TYPE Frontiers in Science Viewpoint
PUBLISHED 14 January 2026
DOI 10.3389/fsci.2025.1721629

Climate change and microplastic pollution in aquatic ecosystems: ecological and societal consequences

Mário Barletta*

Laboratory of Ecology and Management of Coastal and Estuarine Ecosystems, Department of Oceanography, Federal University of Pernambuco, Recife, Brazil

EDITED AND REVIEWED BY
Jennifer M. DeBruyn,
The University of Tennessee, Knoxville, United States

*CORRESPONDENCE
Mário Barletta
mario.barletta@ufpe.br

RECEIVED 09 October 2025
REVISED 03 December 2025
ACCEPTED 16 December 2025
PUBLISHED 14 January 2026

CITATION
Barletta M. Climate change and microplastic pollution in aquatic ecosystems: ecological and societal consequences. *Front Sci* (2026) 3:1721629. doi: 10.3389/fsci.2025.1721629

KEYWORDS

aquatic ecosystem, climate change, nano-microplastics, plastic contamination, plastic pollution, trophic biotransference

A Viewpoint on the Frontiers in Science Lead Article
Plastic pollution under the influence of climate change: implications for the abundance, distribution, and hazards in terrestrial and aquatic ecosystem

Key points

- Climate change exacerbates plastic pollution in aquatic ecosystems, with rising temperatures, extreme weather, and sea-level rise accelerating the fragmentation, transport, and impacts of plastics, transforming them into long-lasting, poorly reversible contaminants.
- Combined stressors threaten biodiversity, fisheries, and human well-being with microplastic contamination in the context of climate change, undermining ecosystem resilience, food and water security, and the livelihoods of communities that depend on rivers, estuaries, and coasts.
- Solutions require systemic transformation based on technological innovation, circular economy policies, and integrated governance, all of which must be coupled with political will and community participation to overcome industrial resistance and safeguard aquatic ecosystems.

Introduction

Unsustainable development has led to a global crisis that is exacerbated by climate change. Plastic pollution in aquatic environments poses significant challenges that negatively impact water quality, biodiversity, and human health. The progression of climate change, which is characterized by rising temperatures, altered precipitation patterns, extreme weather events, and sea-level rise, accelerates the fragmentation, dispersal, and persistence of plastics. These processes have amplified the impacts of plastic pollution on rivers, estuaries, and coastal ecosystems.

In tropical estuarine mangrove forests, for example, climate-driven flooding and salinity changes interact with high levels of plastic waste, creating hotspots of contamination that threaten fisheries and coastal livelihoods (1). Recent research, as published by Kelly et al. (2) in their Frontiers in Science lead article on plastic pollution under the influence of climate change, has shown that climate change effects can transform plastic pollution into a poorly reversible contaminant, with potentially global-scale impacts.

This viewpoint explores the consequences of microplastic contamination under climate change and argues that solutions require not only scientific and technological advances but also governance, education, and societal transformation.

Plastic pollution and climate change in aquatic systems

Rivers, estuaries, and coastal waters, as complex and dynamic systems, are influenced by both climatic and non-climatic drivers, highlighting their importance in environmental research and policy. The El Niño Southern Oscillation (ENSO) events, as observed in 2006 and 2017, have been associated with increased nutrient levels, such as ammonia and phosphorus, particularly in the easternmost South American estuarine and coastal regions (3). Consequently, climate change could exacerbate harmful algal blooms and hypoxia (4). These processes appear to be characterized by arid periods (La Niña) followed by drastically increased rainfall patterns (El Niño), which could also promote the dispersal of plastics, particularly micro- and nanoplastics, into aquatic ecosystems.

Plastics exert both direct and indirect effects on aquatic fauna and flora, including ingestion, organism toxicity (5), habitat alteration, and reduced resilience of ecosystems that are already under stress. The combined effects of climate drivers and plastic pollution compromise biodiversity, fisheries, and essential ecosystem services (6). Recent studies in Bangladesh indicate that flood events remobilize plastic debris from inadequately managed landfills into estuarine waters, substantially increasing downstream contamination (1). Similar processes have been observed in the United Kingdom, where coastal landfill erosion threatens to release significant quantities of plastics into estuaries (7). These case studies exemplify global trends, demonstrating that aquatic organisms at higher trophic levels are particularly vulnerable to the combined impacts of plastics and climate-related stressors (2). Furthermore, evidence indicates that top predators in aquatic ecosystems are becoming increasingly contaminated by microplastics through biotransfer within the food web (8).

The combined effects of climate change and microplastics constitute a significant and escalating threat to aquatic ecosystems. Variations in temperature, precipitation, and extreme weather events intensify river flow, thereby increasing the transport of microplastics into rivers and seas. This sequence of events leads to more frequent algal blooms and hypoxic conditions, thereby amplifying the detrimental impacts of plastics on aquatic organisms. As microplastics transport toxins and pathogens, their risks become closely linked with those of climate change, highlighting the urgent need for integrated monitoring and comprehensive mitigation strategies.

Addressing these interconnected challenges requires context-specific solutions tailored to each aquatic environment. Restoration of wetlands, establishment of riparian buffers, and effective nutrient management can improve water quality and support biodiversity. Community engagement and educational initiatives further enhance the effectiveness of these interventions. These targeted actions are crucial to enhancing ecosystem resilience and fostering sustainable environmental stewardship.

Political and socioeconomic dimensions

Despite growing awareness, large volumes of plastic waste continue to reach aquatic systems daily, particularly from densely populated urban regions where inadequate waste management persists (9). Climate change exacerbates these impacts, while political and economic obstacles delay effective mitigation. Petrochemical industries play a powerful role in influencing governments and slowing the reductions in plastic production. For instance, lobbying efforts have weakened or delayed single-use plastic bans in several countries, and on a global scale, industry resistance has contributed to the breakdown of consensus during the 2025 Geneva negotiations on the Global Plastics Treaty (10). Without decisive policies, reliance on fossil fuels and the increase in plastic output will accelerate biodiversity loss, intensify socio-environmental inequalities, and compromise global climate and sustainability goals.

Pathways toward solutions

Given the importance of this issue to the health of the planet, the main questions are: what should be prioritized, and what specific roles should the aquatic science community play?

Building on these questions, it is important to consider not only immediate research needs but also long-term strategies. This comprehensive approach is essential for impactful collaboration and innovation. By fostering interdisciplinary partnerships and embracing technological advancements, the aquatic science community can lead efforts in ecosystem restoration, sustainable resource management, and public education. Prioritizing these approaches will help ensure that scientific knowledge translates into effective policy and meaningful change for aquatic environments.

Looking ahead, the aquatic science community should also invest in capacity-building initiatives that support emerging researchers and amplify diverse voices within the field. Establishing collaborative networks with stakeholders, including policymakers, indigenous communities, and industry leaders, will further enhance the relevance and application of scientific findings. By promoting open data sharing and transparent communication, the community can accelerate innovation and respond more effectively to emerging challenges. Ultimately, these efforts will build resilience in aquatic ecosystems and empower society to make informed decisions regarding the health and sustainability of our water resources.

Addressing this dual crisis requires comprehensive and coordinated action. An integrated, worldwide, long-term project should establish coordinated global research initiatives that use standardized protocols to assess how microplastic contamination and climate change jointly affect aquatic ecosystems. These projects should harmonize sampling and analytical methods to enable long-term, comparable data on trophic transfer, habitat use, and contamination patterns across riverine, estuarine, and coastal systems.

Conclusion

Plastic pollution in aquatic environments, exacerbated by climate change, is not just a crisis—it is an urgent call to action. Its impacts, ranging from biodiversity loss and fisheries decline to water insecurity and economic costs for coastal communities, are already being felt. The most significant barriers are not only scientific but also political and social.

Plastics in sediment have a negative impact on aquatic ecosystems, as these are ingested by organisms, leading to starvation and physical injury, and release harmful chemicals that disrupt biological processes. These plastics, especially microplastics, can accumulate within the food web and may ultimately enter the human food chain. The persistence of plastics in sediments means that today's emissions will shape aquatic ecosystems for decades to centuries to come, raising profound questions of intergenerational justice and responsibility. The weight of this responsibility cannot be overstated, as the decisions we make today will have a lasting impact on future generations (6).

Overcoming entrenched industrial interests, strengthening governance, and fostering intergenerational responsibility are essential. However, these efforts will be in vain without the collective action of all stakeholders. Transforming concern into collective action will be decisive in restoring the resilience of rivers, estuaries, and coastal ecosystems and in securing a sustainable future for generations to come.

Statements

Author contributions

MB: Investigation, Writing – review & editing, Conceptualization, Methodology, Writing – original draft, Data curation.

Funding

The author declared that financial support was not received for this work and/or its publication.

Conflict of interest

The author declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author declared that they were an editorial board member of Frontiers at the time of submission. This had no impact on the peer review process and the final decision.

Generative AI statement

The author declared that generative AI was not used in the creation of this manuscript.

Publisher's note

References

1. Roebroek CTJ, Harrigan S, van Emmerik T, Baugh C, Eilander D, Prudhomme C, et al. Plastic in global rivers: are floods making it worse? *Environ Res Lett* (2021) 16(2):025003. doi: 10.1088/1748-9326/abd5df

2. Kelly FJ, Wright SL, Woodward G, Fussell JC. Plastic pollution under the influence of climate change: implications for the abundance, distribution, and hazards in terrestrial and aquatic ecosystems. *Front Sci* (2025) 3:1636665. doi: 10.3389/fsci.2025.1636665

3. Dos Santos EM Barletta M, Cysneiros FJA, Veleda D, Tyaquiçã Santos P, Carty S, et al. Long-term water nutrient variations along the easternmost south American estuarine and coastal areas. *Mar Pollut Bull* (2025) 222:118756. doi: 10.1016/j.marpolbul.2025.118756

4. Glibert P. Eutrophication, harmful algae and biodiversity – Challenging paradigms in a world of complex nutrient changes. *Mar Pollut Bull* (2017) 124(2):591–606. doi: 10.1016/j.marpolbul.2017.04.027

5. Carty S, Barletta M, Tavares MIB, Alves MS, Cysneiros FJA, Dos Santos EM, et al. Feeding ecology and microplastic contamination of planktophagous fishes in a tropical Southwestern Atlantic estuarine ecosystem. *An Acad Bras Cienc* (2025) 97(Suppl 3): e20241408. doi: 10.1590/0001-3765202520241408

6. Rillig MC, Kim SW, Kim TY, Waldman WR. The global plastic toxicity debt. *Environ Sci Technol* (2021) 55(4):2717–9. doi: 10.1021/acs.est.0c07781

7. Brand JH. *Assessing the risk of pollution from historic coastal landfills*. Queen Mary University of London (2017). Available at: https://www.qmul.ac.uk/geog/media/geography/staff/academicstaff/191752.pdf

8. Melo RRRCB, Barletta M, Cysneiros FJA, Tavares MIB, Santana KS, Carty S, et al. Top predator feeding ecology and microplastic (MP) contamination on the far eastern South American coast: evidence of MP trophic biotransfer. *Estuar Coast Shelf Sci* (2024) 301:108736. doi: 10.1016/j.ecss.2024.108736

9. Napper IE, Thompson RC. Environmental deterioration of biodegradable, oxo-biodegradable, compostable, and conventional plastic carrier bags in the sea, soil, and open-air over a 3-year period. *Environ Sci Technol* (2019) 53(9):4775–83. doi: 10.1021/acs.est.8b06984

10. United Nations Environment Programme. *Draft report of the intergovernmental negotiating committee to develop an international legally binding instrument on plastic pollution, including in the marine environment, on the work of its resumed fifth session*. Nairobi: UNEP (2025). Available at: https://www.unep.org/inc-plastic-pollution/session-5.2