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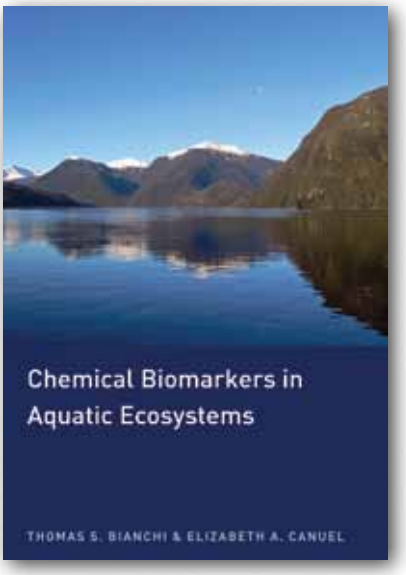
Chemical Biomarkers in Aquatic Ecosystems

By Thomas S. Bianchi and Elizabeth A. Canuel, Princeton University Press, 2011, 396 pages, ISBN 978-0-69d1-13414-7, $95 US Hardcover

REVIEWED BY CHRISTOPHER C. PARRISH



In order to measure inputs, cycling, and loss of material in aquatic ecosystems, a wide range of compounds and analytical tools is now available. Biological markers are compounds, or groups of compounds, that can be used as indicators or signatures of individual organisms or groups of organisms, or of certain environmental processes. Molecular biomarkers can be DNA fragments or smaller molecules that are easily determined using standard chromatographic techniques. Anthropogenic compounds can be used as wastewater markers to locate sources and pathways of transport as well as to determine pollutant loading.

Chemical markers are employed in ecological and biogeochemical studies to assess the health of ecosystems and the degree to which they have been influenced by terrestrial and anthropogenic inputs. They can be used to determine production of biogenic material of dietary value to aquatic organisms as well as to indicate water quality. Marker determination in sediment cores can show the sensitivity of sediments to changes in land-use patterns near the land margin. The relationship between aquatic and terrestrially derived products in cores can indicate the degree to which human land use has affected the pattern of aquatic biogenic productivity in the area.

Chemical Biomarkers in Aquatic Ecosystems by T.S. Bianchi and E.A. Canuel is a textbook aimed at advanced undergraduates and graduate students. It is derived from biogeochemistry classes taught by the authors and their wealth of experience with biomarkers, especially in estuaries, which are among the most complex systems in which to work. Its 14 chapters, spanning close to 300 pages, are written in a clear and patient style. The book has ample supporting material, with over a quarter of its pages devoted to appendices, a glossary, an extensive bibliography, and an index.

The first four chapters should probably be read sequentially, but after that the remaining 10 chapters could be read in any order. The first chapter on metabolic synthesis provides detailed biochemical background material for the book, but it is the next chapter that is the real introduction to biomarker use. It provides a concise and useful introduction to applications of chemical biomarkers, highlighting both their strengths and limitations. Chapter 3 clearly and thoroughly presents background on the use of stable and radioisotopes. Chapter 4 describes the methodology for determining chemical markers, starting with sampling. This long chapter provides good detail on the vast array of analytical tools available for markers and it has many useful figures.

The majority of the text examines biomarkers and anthropogenic markers by compound group, starting with the carbohydrates in Chapter 5. This chapter discusses carbohydrate chemistry, biosynthesis, and use as biomarkers, with a focus on aldoses and substituted aldoses. It describes in some detail the analysis of total carbohydrates and monosaccharides and presents data from rivers, lakes, and porewaters, and from surface and deep seawater. The next two chapters describe the analysis and applications of nitrogenous compounds. Chapter 6 is a very well referenced chapter focusing on proteins, amino acids including nonprotein amino acids, and amines. Although these compounds are less useful than others for determining sources of organic material, their analysis tells us a lot about nitrogen and carbon cycling in aquatic environments. Chapter 7 shows how molecular tools have recently brought huge insight into microbial taxonomy and biochemistry.

Most of the remaining chapters in the book deal with compounds that can be operationally defined as lipids. The basis of this definition is their extractability in organic solvents, which provides a convenient means of separating them from other compounds in an aqueous matrix. Such extracts may contain

multiple subclasses of both biogenic and anthropogenic origin. The heterogeneous nature of lipids means that they are versatile biomarkers; they are widely used in trophic transfer studies in aquatic food webs, and they are increasingly employed for terrestrial food webs as well. These markers are used to delineate carbon cycling and transfer of material through food webs, often with the help of multivariate statistics. The more stable markers have also been extensively used in paleoenvironmental studies.

Chapter 8 concentrates on fatty acids, indicating several areas where data need to be interpreted cautiously as well as important areas for future research. Chapter 9 focuses concisely on the wide diversity of sterols and also briefly discusses related compounds such as the bacterial hopanoids and hopanes, the hydrocarbon derivatives of hopanoids. Chapter 10 continues the discussion of hydrocarbons, detailing the chemistry and geochemistry of the alkanes, alkenes, and other isoprenoid hydrocarbons, including highly branched isoprenoid alkenes derived from microalgae. This chapter presents equations used for the calculation of various indices based on alkane distributions, and compares their uses. The use of lipid indices is also the subject of the next chapter. Chapter 11 shows how polyunsaturated ketones and tetraethers are used as paleotemperature indicators. This concise chapter gives the structures involved and the equations used for their calculation, and it discusses their calibration. Chapter 12 is a very complete and extensively referenced chapter on chlorophylls, carotenoids, and phycobilins. It extends from the chemistry and biosynthesis of pigments to remote sensing from satellites.

The last two chapters differ from previous ones as they deal entirely with delivery of allochthonous materials to aquatic environments. Chapter 13 is a well-developed description of the plant polymers, the lignins, cutins, and suberins, and it emphasizes the importance of using biomarker ratios for constraining sources. Chapter 14 provides a very interesting overview of anthropogenic compounds in aquatic environments, with an introduction to their use as molecular markers. This chapter could certainly form the basis of an environmental chemistry class at the advanced undergraduate or graduate level.

Starting with the classification of organisms and ending with anthropogenic markers, this very complete and dense text covers not only the chemistry and applications of biomarkers but also their biosynthesis and analysis. The only thing that is really missing is a section on chemometric methods for experiment design and analysis of multivariate data. The application of chemometrics to biomarker data is becoming increasingly common as it permits data reduction and an objective interpretation of the results. The text does mention a couple of multivariate techniques in a few places, particularly principal components analysis (PCA), which does have a strong following, but several more sophisticated multivariate analyses are also emerging. They provide a more quantitative analysis and could have been discussed in detail and compared with PCA.

Overall, *Chemical Biomarkers in Aquatic Ecosystems* is a nicely presented organic biogeochemistry text, although it uses quite a small font and suffers from typographical errors in every chapter and also in some of the figures, tables, and references. For the most part, these errors do not detract from the book at all, but in the few times they occur with compound designations they might cause confusion. The writing style is consistent and pleasant, but sometimes is perhaps a bit too conversational, and there are occasional grammatical problems. The text is well broken up by an abundance of figures and tables presented in a similar style throughout; however, the material in them could sometimes use further explanation. The book is also quite acronym laden and it would certainly have been helped by a list of abbreviations that would fill the blank pages left in the appendices. After the appendices, there is a very long bibliography that is broken down by chapters. It would have been more logical to have a single reference list for ease of access and to save space, or to place references at the end of each chapter.

In conclusion, despite a few problems with the presentation, this book certainly does fill a niche. It gives a thorough explanation of the analysis and applications of biomarkers and will be a useful text for all practitioners of the biomarker approach, be they graduate students or established researchers, and it could definitely be employed as the basis for a graduate course in an Earth science, oceanography, or limnology program.

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