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Urban Watershed Microbiology, Volume 2

Environmental Indicators, Regional Case Studies, and Bioremediation Strategies

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Preface

The rapid pace of urbanization is transforming natural environments worldwide, driving profound changes in biological communities and ecological functions. These transformations arise both from direct alterations to local environmental conditions and from the reduced capacity of species to thrive within increasingly fragmented habitats. Urban environments, with their distinctive atmospheric chemistry, geochemistry, climate, hydrology, and vegetation cover, depart dramatically from their natural counterparts, creating unique ecosystems whose dynamics and intricacies are still not fully understood.

Recognizing the urgency of understanding how urbanization influences biodiversity and ecosystem functioning, this work focuses on an often-overlooked aspect: microbial responses to urbanization across diverse spatial scales. Urban watersheds are central to this discussion. They provide essential ecosystem services, such as water purification, degradation of xenobiotics, and nutrient recycling, services largely mediated by microbial communities. Yet, these systems are increasingly stressed by pollution and urban sprawl, culminating in the condition often referred to as the "urban watershed syndrome."

Despite advances in watershed science, several knowledge gaps remain. Microbial communities in urban streams, crucial to global biogeochemical cycles, remain understudied. Urban runoff introduces microbes from diverse sources, posing risks that include the spread of pathogens, disruption of aquatic food webs, and genetic exchanges that may accelerate antimicrobial resistance (AMR). Human activities create pathways that enable urban- and human-derived microbes to infiltrate aquatic systems, historically leading to disease outbreaks. Moreover, microbes are significant contributors to the spread of multidrug resistance, underscoring the urgent need to understand the sources, mechanisms, and ecological contexts of antibiotic resistance genes (ARGs) in urban watersheds.

Watershed Microbiology: Biodiversity Composition, Ecological Function, and Technological Advances is the result of a truly global collaboration with 40 contributions from authors across five continents (Africa, Asia, Europe, North America, and South America) and 24 countries. The breadth of perspectives enriches the exploration of critical and unresolved questions in urban watershed microbiology.

To present the scope of work effectively, the book is published as a two-volume set, each with its own thematic focus and subtitle.

Volume 1: Metagenomic Insights and Resistance Patterns, and Monitoring Approaches

Parts I–III

- *Part I: Metagenomics and Molecular Biology in Watershed Microbial Community Studies*
  This Part synthesizes studies illustrating the application of advanced molecular tools to watershed microbiology. Santiago-Rodriguez et al. highlight viral metagenomics for tracing fecal contamination using crAssphage and Torque teno virus (TTV). Ifon et al. examine how dissolved and anthropogenic organic matter shape microbial communities in urban rivers. Ng et al. and Zemskaya et al. investigate microbial biodiversity in lakes, reservoirs, and sedimentary layers using amplicon sequencing and metabarcoding. Ma et al. assess land cover effects on dissolved organic matter and microbial communities, while Te et al. explore cyanobacterial harmful algal blooms (CHABs) in tropical urban catchments, emphasizing microbial interactions in bloom dynamics and nutrient cycling.
- *Part II: Urban Development and the Occurrence and Persistence of Antimicrobial Resistance and Microbial Source Tracking Technologies*
  This Part examines the link between urban development and AMR spread, as well as the use of microbial source tracking (MST). Henriquez and Marvasi show how urbanization and industrialization intensify AMR spread. Ghosh Roy and Mester highlight microbial bioremediation using *Bacillus* and *Pseudomonas*. Van Wyk and Ubomba-Jaswa discuss advanced treatment technologies for AMR in aquaculture and wastewater. Catalfano et al. explore AMR in *Escherichia coli* from urban watersheds. Book et al. review ARG detection advances, advocating integrated sequencing and biosensor approaches. Urakawa and Hancock demonstrate Quanti-tray-based amplicon sequencing (QT-AMP) for detecting fecal indicator bacteria after Hurricane Ian.
- *Part III: Advances in Biological Monitoring and Modeling in Urban Watersheds and Community Science Monitoring*
  Here, the focus is on monitoring innovations. Acuña-Alonso et al. use Partial Least Squares Path Modeling (PLS-PM) and satellite imagery to predict harmful algal blooms (HABs). Lobo et al. employ the Algae Bloom Monitoring application (AlgaeMAp) for Brazilian water quality assessments. Paulino et al. review

remote sensing in aquatic microbiology. Ella discusses simulation models such as SWAT and HSPF, as well as deep learning and IoT integration. Tolin presents a case study on citizen science mussel monitoring in the Huron River Watershed, illustrating public engagement in aquatic monitoring.

Volume 2: Environmental Indicators, Regional Case Studies, and Bioremediation Strategies

Parts IV–VI

- *Part IV: Microbial Response Indicators of Water Quality and Aquatic Ecosystems Change*
  This Part investigates microbial bioindicators for water quality assessment. Jiang et al. link climate change to intensified cyanobacterial blooms. Murrella et al. study enzymatic responses to fecal and chemical pollutants. Hancock and Urakawa evaluate hydrogen peroxide as a predictive tool for blooms. Gao et al. review benthic biofilm roles in nutrient cycling. Patel et al. use Biolog EcoPlate™ to assess carbon utilization shifts. De Mello et al. advocate integrating microbial metrics with biological indicators. Leareng et al. emphasize microbes as bioindicators of chemical pollution. Otim and Otim analyze climate indicator–algal growth correlations in California inland waters, revealing habitat-specific variability.
- *Part V: Regional and Country-Specific Perspectives on Urban Watershed Health Worldwide*
  This Part offers global case studies. Zhao and Ni (China) discuss nitrogen cycle disruptions. Gorshkova et al. (Russia) examine Lake Baikal tributary pollution. Ogola and Odhiambo (Kenya) address Lake Victoria challenges. Rodríguez-López et al. (Chile) apply remote sensing to study turbidity in Lake Maihue. Krishna et al. (India) assess extreme weather impacts on Vembanad Lake contamination. Cortez and Siringan (Philippines) call for updated microbial water criteria. Karmakar et al. (Bangladesh) emphasize conservation in the Chittagong Hill Tracts.
- *Part VI: Emerging Contaminants and Bioremediation Strategies*
  This Part addresses microbial–pollutant interactions. Bai et al. review steroid estrogen biodegradation and NOM interactions. Garcia et al. focus on hydrogen peroxide's role in contaminant breakdown. Kuroda et al. explore anaerobic treatment for purified terephthalic acid (PTA). Sanchez et al. identify bacterial candidates for organic contaminant biodegradation. Opara et al. examine metal biosorption mechanisms. Chamlee et al. study siderophore production for heavy metal mitigation.

Together, these two volumes present a comprehensive, state-of-the-art synthesis of research, practical applications, and global perspectives in urban watershed microbiology. They are intended as essential references for microbiologists, ecologists, hydrologists, environmental engineers, and public health professionals, as well as for policymakers seeking to safeguard water resources in an era of rapid urban change.

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