

Xenobiotics in Urban Ecosystems

Rishikesh Singh

Pardeep Singh • Sachchidanand Tripathi

K. K. Chandra • Rahul Bhadouria

Editors

Xenobiotics in Urban Ecosystems

Sources, Distribution and Health Impacts



Springer

Editors

Rishikesh Singh
Department of Botany
Panjab University
Chandigarh, India

School of Earth and Environment Sciences
Amity University Punjab
Mohali, India

Sachchidanand Tripathi
Department of Botany
Deen Dayal Upadhyaya College
University of Delhi
Delhi, India

Rahul Bhadouria
Department of Environmental Studies
Delhi College of Arts and Commerce
University of Delhi
New Delhi, Delhi, India

Pardeep Singh
Department of Environmental Studies
PGDAV College, University of Delhi
Delhi, India

K. K. Chandra
Department of Forestry, Wildlife &
Environmental Sciences
Guru Ghasidas Central University
Bilaspur, Chhattisgarh, India

ISBN 978-3-031-35774-9

ISBN 978-3-031-35775-6 (eBook)

<https://doi.org/10.1007/978-3-031-35775-6>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2023

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Paper in this product is recyclable.

Foreword

In the last century when the chemical industries were a hot cake for the industry, it was thought that synthesising and producing novel compounds in laboratories for the use in health, agriculture and provisional sectors shall provide enormous options for the commercially viable synthetic products on comparatively lower cost and in a shorter duration. When one successful compound is commercialised, hundreds of its by-products and other chemicals involved in the production process are put to the waste pipeline and finally enter into the rivers, lakes and other water bodies or get emitted through the chimneys in the air. These new synthetic substances, which are considered as xenobiotic compounds are generally non-biodegradable and due to its non-natural origin are highly persistent in the ecosystems.

The urban ecosystems are specific in nature with cluster of houses and commercial centres with a high population in small areas. The industrial clusters in the urban or peri-urban regions with its regular discharges are major source points for the release of several toxic xenobiotic compound in huge quantity. It contaminates water, soil, air and food stuff, which subsequently get transferred to human bodies through the food systems, liquid intakes and breathing etc. and cause several serious health concerns.

The present book entitles “*Xenobiotics in Urban Ecosystems; Source, Distribution and Health Impacts*” edited by the subject experts Drs Rishikesh Singh, Pradeep Singh, Sachidanand Tripathi, K.K. Chandra and Rahul Bhadauria and authored by about twenty subject experts across the world is a very significant contribution in this field in which the analyses and discussions are focused on the xenobiotic contaminations of the complex urban ecosystems and its health concerns which may impact a large number of the human population of different ethnic and socio-economic backgrounds.

I appreciate the concept, contents and presentations in this book which will fulfil the long awaited need to understand the contemporary xenobiotic contaminations in the urban ecosystems and their emerging health impacts. I believe that the book will enrich our knowledge in this field.

Rana Pratap Singh
(www.ranapratap.in)

Preface

The release of domestic, industrial and agricultural toxins into the ecosystem has polluted the environment at a wider scale. Chemicals and pharmaceutical interactions are ubiquitous in our daily lives. They help to ensure our high standard of living, safety and mobility, communication technology, food, health, textiles, and drinking water purification. Anthropogenic activities such as chemical manufacturing, storage, transportation, and use discharge the organic and inorganic compounds into the environment every day. It has been observed in recent years that the goods from chemical and pharmaceutical industries are producing novel environmental contaminants, which may be hazardous to people's health. In so-called open applications, such as personal care, hygiene, plant protection, health, and textiles, most chemicals are used at excessive levels. Many chemicals, such as scents, detergents, textile chemicals, surface disinfectants, insecticides, and others, are inevitably emitted into the environment due to their intended usage. Among these chemicals, some are existing naturally, and due to anthropogenic activities released into the environment in large amount, however, a majority of them are not found in biological systems and classified as 'xenobiotics'. Xenobiotic substances have been reported to negatively influence ecosystem components (air, water, and soil) and the ecosystem services they provide. These xenobiotic pollutants may influence on the ecosystems from both point and non-point sources. This has raised worldwide concerns, prompting the international scientific community to invent and develop methods for combating this threat. Urban ecosystems act as a hotspot of these chemicals. Moreover, among different components of an urban ecosystem, urban soils act as a suitable resort for the long-term persistence of these chemicals. Thus, the need for sustainable management of urban soils has been emerged in the past few years.

In recent years, various remedial measures have been adopted against xenobiotic pollutants. Among these, in bio-remedial measures, microbial applications were proved significant, owing to the presence of a number of metabolic catalysts in microbes that may help in detoxifying xenobiotics. Moreover, an extensive metabolic capability and genetic flexibility allow microbes to break down virtually all organic molecules from natural or anthropogenic xenobiotics, and transform or acquire heavy metals existing as environmental contaminants. Hence,

microorganisms may play an important role in ‘bioremediation’ of these environmental pollutants. Ex situ treatment of soil or water that has been removed from a polluted site or in situ clean-ups of a contaminated site through in-place treatment are examples of such processes. Microbes have also been applied in bio-remedial measures such as bio-stimulation, bioaugmentation, rhizo-stimulation, bioleaching, and bio-immobilization. Degradation or decomposition of xenobiotics using plants is ‘phytoremediation’. In recent years, many plants including the transgenic plants have been adopted for phytoremediation of xenobiotics from soil and water from the urban ecosystems. It is noteworthy that bioremediation and phytoremediation processes are an innovative, ecologically beneficial, and cost-effective techniques for the removal or degradation of xenobiotic pollutants. Further, advancement in microbiological and plant biotechnology techniques have made the use of these remedial processes more efficient. New techniques such as next-generation sequencing can be applied to identify and utilize microbial communities having potential to degrade xenobiotic substances.

This book encompasses the wide range of issues from xenobiotic chemical characterization to their environmental fate, advancement in assessment techniques along with remediation methods of xenobiotics in urban systems. The book contains 20 chapters which have been further categorised in six different parts, viz., (I) Xenobiotics in the Urban Ecosystems: An Introduction, (II) Fate and Transport of Xenobiotics in the Urban Ecosystems, (III) Impact of Xenobiotics on Biotic Components of the Urban Ecosystems, (IV) Remediation Strategies for the Xenobiotics in Urban Systems, (V) Analytical Tools and Techniques for Assessment of Xenobiotics, and (VI) Socio-economic Aspects, Livelihood Status and Policy Regulations. A brief insight on the key outcomes of different chapters has been given as following:

Part I of the book consists of three chapters (chapters “[Impact of Xenobiotics Under Changing Climate Scenario](#)”, “[Xenobiotics in the Urban Water Cycle](#)”, and “[Assessment of the Consequences of Xenobiotics in Soil Ecosystem](#)”) providing an introduction on the topic. Abhay Punia et al. explore the wide range of xenobiotics, their interaction with the soil environment, and techniques used for soil decontamination and bioremediation in chapter “[Impact of Xenobiotics Under Changing Climate Scenario](#)”. In chapter “[Xenobiotics in the Urban Water Cycle](#)”, Greeshma Odukkathil et al. discuss the source and translocation along with the toxicological effect of different categories of xenobiotics in the urban water cycle. Alok Bharadwaj et al. explore various xenobiotic components, their types along with their mechanism of action, and remediation techniques in soil ecosystem in chapter “[Assessment of the Consequences of Xenobiotics in Soil Ecosystem](#)”.

Chapters “[Transport and Metabolism of Xenobiotics in the Urban Ecosystem](#)” and “[Xenobiotics: Sources, Pathways, Degradation and Risk Associated with Major Emphasis on Pharmaceutical Compounds](#)” have been categorized in Part II presenting fate and transport of xenobiotics in urban systems. Soumita Paul et al. discuss different transporters and metabolic genes that are associated with xenobiotics metabolism as well as removal in chapter “[Transport and Metabolism of Xenobiotics in the Urban Ecosystem](#)”. In chapter “[Xenobiotics: Sources, Pathways, Degradation](#)”.

and Risk Associated with Major Emphasis on Pharmaceutical Compounds”, Manbir Singh et al. focus on the types and sources of various xenobiotics, their introduction in the atmosphere and soil, pathways and migration in the soil and aquatic systems, and the decomposition of pharmaceutical chemicals in the environment.

The next five chapters (chapters “Food Chain Contamination and Impact of Xenobiotics on Human Health”, “Pesticides and Chemical Fertilizers: Role in Soil Degradation, Groundwater Contamination, and Human Health”, “Ingression of Heavy Metals in Urban Agroecosystems: Sources, Phytotoxicity and Consequences on Human Health”, “Polyaromatic Hydrocarbons (PAHs): Sources, Distribution and Health Impacts in Aquatic Vertebrates”, and “The Effects of Xenobiotics on Soil and Human Health”) placed in Part III of the book present a thorough insight on the impact of xenobiotics on different biotic components of the urban ecosystems. Hadia Hemmami et al. explore the potential of selected plants for the phytoremediation of xenobiotics in chapter “Phytoremediation and Xenobiotics: Exploring the Potential of Selected Plants”. Anamika Nath et al. analyse the effects of chemical pesticides and fertilizers on soil health, groundwater quality, and human health along with the regulatory measures to safeguard the ecosystem from their hazardous effects in chapter “Pesticides and Chemical Fertilizers: Role in Soil Degradation, Groundwater Contamination, and Human Health”. In chapter “Ingression of Heavy Metals in Urban Agroecosystems: Sources, Phytotoxicity and Consequences on Human Health”, Siril Singh et al. discuss about heavy metal pollution of urban agroecosystems and food chains along with their adverse consequences on human beings. The authors conclude that the transfer of heavy metals via the food chain in urban ecosystems declines the health and nutritional status of soil and crops and poses detrimental impacts on human health. Chapter “Polyaromatic Hydrocarbons (PAHs): Sources, Distribution and Health Impacts in Aquatic Vertebrates” by Sukhendu Dey et al. emphasize on diverse pathways of polycyclic aromatic hydrocarbons distribution in different environmental segments along with human health risks and harmful effects. Ruchi Urana et al. explore the impacts of xenobiotics on soil and human health in chapter “The Effects of Xenobiotics on Soil and Human Health”.

Part IV of the book comprises six chapters (chapters “Remediation Strategies of Xenobiotics in Urban Soil and Water”, “Explosive Contamination in Soil: Sources, Environmental Concerns, and Phytoremediation”, “Phytoremediation and Xenobiotics: Exploring the Potential of Selected Plants”, “Bioremediation: An Alternative Tool for Restoration of Urban Agro-Ecosystem Contaminated with Harmful Xenobiotics”, “Potential Application of Bacteria in Degrading Xenobiotics for Sustainable Environmental Management”, and “Bioremediation Strategies for Microplastic Removal in Impacted Aquatic Environments”) dealing with various bioremediation techniques adopted for managing different types of xenobiotic compounds present in the urban ecosystems. In chapter “Remediation Strategies of Xenobiotics in Urban Soil and Water”, Ritika Sharma et al. emphasize on various xenobiotic sources, toxicity, and risks to human health and the environment along with their remediation techniques. In chapter “Explosive Contamination in Soil: Sources, Environmental Concerns, and Phytoremediation”, Dickson Heisnam et al.

assess the sources of explosives in urban soils, environmental concerns, transport, and various explosive removal techniques in general and phytoremediation in particular. Bachir Ben Seghir et al., in chapter “[Food Chain Contamination and Impact of Xenobiotics on Human Health](#)”, elaborate on the different categories and sources of xenobiotics and recent advancement in technologies for characterizing microorganisms to degrade it. In chapter “[Bioremediation: An Alternative Tool for Restoration of Urban Agro-Ecosystem Contaminated with Harmful Xenobiotics](#)”, Shamshad Ahmad and Swati Sachdev discuss the sources and health impact of xenobiotic contaminants on soil, microorganisms, plants, and humans – problems related to the use of conventional methods for the decontamination of soil – and explore the potential of the sustainable biological approach to reduce harmful effects of xenobiotic on urban agriculture. Shreya Banerjee et al., in chapter “[Potential Application of Bacteria in Degrading Xenobiotics for Sustainable Environmental Management](#)”, review the importance of bacteria in controlling xenobiotics for human well-being in the urban settlements. Milena Roberta Freire da Silva et al. focus on the bioremediation strategies for microplastic removal in the impacted aquatic environments in chapter “[Bioremediation Strategies for Microplastic Removal in Impacted Aquatic Environments](#)”.

Part V, the penultimate part of the book consisting of chapters “[Recent Advancements in Bioremediation of Xenobiotics Using Microbes](#)” and “[Advancements in the Analytical Techniques for Precise Xenobiotics Assessment: A Special Emphasis on Pesticides Detection](#)”, provides a brief insight on different tools and techniques utilized for assessing the presence of xenobiotics in different urban systems. Anwesha Gohain et al. provide insights into different types of xenobiotics and the capability of microbes to degrade xenobiotics and their compounds in chapter “[Recent Advancements in Bioremediation of Xenobiotics Using Microbes](#)”. The chapter also discussed advanced techniques such as omics approaches to understand their metabolic machinery in the degradation process. Jatinder Singh, in chapter “[Advancements in the Analytical Techniques for Precise Xenobiotics Assessment: A Special Emphasis on Pesticides Detection](#)”, provided an insight on the understanding of advanced methods to assess the various xenobiotics in the environment. The chapter mainly focus on the assessment of pesticides.

The ultimate part, i.e. Part VI of the book consisting of two chapters (chapters “[Impacts of the Pesticides on Urban Aquatic Ecosystems and Their Regulation Measures](#)” and “[Xenobiotics in Urban Soils and Water: Remediation Strategies, Socio-Economic Impacts and Regulatory Provisions](#)”), deals with the socio-economic aspects and policies for the regulation of xenobiotics in the urban systems. In chapter “[Impacts of the Pesticides on Urban Aquatic Ecosystems and Their Regulation Measures](#)”, Karolayne Silva Souza et al. review the impact of pesticides on urban aquatic ecosystems along with their regulation measures. In chapter “[Xenobiotics in Urban Soils and Water: Remediation Strategies, Socio-Economic Impacts and Regulatory Provisions](#)”, Sharda Bharti and Awanish Kumar discuss the remediation strategies, socio-economic impacts, and regulatory provisions of xenobiotics in urban soils and water systems.

Overall, the content of the book provides a state-of-the-art information on xenobiotics present in the urban ecosystems, in addition to providing up-to-date information on xenobiotic types and chemical composition, environmental fate, remedial approaches, socio-economic impacts, and regulatory policies. The book incorporates theoretical and practical aspects pertaining to the xenobiotics to assess their threat level in urban ecosystems, while determining appropriate response and remediation measures to curb harmful impacts and prevent future contaminations. The content of the book will be of interest to the students and researchers working in the field of urban agriculture and environmental sciences, mainly agriculturists, ecological engineers, soil scientists, and urban policymakers.

Chandigarh, India
Delhi, India
Delhi, India
Chhattisgarh, India
Delhi, India

Rishikesh Singh
Pardeep Singh
Sachchidanand Tripathi
K. K. Chandra
Rahul Bhadouria

Contents

Part I Xenobiotics in the Urban Ecosystems: Introduction

Impact of Xenobiotics Under Changing Climate Scenario 3

Abhay Punia, Ravindra Pratap Singh, and Nalini Singh Chauhan

Xenobiotics in the Urban Water Cycle 27

Greeshma Odukkathil, Karuvelan Murugan,
Dhanesh Kumar Chalunkal Lambodharan,
and Namasivayam Vasudevan

Assessment of the Consequences of Xenobiotics in Soil Ecosystem 51

Alok Bharadwaj, Amisha Rastogi, Swadha Pandey, and Saurabh Gupta

Part II Fate and Transport of Xenobiotics in the Urban Ecosystems

Transport and Metabolism of Xenobiotics in the Urban Ecosystem 69

Soumita Paul, Ujjal Ghosh, and Mousumi Saha

Xenobiotics: Sources, Pathways, Degradation, and Risk Associated with Major Emphasis on Pharmaceutical Compounds. 87

Manbir Singh, Ratish Chandra Mishra, Iqbal Shah, Vaishali Wadhwa,
and Vikram Mor

Part III Impact of Xenobiotics on Biotic Components of the Urban Ecosystems

Food Chain Contamination and Impact of Xenobiotics on Human Health 109

Bachir Ben Seghir, Imane Kouadri, Mohammad Messaoudi,
Abdelkrim Rebiai, Soumeia Zeghoud, Hadia Hemmami,
and Ilham Ben Amor

Pesticides and Chemical Fertilizers: Role in Soil Degradation, Groundwater Contamination, and Human Health	131
Anamika Nath, Pranamika Bhuyan, Nirmali Gogoi, and Pratibha Deka	
Ingression of Heavy Metals in Urban Agroecosystems: Sources, Phytotoxicity and Consequences on Human Health	161
Siril Singh, Rajni Yadav, and Anand Narain Singh	
Polyaromatic Hydrocarbons (PAHs): Sources, Distribution, and Health Impacts in Aquatic Vertebrates	185
Sukhendu Dey, Tridib Mondal, and Palas Samanta	
The Effects of Xenobiotics on Soil and Human Health	209
Ruchi Urana, Jyoti Jaglan, and Bhagwan Narayan Rekadwad	
Part IV Remediation Strategies for the Xenobiotics in Urban Systems	
Remediation Strategies of Xenobiotics in Urban Soil and Water	227
Ritika Sharma, Arti Hansda, and Sasmita Chand	
Explosive Contamination in Soil: Sources, Environmental Concerns, and Phytoremediation	241
Dickson Heisnam, Shiv Shankar, Deepa Chandra, Divya Goel, Anuradha Mishra, and Manzari Kushwaha	
Phytoremediation of Xenobiotics: Principles and Applications in Environmental Pollution Removal	261
Hadia Hemmami, Ilham Ben Amor, Soumeia Zeghoud, Abdelkrim Rebiai, Bachir Ben Seghir, Imane Kouadri, and Mohammad Messaoudi	
Bioremediation: An Alternative Tool for Restoration of Urban Agroecosystem Contaminated with Harmful Xenobiotics	291
Shamshad Ahmad and Swati Sachdev	
Potential Application of Bacteria in Degrading Xenobiotics for Sustainable Environmental Management	321
Shreya Banerjee, Aparajita Basu, Saptarshi Chatterjee, and Mousumi Saha	
Bioremediation Strategies for Microplastic Removal in Impacted Aquatic Environments	341
Milena Roberta Freire da Silva, Karolayne Silva Souza, Francisco Henrique Santana da Silva, Camila Manoel Crnkovic, Fabricio Motteran, Livia Caroline Alexandre de Araújo, and Maria Betânia Melo de Oliveira	

Part V Analytical Tools and Techniques for Assessment of Xenobiotics**Recent Advancements in Bioremediation of Xenobiotics****Using Microbes 355**

Anwesha Gohain, Rupak Sarma, and Pardeep Singh

Advancements in the Analytical Techniques for Precise Xenobiotics**Assessment: A Special Emphasis on Pesticides Detection 375**

Jatinder Singh

**Part VII Socio-economic Aspects, Livelihood Status
and Policy Regulations****Impacts of the Pesticides on Urban Aquatic Ecosystems
and Their Regulation Measures. 391**Karolayne Silva Souza, Milena Roberta Freire da Silva,
Lívia Caroline Alexandre de Araújo, Kaline Catiely Campos Silva,
Francisco Henrique Santana da Silva, Camila Manoel Crnkovic,
Fabricio Motteran, and Maria Betânia Melo de Oliveira**Xenobiotics in Urban Soils and Water: Remediation Strategies,
Socioeconomic Impacts, and Regulatory Provisions 399**

Sharda Bharti and Awanish Kumar

Index. 431