

# **The Handbook of Environmental Chemistry**

**Founded by Otto Hutzinger**

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**Volume 58**

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# Freshwater Microplastics

## Emerging Environmental Contaminants?

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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/](http://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



# Preface

## **Freshwater Microplastics as Emerging Contaminants: Much Progress, Many Questions**

Historically – if one can say that given the infancy of the field – environmental plastic debris has been the baby of marine research. Driven by the rediscovery of long forgotten, 1970s studies on the occurrence of small plastic fragments (today termed microplastics) in the oceans, oceanographers and marine biologists resurrected the topic in the early 2000s. Since then, the field has rapidly expanded and established that plastics are ubiquitous in the marine system, from the Arctic to Antarctic and from the surface to the deep sea.

While obviously the sources of environmental plastics are land-based, much less research has been dedicated to investigating them in freshwater systems. At the time of writing this book, less than four percent of publications had a freshwater context, reflecting the idea that streams, rivers, and lakes are mere transport routes transferring plastics to the oceans similar to a sewer. Because this is too simplistic, this book is dedicated to the in-between. Our authors explore the state of the science, including the major advances and challenges, with regard to the sources, fate, abundance, and impacts of microplastics on freshwater ecosystems. Despite the many gaps in our knowledge, we highlight that microplastics are pollutants of emerging concern independent of the salinity of the surrounding medium.

Environmental (micro)plastics are what some call a wicked problem, i.e., there is considerable complexity involved when one tries to understand the impact of these synthetic materials on the natural world. Just as an example, there is no such thing as “the microplastic.” Currently, there are in commerce more than 5,300 grades of synthetic polymers.<sup>1</sup> Their heterogeneous physico-chemical properties will likely result in very heterogeneous fates and effects once they enter the

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<sup>1</sup>According to the plastics industry’s information system CAMPUS (<http://www.campusplastics.com>, last visited on June 20, 2017).

environment. In the light of this, treating microplastics as a single pollutant does not make sense. Therefore, we kick off the book by giving a brief overview on what plastics are, where they come from, and where they go to in the environment. As the research on engineered nanomaterials faces similar challenges, we then look more deeply into the (dis)similarities of nanoparticles and microplastics and try to learn from past experiences.

We continue with five chapters focusing on the abundance of microplastics in freshwater systems, touching on analytical challenges, discussing case studies from Europe, Asia, and Africa as well as approaches for modeling the fate and transport of microplastics. As the biological interactions of synthetic polymers will drive their environmental impacts, we review the state of the science with regard to their toxicity in freshwater species and biofilm formation. While, admittedly, progress in this area is slow, we already learned that “It’s the ecology, stupid!” to paraphrase Bill Clinton.

The last part of the book is dedicated to the question how society and microplastics interact. We take a sociological perspective on the risk perception of the issue at hand and discuss how this “vibrates” in the medial and political realm and the society at large. While the uncertainty in our understanding is still enormous, we conclude our book with an outlook on how to solve the problem of environmental plastics. We have in our hands a plethora of regulatory instruments ranging from soft to hard measures, of which some are already applied. However, because the linear economical model our societies are built on is at the heart of the problem, we critically revisit available solutions and put it into the larger context of an emerging circular economy.

Given the wickedness of the plastics problem in terms of material properties, analytical challenges, biological interactions, and resonance in society, we clearly need an inter- and transdisciplinary effort to tackle it. We hope this book promotes such view. We also hope it conveys the idea that we need to embrace the inherent complexity to solve it. We thank our authors, reviewers, the publisher, and all funders for following this path and making this book happen (and open access).

Frankfurt am Main, Germany  
June 2017

Martin Wagner  
Scott Lambert

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