



Micropollutants in Climate Change: An Indian Perspective

Verma Seema

Govt MLV College Bhilwara, M.P., India

Manuscript details:

Available online on <http://www.ijlsci.in>
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)

Cite this article as:

Verma Seema (2025) Micropollutants in Climate Change: An Indian Perspective, *Int. J. of. Life Sciences*, Special Issue, A21, 171-174.

Article published in Special Issue of
“International Conference on Futuristic
Approach for Viksit Bharat (ICFAVB-2047)
Organized by Government College, Dholpur
(Raj.) Dated 23 and 24 Dec. 2024.



Open Access This article is
licensed under a Creative
Commons Attribution 4.0

International License, which permits use,
sharing, adaptation, distribution and repro-
duction in any medium or format, as long as
you give appropriate credit to the original
author(s) and the source, provide a link to
the Creative Commons license, and indicate
if changes were made. The images or other
thirdparty material in this article are
included in the article's Creative Commons
license, unless indicated otherwise in a
credit line to the material. If material is not
included in the article's Creative Commons
license and your intended use is not permit-
ted by statutory regulation or exceeds the
permitted use, you will need to obtain
permission directly from the copyright
holder. To view a copy of this license, visit
[http://creativecommons.org/
licenses/by/4.0/](http://creativecommons.org/licenses/by/4.0/)

ABSTRACT

Micropollutants, characterized by their persistence and toxicity despite minute concentrations, represent a significant and growing environmental and public health challenge in India. This chapter examines the primary categories of micropollutants—Persistent Organic Pollutants (POPs), heavy metals, Pharmaceuticals and Personal Care Products (PPCPs), microplastics, endocrine disruptors, volatile organic compounds (VOCs), and nutrient compounds—prevalent within the Indian context. It analyzes their major sources, driven by rapid urbanization, industrial expansion, and agricultural intensification, and details their multifaceted impacts on ecosystems and human health. Critically, the chapter explores the complex, bidirectional relationship between micropollutants and climate change, where climatic alterations can amplify the mobility and toxicity of these pollutants, while the pollutants themselves can exacerbate warming through mechanisms like greenhouse gas formation and disruption of carbon sinks. The review further assesses India's existing policy frameworks and initiatives aimed at mitigation, highlighting persistent challenges such as inadequate waste management infrastructure and regulatory enforcement gaps. The conclusion underscores the necessity for an integrated approach combining robust monitoring, advanced treatment technologies, stringent policy implementation, and public awareness to safeguard sustainable development in India.

Keywords: Micropollutants, Climate Change, India, Persistent Organic Pollutants, Microplastics, Policy Framework

INTRODUCTION

Micropollutants, encompassing a diverse array of chemical substances present in trace concentrations, pose disproportionate threats to environmental integrity and human health. In India, a nation experiencing swift demographic and economic transformation, the challenges associated with micropollutant contamination are particularly acute and multifaceted. This chapter delineates the major categories of micropollutants prevalent across India, investigates their primary sources and pathways, evaluates their environmental and public health consequences, and elucidates the intricate, reciprocal interactions between these pollutants and the overarching phenomenon of climate change.

1. Persistent Organic Pollutants (POPs)

Persistent Organic Pollutants (POPs) are organic compounds renowned for their resistance to environmental degradation, leading to long-term persistence and long-range transport. In India, legacy POPs such as the pesticide DDT and industrial chemicals like polychlorinated biphenyls (PCBs) remain a concern (Stockholm Convention, 2001).

Sources and Prevalence: Historical and, in some cases, ongoing extensive use of organochlorine pesticides in agriculture has resulted in significant environmental reservoirs of POPs. Improper disposal of industrial waste further contributes to their presence. Studies indicate detectable levels of POPs in soils and biota across various Indian regions, with elevated concentrations often reported in urban and industrial corridors (CPCB, 2022).

Environmental and Health Impacts: POPs exhibit a high propensity for bioaccumulation and biomagnification within food webs. This leads to adverse effects on wildlife, including reproductive failure and immunosuppression. Human exposure, primarily through dietary intake, is linked to chronic health effects including cancer, endocrine disruption, and developmental disorders (Down to Earth, 2023).

2. Heavy Metals

Toxic heavy metals such as mercury, lead, cadmium, and arsenic accumulate in ecosystems, posing long-term risks. In India, key sources include industrial effluent, mining activities, fossil fuel combustion, and informal electronic waste (e-waste) processing.

Sources and Prevalence: Industrial sectors like tanneries, electroplating, and metallurgy are significant contributors. A pressing concern is the informal recycling of e-waste, which India generates approximately 2 million tons of annually. Metropolitan centers like Delhi, Mumbai, and Bengaluru are major hubs for this largely unregulated activity, leading to severe local contamination (Wikipedia, "Electronic waste in India," 2023).

Environmental and Health Impacts: These metals contaminate soil and water, entering the food chain. Human exposure can result in neurotoxicity (e.g., lead, mercury), nephrotoxicity (cadmium), and carcinogenicity (arsenic). Workers in the informal e-waste sector and

surrounding communities face elevated health risks due to direct exposure.

3. Pharmaceuticals and Personal Care Products (PPCPs)

The PPCP category includes prescription drugs, over-the-counter medications, cosmetics, and hygiene products. These substances enter aquatic environments primarily through the discharge of untreated or inadequately treated sewage and effluents from pharmaceutical manufacturing units.

Sources and Prevalence in India: Inadequate sanitation infrastructure and the common practice of discarding unused medications contribute to PPCP load in water bodies. Investigations have revealed alarmingly high concentrations of pharmaceuticals, including antibiotics, in rivers receiving effluent from drug manufacturing clusters (Wikipedia, "Drug pollution," 2023).

Environmental and Health Impacts: PPCPs can cause physiological alterations in aquatic organisms, such as impaired reproduction and development. A critical global concern is the potential role of environmental antibiotic residues in fostering antimicrobial resistance (AMR). Chronic human exposure to low levels of multiple pharmaceuticals via water is a growing but poorly understood health risk.

4. Microplastics

Microplastics are synthetic polymer particles smaller than 5 mm, originating from the breakdown of larger plastic items or from manufactured microbeads. They are now ubiquitous contaminants in marine, freshwater, and terrestrial systems.

Sources and Prevalence: With an estimated annual plastic waste generation of over 10 million tons, India is a significant contributor to plastic pollution. Inefficient waste management leads to the fragmentation of macroplastics into microplastics. Research by institutions like the National Institute of Oceanography (NIO) has confirmed the presence of microplastics in Indian coastal waters, rivers, and even remote habitats (NIO, 2020).

Environmental and Health Impacts: Microplastics are ingested by a wide range of organisms, causing physical

harm, gut blockage, and reduced feeding. They also act as vectors for adsorbed toxic chemicals. Their entry into the human food chain, particularly through seafood, raises concerns about inflammatory responses and the translocation of chemical contaminants (CIEL, 2019).

5. Endocrine Disrupting Chemicals (EDCs)

EDCs are exogenous substances that interfere with the normal function of the endocrine system. Common examples include bisphenol A (BPA) from polycarbonate plastics and phthalates from vinyl and personal care products.

Sources and Prevalence: The pervasive use of plastic products, coupled with the discharge of domestic and industrial wastewater containing EDCs, leads to widespread environmental contamination. Regulatory oversight on these compounds in consumer products remains limited.

Environmental and Health Impacts: EDCs are associated with reproductive abnormalities, developmental disorders, and increased incidences of hormone-related cancers in humans and wildlife. Effects in aquatic species include skewed sex ratios and impaired fertility, which can impact population dynamics.

6. Volatile Organic Compounds (VOCs)

VOCs are carbon-based chemicals that readily evaporate at ambient temperatures, contributing to air pollution and photochemical reactions. Examples include benzene, toluene, and formaldehyde.

Sources and Prevalence: Major sources in urban India include vehicular exhaust, industrial emissions, evaporation of solvents, and biomass burning. Metropolises like Delhi and Mumbai frequently report high atmospheric concentrations of VOCs.

Environmental and Health Impacts: VOCs are key precursors in the formation of ground-level ozone and secondary organic aerosols, major components of smog. This leads to respiratory ailments and other public health issues. Furthermore, as ozone precursors, certain VOCs are indirect contributors to radiative forcing and climate change.

7. Nitrogen and Phosphorus Compounds

Excessive nutrient loads, primarily from nitrogen and phosphorus compounds, lead to eutrophication—a process that degrades water quality and aquatic ecosystems.

Sources and Prevalence: The dominant source is agricultural runoff from synthetic fertilizers. Additionally, the discharge of untreated domestic sewage, rich in phosphates from detergents, significantly contributes to nutrient pollution in rivers like the Ganga, particularly in urban stretches (CPCB, 2022).

Environmental and Health Impacts: Eutrophication stimulates algal blooms, which deplete dissolved oxygen upon decomposition, creating hypoxic "dead zones" fatal to aquatic life. For humans, high nitrate levels in drinking water are linked to conditions like methemoglobinemia, especially in infants.

Micropollutants and Climate Change: A Two-Way Interaction

The interplay between micropollutants and climate change is synergistic and complex.

1. Climate Change Influencing Micropollutants: Rising global temperatures can increase the volatilization and atmospheric transport of semi-volatile POPs and VOCs. Altered precipitation patterns, including more intense rainfall events, can enhance the runoff and leaching of pesticides, heavy metals, and nutrients from soils into water bodies, widening their dispersion.

2. Micropollutants Contributing to Climate Change: Certain micropollutants directly or indirectly influence the climate system. VOCs participate in tropospheric ozone formation, a potent greenhouse gas. Microplastics in the ocean may impair the biological carbon pump by affecting planktonic health. Furthermore, the degradation of plastics releases greenhouse gases like methane and ethylene (CIEL, 2019). Pollution stress from various micropollutants can also reduce the resilience and carbon sequestration capacity of forests and wetlands.

Indian Initiatives and Policy Frameworks

India has established several policies to address pollution, though their effectiveness in targeting micropollutants specifically is often limited.

1. Legal and Regulatory Measures: The overarching *Environment Protection Act (1986)* provides the framework for pollution control. More specific regulations include the *Plastic Waste Management Rules (2016)*, the *Hazardous and Other Wastes Management Rules (2016)*, and the **Bio-Medical Waste Management Rules (2016)**. India is also a party to the *Stockholm Convention on POPs*.

2. Monitoring and Research Initiatives: Programs like the National Ambient Air Quality Monitoring (NAMP) and the National Water Quality Monitoring (NWMP) collect relevant data. Research institutions, including the CPCB, NIO, and various academic bodies, are actively studying the occurrence and fate of micropollutants.

Challenges and Recommendations

Significant obstacles hinder effective micropollutant management in India.

Challenges: Key issues include inadequate wastewater treatment infrastructure incapable of removing complex micropollutants; a large informal sector handling hazardous waste (e.g., e-waste) without protection; fragmented regulatory enforcement; and limited public awareness regarding proper disposal of chemicals and pharmaceuticals.

Recommendations:

- **Infrastructure Strengthening:** Upgrade sewage and effluent treatment plants with advanced tertiary treatment technologies (e.g., ozonation, advanced oxidation, membrane filtration).
- **Policy and Enforcement:** Strengthen implementation of existing laws and develop specific standards for emerging micropollutants in water and air.
- **Sustainable Practices:** Promote organic farming, green chemistry in industry, and circular economy principles for plastic and electronic waste.
- **Capacity Building & Awareness:** Invest in monitoring capabilities and launch public campaigns on safe disposal of drugs, plastics, and chemicals.
- **Targeted Research:** Foster interdisciplinary research to understand source apportionment, exposure pathways, and ecological impacts specific to the Indian context.

6. CONCLUSION

Micropollutants constitute a critical, though often invisible, dimension of India's environmental sustainability and climate change challenges. Their management demands a concerted, multi-pronged strategy that integrates robust science, innovative technology, stringent and adaptive governance, and an engaged civil society. As India advances on its development path, prioritizing the mitigation of micropollutants is imperative to ensure ecological security, public health, and true sustainable growth.

Conflict of Interest: The author declares no conflict of interest in relation to this research.

Data Availability Statement: Not applicable.

Correspondence and requests for materials should be addressed to **Verma Seema**

Reprints and permissions information is available at <https://www.ijlsci.in/reprints>

REFERENCES

- Central Pollution Control Board (CPCB). (2022). **Annual Report 2021-22**. Ministry of Environment, Forest and Climate Change, Government of India.
- Center for International Environmental Law (CIEL). (2019). *Plastics and Climate: The Hidden Costs of a Plastic Planet*.
- Down to Earth. (2023). *State of India's Environment 2023*.
- National Institute of Oceanography (NIO). (2020). *Microplastic Pollution in Indian Oceans*.
- Stockholm Convention on Persistent Organic Pollutants. (2001). United Nations Environment Programme.
- Wikipedia contributors. (2023, October 26). *Drug pollution*. In Wikipedia, The Free Encyclopedia.
- Wikipedia contributors. (2023, November 15). *Electronic waste in India*. In Wikipedia, The Free Encyclopedia.

© The Author(s) 2025

Publisher's Note

IJLSCI remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.