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

Preface

When we think of a hospital, what first comes to mind is a facility that should improve and guarantee the health of patients while carrying out investigations to fight and overcome diseases.

In order to achieve these goals, hospital staff use a wide spectrum of chemicals for therapeutic and diagnostic purposes, room cleaning and equipment disinfection. Unavoidably, residues of these chemicals are present in hospital waste and in particular in hospital effluents. Most of these substances belong to the group of so-called *emerging contaminants*, most of which occur at low concentrations – ng/L or µg/L – in (waste)water and are therefore known as *micropollutants*. Examples are antibiotics, analgesics, anaesthetics, cytostatics and X-ray contrast media.

Although these emerging contaminants are still unregulated compounds in water, their use, consumption and fate in the water cycle represent issues of increasing worldwide concern. In this context, the effluent of health care structures has been the focus of great research and discussion over the last 15 years. Investigations have mainly dealt with: (1) the characteristics of hospital wastewater, exploring its chemical, physical and microbiological composition, (2) the efficiency of conventional treatments in removing targeted micropollutants and the treatment options for improving their removal and (3) the assessment of the environmental risk posed by the residues of pharmaceuticals and other chemicals commonly used in health care structures, still present after the adopted treatments.

It is well known that investigations have dealt with a comparatively low number of compounds, with regard to the thousands of active ingredients used in pharmaceutical preparations. Targeted compounds were generally selected on the basis of the available analytical techniques, consumption data and results from past studies. It is also known that, mainly in the first years of investigations, some compounds were more frequently selected for monitoring programmes and some of them were regularly included in the analyte lists. This prominence was often dictated by the fact that interest given to them in the past generated more attention in the future.

This is the so-called *Matthew Effect*, a psychological phenomenon analysed for the first time by Robert Merton in 1968 [1] and used by Grandjean and colleagues

[2] "to explain the biased path followed by many of the incremental and repetitive findings of environmental science" [3].

In the last few years, attention has also been paid to other emerging contaminants as new analytical techniques have allowed the monitoring of a wider group of substances, and as the scientific community has become more aware that it is necessary to enlarge the spectrum of targeted compounds in order "to reduce biases and uncertainties in the exposure assessment process and in environmental risk assessment" [4].

In addition to compound selection, other issues have been widely discussed: the sampling mode and frequency of the different pharmaceuticals, spatial and temporal variability of concentrations of micropollutants, accuracy of direct measures, uncertainties in predicting concentrations; the reliability and representativeness of measurements and predictions; prioritization of pharmaceuticals; options in the adopted treatment worldwide and promising technologies (on the basis of lab and pilot scale investigations); environmental risk assessment and the release of antibiotic-resistant bacteria and genes.

An attempt to represent the complexity of the problems related to the management and treatment of hospital effluents is made in Fig. 1. Three main fields were identified: composition, management and treatment, and the environmental risk posed by residues in the treated effluent. For each of them, the main subfields are also outlined.

What is known in each field is only the tip of a big iceberg: in Fig. 1 it corresponds to the region above the reference system which separates the space of "*Knowns and Data of absence*" from the space of "*Absence of data and*

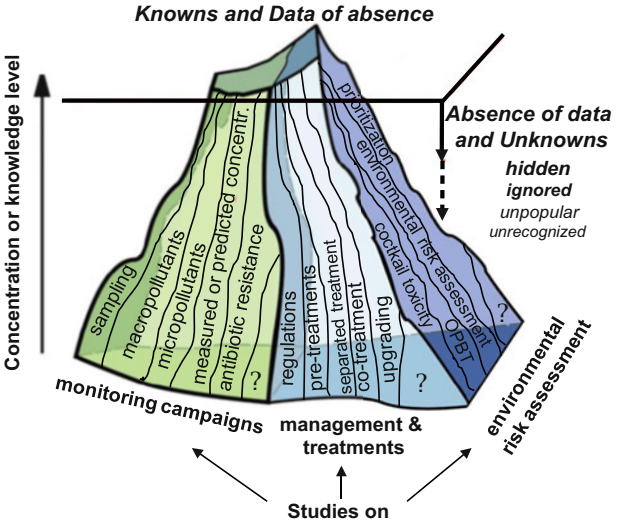

Fig. 1 What is known and what is unknown referring to hospital effluent characterization, treatment and management (adapted from [5])

Unknowns". The "unknowns" include "known-unknowns" that are some things we know we do not know and also "unknown unknowns" that are the ones we don't know we don't know (represented by the three areas with a question mark).

Looking back to past research, this book provides the main findings achieved by different research groups, comments on what is known and what is still unknown and, looking forward, it underlines the perspectives and future needs of the different research issues, promoting investigations in the sphere of known-unknowns and unknown-unknowns.

In brief, it consists of a series of 12 contributions referring to a worldwide overview regarding the regulation of this kind of wastewater (chapter "Hospital Wastewater: Existing Regulations and Current Trends in Management"), a snapshot of the observed range of concentrations of conventional pollutants and micropollutants (pharmaceuticals, heavy metals, microorganisms and viruses) and the ecotoxicity of the effluent (chapters "Occurrence of Common Pollutants and Pharmaceuticals in Hospital Effluents" and "Ecotoxicity of Hospital Effluents"). Then it presents a prioritization of pharmaceuticals on the basis of two approaches: OPBT (Occurrence, Persistence, Bioaccumulation and Toxicity) and assessment of the environmental risk based on calculation of the risk quotient (chapter "Prioritization of Active Pharmaceutical Ingredients in Hospital Wastewater"); a focus on three groups of pharmaceuticals commonly present in hospital effluents (antibiotics, cytostatics and X-ray contrast media) in terms of their occurrence and potential environmental implications (chapter "Occurrence and Risks of Contrast Agents, Cytostatics and Antibiotics in Hospital Effluents") and a discussion of the accuracy and uncertainties in evaluating hospital effluent concentrations and loads by direct measurements and predictive models (chapter "Pharmaceutical Concentrations and Loads in Hospital Effluents: Is a Predictive Model or Direct Measurement the Most Accurate Approach?").

Regarding management and treatment of this kind of wastewater, the book includes an evaluation of the contribution of hospital effluents and urban wastewater to the pharmaceutical load in a catchment area (chapter "Contribution of Hospital Effluents to the Load of Micropollutants in WWTP Influents") and an analysis of the adopted treatments in different countries (chapters "Lessons Learned from European Experiences and Presentation of Case Studies" and "Hospital Wastewater Treatments Adopted in Asia, Africa and Australia").

The following two chapters deal with the description of full-scale plants for the separate treatment of hospital effluents (chapter "Full Scale Plants for Dedicated Treatment of Hospital Effluents") and the most promising technologies aimed at improving the removal of targeted microcontaminants investigated at a lab or on a pilot scale (chapter "Overview on Pilot-Scale Treatments and New and Innovative Technologies for Hospital Effluent"). The conclusions summarize remarks on occurrence, management and treatments of hospital effluent and underline perspectives in future research (chapter "Final Remarks and Perspectives in Management and Treatment of Hospital Effluent").

The book is intended for a broad audience which includes researchers and scientists involved in management and treatment of hospital effluents and wastewater containing micropollutants, administrators and decision-makers who could find strategies adopted in different countries and descriptions of full-scale treatment plants, legislators involved in the authorization and management of health care structure effluents, environmental engineers involved in the design of wastewater treatment plants and also newcomers and students interested in these issues.

Finally, my sincere acknowledgements to all the authors who agreed to take part in this editorial project and who devoted their time to developing their research contribution and, above all, for sharing their knowledge and findings with other readers. A special thanks to Prof. Damia Barceló, HEC Series Editor, who invited me to be the Editor of this book on hospital wastewater and Dr. Andrea Schlitzberger and all her team at Springer Publishers who supported me in every step of its creation.

Ferrara, Italy Paola Verlicchi
May 2017

References

1. Merton R (1968) The Matthew Effect in Science: the reward and communication systems of science are considered. Science 159:156–163
2. Grandjean P, Eriksen ML, Ellegaard O, Wallin JA (2011) The Matthew Effect in environmental science publication: a bibliometric analysis of chemical substances in journal article. Environ Health-Glob 10(1):96
3. Sobek A, Bejgarn S, Rudén C, Breitholz M (2016) The dilemma in prioritizing chemicals for environmental analysis: known *versus* unknown hazard. Environ Sci 18(8):1042–1049
4. Daughton CG (2014) The Matthew Effect and widely prescribed pharmaceuticals lacking environmental monitoring: case study of an exposure-assessment vulnerability. Sci Total Environ 466–467:315–325
5. Daughton CG. Exploring the Matthew Effect, 2013. Available on the web site: https://www.epa.gov/innovation/pathfinder-innovation-projects-awardees-2013

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