

The Handbook of Environmental Chemistry

Founded by Otto Hutzinger

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Volume 42

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Experiences from Surface Water Quality Monitoring

The EU Water Framework Directive
Implementation in the Catalan River Basin
District (Part I)

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The Handbook of Environmental Chemistry

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- Aims and Scope
- Instructions for Authors
- Sample Contribution

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Aims and Scope

Since 1980, *The Handbook of Environmental Chemistry* has provided sound and solid knowledge about environmental topics from a chemical perspective. Presenting a wide spectrum of viewpoints and approaches, the series now covers topics such as local and global changes of natural environment and climate; anthropogenic impact on the environment; water, air and soil pollution; remediation and waste characterization; environmental contaminants; biogeochemistry; geoecology; chemical reactions and processes; chemical and biological transformations as well as physical transport of chemicals in the environment; or environmental modeling. A particular focus of the series lies on methodological advances in environmental analytical chemistry.

Series Preface

With remarkable vision, Prof. Otto Hutzinger initiated *The Handbook of Environmental Chemistry* in 1980 and became the founding Editor-in-Chief. At that time, environmental chemistry was an emerging field, aiming at a complete description of the Earth's environment, encompassing the physical, chemical, biological, and geological transformations of chemical substances occurring on a local as well as a global scale. Environmental chemistry was intended to provide an account of the impact of man's activities on the natural environment by describing observed changes.

While a considerable amount of knowledge has been accumulated over the last three decades, as reflected in the more than 70 volumes of *The Handbook of Environmental Chemistry*, there are still many scientific and policy challenges ahead due to the complexity and interdisciplinary nature of the field. The series will therefore continue to provide compilations of current knowledge. Contributions are written by leading experts with practical experience in their fields. *The Handbook of Environmental Chemistry* grows with the increases in our scientific understanding, and provides a valuable source not only for scientists but also for environmental managers and decision-makers. Today, the series covers a broad range of environmental topics from a chemical perspective, including methodological advances in environmental analytical chemistry.

In recent years, there has been a growing tendency to include subject matter of societal relevance in the broad view of environmental chemistry. Topics include life cycle analysis, environmental management, sustainable development, and socio-economic, legal and even political problems, among others. While these topics are of great importance for the development and acceptance of *The Handbook of Environmental Chemistry*, the publisher and Editors-in-Chief have decided to keep the handbook essentially a source of information on "hard sciences" with a particular emphasis on chemistry, but also covering biology, geology, hydrology and engineering as applied to environmental sciences.

The volumes of the series are written at an advanced level, addressing the needs of both researchers and graduate students, as well as of people outside the field of

“pure” chemistry, including those in industry, business, government, research establishments, and public interest groups. It would be very satisfying to see these volumes used as a basis for graduate courses in environmental chemistry. With its high standards of scientific quality and clarity, *The Handbook of Environmental Chemistry* provides a solid basis from which scientists can share their knowledge on the different aspects of environmental problems, presenting a wide spectrum of viewpoints and approaches.

The Handbook of Environmental Chemistry is available both in print and online via www.springerlink.com/content/110354/. Articles are published online as soon as they have been approved for publication. Authors, Volume Editors and Editors-in-Chief are rewarded by the broad acceptance of *The Handbook of Environmental Chemistry* by the scientific community, from whom suggestions for new topics to the Editors-in-Chief are always very welcome.

Damià Barceló
Andrey G. Kostianoy
Editors-in-Chief

Foreword

Environmental quality is going to be a crucial issue for the people in charge of public affairs in the next years. To manage an environment where air, water, and soil should be in good conditions is not only an objective but a compulsory requirement in terms of well-being and of public health.

From older times water management has been a very important issue, but recently, water managers have had to cope with new challenges arising from social demands mainly focused on ecological improvement. Flowing water in rivers, lakes, estuaries, coastal waters, or reservoirs is not only regarded as resource but as a key element for sustaining aquatic ecosystems and services they provide. Good ecological status meets services and goods sustaining human well-being as well as suitable freshwater quality for safety human uses. To take into account aquatic ecosystems, preservation requires building stronger linkages between ecological, economic, and social demands with the purpose of improving water management. This framework offers the most promising way forward for the field of conservation together with a suitable human development.

Nevertheless, this challenge requires changes. Thus, in the legal side, new laws, directives, etc., are needed and institutional changes and new administrative models (development of new agencies, water authorities) are necessary. On the other side, developing new monitoring programs in order to provide suitable and enough information on water status under an ecological integrative perspective is required. Also, water management plans should be developed which encompass a comprehensive water management combining sustainable human use together with good ecological status, economic sustainability (cost recovery strategies), and social participation. Moreover, climate change should be also considered which demonstrates the scope and complexity of this challenge.

The above mentioned target makes necessary the development of new monitoring tools for water quality assessment adapted to water ecosystem types and new quality elements must be measured. Therefore, there has been a rapid increase in the development and application of ecological indicators for water quality assessment and management in developed countries. For instance, the United States, Canada,

Europe, and Australia have been developing new water monitoring programs based on biological and ecological indicators for water management purposes and planning. In the European Union (EU), the Water Framework Directive (WFD) (2000/60/EC) launched in 2000 a new framework for the protection of groundwater and inland and coastal waters. The WFD represents an opportunity for a new water resource management in Europe based on ecological and economical sustainability, with the requirement of a wide social involvement. The WFD was an important conceptual change of the way that EU Member States (MS) should consider water management by putting ecosystem integrity at the base of management decisions. Since then, all MS expended considerable time and resources to collect appropriate biological, environmental, and human pressure data to develop operative tools aiming at elaborating new monitoring programs and innovative river basin management plans. As the magnitude and difficulties of this large-scale endeavor became evident, both the European community and individual MS have funded a large number of research projects, particularly in the areas of ecological assessment for water management, to develop and improve the expert knowledge. The WFD was relevant for its innovativeness and the shift towards measuring the status of all surface and coastal waters using a range of biological communities rather than the more limited aspects applied so far.

In Catalonia, the government has been deeply involved on all this process and has been implementing the WFD soon after it was adopted. Hence the administrative institution especially devoted to water management, the Catalan Water Agency (ACA), was created in 2000. ACA is in charge of planning and carrying out water management strategies in Catalonia, taking into account both water demands and environmental protection. The ACA is nowadays in charge of building and maintaining urban wastewater treatment plans, water supply management, flooding protection plans, etc. Moreover, it has been monitoring all aquatic ecosystems, including inland and coastal waters and groundwater relationship, and has been developing new tools to ensure ecological and chemical status measurements in surface waters and chemical and quantitative status in groundwater, in accordance with the WFD requirements. Additionally, some research institutes have also been promoted mainly focused on water management. An example of this is the Catalan Institute for Water Research (ICRA), that focuses its research lines in the integral water cycle, hydraulic resources, water quality (in the broadest sense of the term: chemical, microbiological, ecological, etc.), and treatment and evaluation technologies. The research carried out at the ICRA has to do with all the aspects related with water, particularly those associated with its rational use and the effects of human activity on hydraulic resources.

Over the last decades, it has been necessary to monitor and to assess the ecological status of water bodies following the WFD guidelines. Accordingly, the ACA started a close science to policy relationship with research institutions, which have been closely involved in such development. From this collaboration novel methodologies have been proposed, and a huge amount of data has been gathered over more than a decade. Overall, this cooperation has proved to be a stimulating and fertile ground for research of the interface between science and management. Accordingly, the Catalan Water Agency (ACA) established a new monitoring

program in order to provide a proper water status diagnosis just before the water management plan's updating in the Catalan River Basin District. The ACA has now a global picture of the ecological and chemical status of all water bodies in Catalonia. The experience gained by the Agency over the last 15 years has been incorporated in these two different book volumes that I have the privilege to introduce in this preface: *Experiences from Surface Water Quality Monitoring: The EU Water Framework Directive Implementation in the Catalan River Basin District (Part I)* and *Experiences from Ground, Coastal and Transitional Water Quality Monitoring: The EU Water Framework Directive Implementation in the Catalan River Basin District (Part II)*. Both books summarize all the findings on water monitoring for WFD purposes, and they discuss further perspectives according to the new knowledge obtained. They are devoted to such effort which has resulted in a series of protocols adapted to the aquatic ecosystem monitoring in Catalonia. Both books encompass several specific chapters focused on different aquatic systems (rivers, lakes, wetlands, reservoirs, estuaries, bays, coastal waters, and groundwater) and are written by several researchers in close collaboration with ACA's technicians. They provide good examples and suitable monitoring tools for aquatic ecosystem monitoring in Catalonia that can also be easily extrapolated to other Mediterranean river basin districts. Data analyzed and information obtained are not only useful in understanding the current quality status but also gathering the necessary knowledge to design the best tools for aquatic ecosystem management and restoration and/or conservation measures adapted to each aquatic ecosystem type, paying special attention to Mediterranean conditions which deeply affect water management in southern Europe. At that time, just to end I can say that we are proud of the work done by our community of experts in water management working in public administrations, in research centers, and in private companies. I hope that the materials and experiences enclosed in the two volumes reflect a step forward of a better management of water and stimulate new developments for the future.

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Volume Preface

Freshwater systems in Europe are threatened by a variety of stressors (chemical pollution, geomorphological alterations, changes in land uses, climate variability and change, water abstraction, invasive species, and pathogens). Chemical aquatic pollution today comprises a wide range of emerging chemical substances, such as pharmaceuticals, personal care products, or pesticides, among others. Stressors are of diverse nature but cause adverse effects on biological communities and ecosystems. It is well known that the relationship between multiple stressors might determine changes in the chemical and ecological status, which are the key objectives of the European Union Water Framework Directive (WFD). This important piece of legislation has pushed the EU River Basin Authorities to carry out advanced monitoring programs in collaboration with universities and research centers.

These two volumes of *The Handbook of Environmental Chemistry* we introduce here (Volume I: *Experiences from Surface Water Quality Monitoring: The EU Water Framework Directive Implementation in the Catalan River Basin District (Part I)* and Volume II: *Experiences from Ground, Coastal and Transitional Water Quality Monitoring: The EU Water Framework Directive Implementation in the Catalan River Basin District (Part II)*) correspond to an excellent collaborative example between the River Basin Authority from the Catalan River Basin District (NE Spain), the so-called Catalan Water Agency (ACA), with the Catalan Universities and Research Centers. These books cover the main research outcomes achieved during the last 10 years following WFD implementation. It contains a total of 26 chapters and over 75 authors who explain how, from the interaction between the ACA and several academic centers, the different quality elements included in the WFD have been adapted to Mediterranean aquatic ecosystems. We want to remark the importance of this interaction between the members of the ACA and the members of academia or experts in a collaborative effort that probably is unique in the WFD implementation in Europe.

Why ACA has developed such collaborative effort? First of all because for most of the biological elements, no or few experience in how to use such elements

existed in Spain Water authorities. ACA had more experience in the analysis of chemical parameters, i.e., priority substances. Second, the methods to be used by WFD guidelines should be inter-calibrated; therefore ACA was aware that a set of methodologies with a robust scientific background was needed, so their results could be compared to other European countries. Third, most of the streams in Catalonia are in a Mediterranean climate area, and for this reason, taxa present in aquatic ecosystems and their environmental constraints are different from those of more temperate ecosystems from Europe. Scientifically robust methodologies should be adopted by ACA to explain why our aquatic ecosystems are different and how these differences affect the way in which the water quality is measured.

The ACA has easily found the way to build up from the scientific knowledge the tools needed by the administration to measure the status of the water. Catalonia has a long tradition on water quality studies which is grounded in the shoulders of several Masters and Commanders of Science. We think that at least two of them should be quoted: the former professors of the University of Barcelona Ramón Margalef and Enric Casassas. Margalef was a well-known ecologist and the first professor of Ecology in Spain, and Cassassas was the introducer of modern analytical techniques in Spain. In a postwar situation, after Spanish civil war (1936–1939) and the second world war (1939–1945), scientific research in Spain was very poor and many times under scientifically unreliable people. The late professors Ramon and Enric were extremely clever and open-minded people, and despite many obstacles, they found a way to put the roots of what now is one of the best schools of aquatic studies in Europe. Both were excellent professors and researchers and generous people with new ideas and solutions. Certainly they were an example of scientists with a global vision but with a local action, with a real compromise with their homeland, Catalonia. This school has produced an array of young scientists (not so young anymore) that have studied in-depth many aspects of ecology or chemistry in freshwater systems with a deep vision on the Mediterranean water bodies. At the same time, most of these students formed many other students and these to other, so the first grand-grand-children are at this moment at the front line of water quality research studies. Other masters exist also in Catalonia in hydrogeology, microbiology, or fish ecology, that several of the authors of this book have taken advantage.

Thanks to the effort of Margalef, Cassasas, and others and his students; when ACA started to think what to do for the implementation of the WFD, most of the fundamentals for such work were there. But in many cases the scientific research is not applied for the administration because the two worlds are hardly in contact. The merit to understand that such relationship is necessary should be given to some of the directors of the ACA and some of the ministers of the environment of the regional government of Catalonia who recognized the importance of such collaboration. It was of help too that some of the disciples who did their Ph.D. with students of the two masters already mentioned took a position in ACA. These people are now coeditors, with Prof. Prat, of these two books: Antoni Munné and Antoni Ginebreda. Both are Ph.D. from Catalan universities and understand that without the collaboration of scientist and managers, it is almost impossible to produce

enough robust tools to be compared with other well-known tools developed elsewhere. We, the scientists, should be very aware of the role of these two people because without their effort these two books could never be produced.

We hope that this book will be of much interest for many international readers too. We think that it will be a useful guide for other European river basins, as well as in other parts of the world, as a good example of the added value of collaborative research on aquatic sciences. Indeed the books contain a comprehensive list of monitoring programs of importance for WFD implementation to the Mediterranean climate aquatic ecosystems. The literature references of the different chapters contain great amount of work produced by these numerous groups of academics and managers working and publishing together in the most relevant journals of ecology, fishes, microbiology, analytical chemistry, etc. We thank all of them for their time spent writing all the different chapters and making these books unique in this series.

We, as the most senior authors and former students of Margalef and Cassasas, are very proud of this work. We thank very much the ACA and the government of Catalonia for continuously supporting such work. We encourage as well, even under the present economic difficulties, to maintain such effort. It is obvious that new methodologies and tools will need to be incorporated to monitor programs in the future. We believe that the best way to do it is by establishing bridges of collaboration between scientist and managers.

Barcelona, Spain

Narcís Prat and Damià Barceló

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