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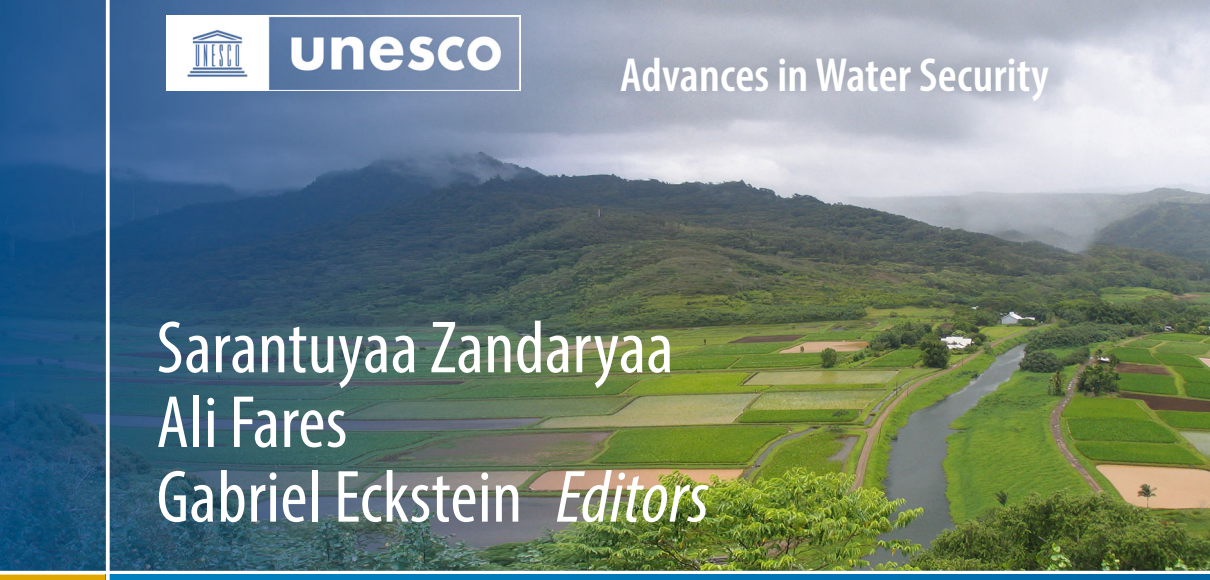
Advances in Water Security



Sarantuyaa Zandaryaa
Ali Fares
Gabriel Eckstein *Editors*

Emerging Pollutants

Protecting Water Quality for the Health of People and the Environment

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Springer

Advances in Water Security

Series Editor

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Emerging Pollutants

Protecting Water Quality for the Health of People and the Environment

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S H O R T S U M M A R Y

Emerging Water Pollutants: Advancing Science to Shape Policies

Water is vital for life on Earth. Water quality is declining worldwide, threatening human health, food security, ecosystems, and biodiversity. The United Nations 2030 Agenda for Sustainable Development and the Sustainable Development Goals recognize the crucial need to provide **access to safe water—a fundamental human right**—and protect the world's water resources from pollution.

Water quality management has historically focused on pathogens, nutrients, and heavy metals. A new class of pollutants known as emerging pollutants has garnered increasing attention due to potential risks to human health and ecosystems. Emerging pollutants, which include pharmaceuticals, personal care products, endocrine-disrupting compounds, chemicals, microorganisms, and micro- and nano-plastics, are found in water resources and known to cause chronic toxicity and endocrine disruption in humans and aquatic wildlife, and the development of bacterial pathogen resistance.

Limited knowledge about emerging pollutants hinders the development of appropriate regulatory, monitoring, prevention, and control measures.

More than **8 million tonnes** of plastic enter **the ocean** each year through **rivers** and **waterways**

UNESCO promotes research, knowledge generation and dissemination, capacity building, and awareness of emerging water pollutants. This book presents state-of-the-art research findings and proposes science-based policy recommendations on managing emerging pollutants toward sustainable water management and healthy ecosystems in the face of global changes and evolving environmental threats.

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"Since wars begin in the minds of men and women it is in the minds of men and women that the defences of peace must be constructed"

Foreword

Water, the source of life on Earth, is essential for ecosystems, biodiversity, human well-being, food security, social and economic activities. Protecting and sustainably managing water resources are, therefore, the foundation for the sustainable development of societies. Yet, the world's water resources are increasingly threatened by pollution, unsustainable use and climate change. New and emerging pollutants further excretable water pollution, adversely affecting both natural ecosystems and human health.

This publication is timely and essential on emerging water pollutants. Rapid industrialisation, urban expansion, and intense agricultural activities have introduced a wide and complex array of new contaminants into freshwater bodies, posing human health and ecological risks that often go unnoticed until it is too late.

The Intergovernmental Hydrological Programme (IHP)—UNESCO's international scientific cooperative program in water research, water resource management, water education, and capacity-building, and the only broadly-based science programme of the UN system in this area—has been at the forefront of addressing water-related issues for over five decades now. It fosters scientific collaboration and interdisciplinary research to support countries in enhancing their capacities to monitor, manage and protect water quality, promoting the sustainable use of this vital resource for sustainable development. In particular, IHP has been championing research promotion, knowledge generation, and capacity building on emerging pollutants during the past decade.

This critical book reflects our restless commitment to advancing scientific understanding of emerging pollutants, a crucial resource for scientists, policymakers, and practitioners. By integrating scientific knowledge with practical applications, this publication aims to foster a deeper understanding of the interconnectedness of water, health, and the environment. The chapters within this book explore the sources and effects of emerging water pollutants and highlight the urgent need for decision-makers to fully understand and rapidly exploit these trustful scientific findings to act and design comprehensive strategies to preserve ecosystems and protect people's health.

I invite you to delve into this critical collective work and join us in pleading for urgent action to protect and better manage our water resources for a cleaner, healthier, and more sustainable world.

Lidia Brito
Assistant Director-General for Natural
Sciences of UNESCO

Preface

Pollutants of emerging concern are a wicked problem. New and emerging pollutants are known to be harmful to people and the environment. These substances are used and released continuously into the environment, even in low quantities. Some may cause chronic toxicity and endocrine disruption in humans and aquatic wildlife and contribute to anti-microbial-resistant pathogens. Yet, the sheer number and diversity of these contaminants and the complexities of their origins, transport, toxicity, chronic effects, intermixing, cumulative effects, and elimination make it especially challenging to formulate appropriate policy responses.

Current knowledge of the extent of human and ecosystem health risks posed by emerging pollutants is inadequate. Moreover, most emerging pollutants found in the environment are not regulated through environmental, water quality, wastewater discharge, or health impact regulations. Similarly, regulations for monitoring or tracing the origin or fate of these substances are lacking. Traditional water treatment technologies often fail to remove emerging pollutants, highlighting the need for advanced research and effective monitoring and control measures. As a result, there is an urgent need to implement appropriate measures and policies to reduce emerging pollutants and associated threats to humans and ecosystems. In particular, more research and action are needed to: strengthen scientific knowledge and adopt appropriate technological and policy approaches to monitor emerging pollutants in water resources and wastewater; assess the potential human health and environmental risks posed by emerging pollutants; prevent and control the disposal of emerging pollutants into water resources and the environment; and develop regulations to mitigate and prevent the introduction of these pollutants in the aquatic environment.

Aiming to achieve some of these goals, the United Nations Educational, Scientific and Cultural Organization (UNESCO), through its Intergovernmental Hydrological Programme (IHP) and jointly with the International Water Resources Association, organized an online conference under the theme of *Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment* in January 2023. The conference highlighted research findings, approaches, methodologies, technologies, and policies that communities worldwide can use to advance knowledge and research, identify solutions, and develop policies for managing pollutants of emerging concern in the aquatic environment.

Aligned with the theme of Springer series *Advances in Water Security*, this book focuses on protecting water quality from emerging pollutants. It features selected contributions presented at the conference and proposes science-based policy recommendations. A few exceptional articles were also invited to enrich this compilation of research and scientific studies on emerging water pollutants. The book emphasizes the importance of interdisciplinary scientific collaboration, innovative policies, and

adaptive governance. It is an important, comprehensive knowledge resource for policymakers, researchers, and stakeholders to manage emerging pollutants and mitigate associated risks.

As the series and book editors and the conference's International Scientific Committee co-chairs, we are grateful for the excellent contributions of all authors, as well as for the scientific work of researchers worldwide who dedicate their expertise and research in various disciplines to advancing knowledge in this developing area of crucial importance. Their efforts are indispensable to the global efforts to find solutions to improve and protect water quality and manage emerging pollutants in our changing world. Only through better knowledge, scientific evidence, and collaborative efforts will we be able to identify sustainable solutions to the wicked problem of pollutants of emerging concern.

Lead editor of this book Dr Sarantuyaa Zandaryaa, who coordinated UNESCO IHP Theme on Water Quality during IHP-VII and IHP-VIII phases, recalls UNESCO's pioneering role in research promotion and knowledge generation on emerging water pollutants, which began as a case study back in 2011 and evolved into the implementation of a comprehensive UNESCO project in 2015–2018 dedicated to scientific cooperation, research, policy development, capacity building, and awareness raising on emerging pollutants and microplastics in freshwater resources. UNESCO's work on emerging pollutants catalyzed and fostered a rich landscape of research in various scientific disciplines across world's regions investigating different aspects of emerging pollutants and exploring solutions for addressing this global concern. As this book elucidates, the scientific advancements in understanding human and environmental health effects of emerging pollutants reflect not only the dedication of researchers worldwide but also the critical role that international scientific cooperation plays in tackling global environmental challenges. Through the concerted efforts facilitated by UNESCO, a dynamic field of study has emerged, positioning the global scientific community at the forefront of addressing the complexities posed by these new and emerging pollutants. As the world is facing increasingly acute challenges associated with climate change, population growth, and pollution, the insights provided in this book are more crucial than ever. Readers will discover not only state-of-the-art research findings but key policy recommendations guiding action.

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