and solve a problem in a few iterations. This intuition is learned by working out the numerous examples provided in the book. A computer program which allowed students to set up the tableau and make guesses without having to laboriously grind through the iterations on a hand calculator would greatly speed this learning process and would make a nice appendix for future editions.

I highly recommend this book for an advanced undergraduate course or graduate course. It emphasizes the importance of biological processes in regulating the chemistry of natural waters more strongly than most of the current books in this field and is a novel addition to the present array of texts dealing with aquatic chemistry. Dr. Morel makes a real attempt to keep the prose entertaining and it is an enjoyable book to read. There is a very full semester's worth of material here, so unless the students are quite well prepared, it may be necessary to omit most of the optional topics set off by squares in the text.

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