

The Handbook of Environmental Chemistry

Founded by Otto Hutzinger

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Volume 30

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The Handbook of Environmental Chemistry

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and C.A. Grady
Vol. 30, 2014

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Vol. 13, 2011

Potable Water

Emerging Global Problems and Solutions

Volume Editors: Tamim Younos · Caitlin A. Grady

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*For
Taesha, Camina, Abigail, Emma, Hannah,
Thomas and all children of the world.*

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The Handbook of Environmental Chemistry

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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

Volume Preface

Despite magnificent advances in many facets of human life, access to safe drinking water and adequate sanitation still remain beyond the reach of much of the world's population. Across the globe acute and chronic diseases caused by the consumption of contaminated water affect millions of people. Many urban and rural regions suffer from water scarcity and require long-distance transportation of water to meet potable water needs. This increased demand strains energy resources needed for both water treatment and transport. Additionally, providing safe drinking water to many rural and lightly populated areas remains cost prohibitive.

This volume by no means presents all complex issues related to potable water. However, it presents a timely and comprehensive glimpse of current and emerging issues of concern related to potable water access and presents possible alternative ways and solutions to alleviate current and emerging global potable water problems. Themes and issues discussed in this book include the following: (1) historical perspective of the evolution of drinking water science and technology, standards and regulations, and global potable water problems; (2) emerging issues of drinking water quality, water distribution, and energy demand for water treatment and transportation; and (3) using alternative water sources and alternative methods of water treatment and distribution that could resolve current and emerging global potable problems.

This book contains eight chapters. The chapter, "Potable Water Quality Standards and Regulations: A Historical and World Overview," presents an overview of the evolution of drinking water technology and standards from ancient to modern times. The chapter, "Global Potable Water: Current Status, Critical Problems and Future Perspectives," presents potable water access as a human rights issue and discusses problems relating to providing global potable water including social and political factors. The chapter, "Coping with Emerging Contaminants in Potable Water Sources," provides an overview of the types of emerging contaminants found in potable water sources, their removal in treatment plants, and a social perspective of emerging contaminants in potable water. The chapter, "Drinking Water Distribution: Emerging issues in Minor Water Systems," provides an overview of drinking water distribution systems with a focus on emerging issues in minor systems, i.e., plumbing systems in homes and other buildings, and contaminant intrusion in minor systems. The chapter, "The Effects of the Water–Energy Nexus on Potable Water Supplies," discusses energy demand for water treatment and

delivery and an overview of the ways in which the water–energy nexus creates challenges and opportunities in meeting potable water demands. The chapter, “Municipal Wastewater: a Rediscovered Source for Sustainable Water Use,” discusses municipal wastewater as a viable source and provides an appraisal of the varying qualities and characteristics of municipal wastewater affecting water reuse. The chapter, “Advances in Desalination Technologies: Solar Desalination,” discusses seawater as a potable water source, provides an overview of desalination technologies, and discusses methods and advantages of small- and large-scale solar desalination technologies. The chapter, “Bottled Water: Global Impacts and Potential,” discusses problems associated with bottled water production and consumption and the potential advantage of bottled water as a decentralized system for delivering potable water.

In “Potable Water Quality Standards and Regulations: A Historical and World Overview,” Kroehler provides an overview of drinking water in ancient times and the development of water treatment systems and discusses the evolution of water analysis and drinking water standards. The chapter also includes examples of current standards and regulations around the world, emerging standards and regulatory challenges, and global drinking water goals.

In “Global Potable Water: Current Status, Critical Problems and Future Perspectives,” Grady, Weng, and Blatchley provide an overview of critical problems related to providing potable water in both developed and emerging countries. Issues discussed include acute and chronic health issues attributed to unsafe drinking water; natural and human influences that will alter our current water supply in the coming decades; the technical limitations to water treatment in both developed and emerging economies; social and political factors influencing potable water access such as government capacity, competing interests, and the influence of food choices on water availability; and some current innovative approaches and suggested strategies for future water management.

In “Coping with Emerging Contaminants in Potable Water Sources,” Gall and Mina discuss emerging contaminants, such as pharmaceuticals and hormones, their sources, and their pathways to drinking water systems. Authors provide an overview of the types of emerging contaminants found in potable water sources, issues associated with their removal in water treatment plants, and a social perspective of the public’s concerns regarding emerging contaminants in potable water.

In “Drinking Water Distribution: Emerging issues in Minor Water Systems,” Lee and Farooqi discuss emerging issues in minor drinking water systems (in-building plumbing) along with general characteristics of drinking water distribution systems as a whole. The authors describe experimental studies which demonstrate that hydraulic transients triggered from water mains result in low-pressure occurrences in service lines. Such occurrences can allow possible intrusion of microbial and chemical contaminants at the service line. Lee and Farooqi conclude that structural integrity of service lines and hydraulic integrity at drinking water distribution systems should be maintained so that any public health risks will be minimized.

In “The Effects of the Water–Energy Nexus on Potable Water Supplies,” Lawson, Zhang, Joshi, and Pai discuss complicated interactions between water and energy in potable water systems. A rising global population will increase energy demand for treating and delivering water and may necessitate the energy-intensive treatment of alternative water sources such as wastewater and saline water for potable use. Authors also discuss the impact of electricity production and climate change on potable water sources. The chapter provides an overview of the ways in which the water–energy nexus creates challenges and opportunities in meeting potable water demand.

In “Drinking Water Distribution: Emerging issues in Minor Water Systems,” Mohan, Speth, and Garland argue that while significant progress has been made in building new water infrastructure, there exists a considerable difference between the supply of and demand for high-quality water. They assert that both the cost and unsustainable nature of diverting large volumes of water to water-stressed areas have become difficult to justify. The authors state that municipal wastewater has been identified as a viable alternative water source, and they provide an appraisal of the various qualities and characteristics of municipal wastewater affecting its reuse. Conventional and advanced technologies used for treating municipal wastewater to meet reuse standards are then evaluated; several case studies demonstrating water reuse schemes in different parts of the world are described in brief.

In “Advances in Desalination Technologies: Solar Desalination,” Abou-Rayan and Djebedjian provide an overview of desalination technologies and state that advances in these technologies clearly show that potable water can be obtained from desalinated water. The authors state that introducing solar energy as the power source in the desalination process has opened a new way to expand desalination technology. For countries suffering from freshwater shortages, particularly in rural and isolated areas, they argue for the importance of solar desalination. The chapter highlights existing solar desalination technologies and case study projects in several countries.

In “Bottled Water: Global Impacts and Potential,” Younos discusses the rationale beyond global expansion of bottled water and the problems associated with its production and consumption, energy demands, health concerns, and plastic pollution. The authors conclude that the current bottled water industry is not part of a sustainable solution to the overall challenge of providing potable water worldwide. However, bottled water could become part of an overall future solution to global lack of potable water shortages and community development. This would involve the bottled water industry to incorporate innovative water treatment technologies, renewable energy, and biodegradable plastics (or similar materials) in bottled water production and infrastructure systems.

Key issues will continue to influence access to potable water in both developing and developed countries: population growth, human migrations, competing demands among various water consumers such as agriculture, water infrastructure that has deteriorated or is wholly absent, energy constraints, and climate change. As scientific investigations and water treatment technologies continue to evolve, potable water shortages can be more efficiently addressed by developing alternative

sources such as treated municipal wastewater and desalinated brackish and seawater. Likewise, as renewable energy technologies advance and water infrastructure becomes decentralized, treatment and delivery of potable water will become less dependent on fossil fuels.

Avenues of research not addressed here include analysis of the life cycles of potential solutions and evaluation of social and political facets of sustainable potable water access and water use. There is a critical need worldwide to consider innovative procedures that will enable policy and decision-makers to consider bold intellectual and financial investments that will provide potable water to unserved communities.

We hope this volume serves as a valuable resource and reference for graduate and undergraduate students and for researchers concerned with global potable water sustainability. Equally, we hope it will be a useful guide to those affiliated with international agencies working to provide safe water supplies to communities around the world.

Blacksburg, VA
West Lafayette, IN

Tamim Younos
Caitlin A. Grady

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