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REGULATORY GAPS IN MICROPLASTIC POLLUTION CONTROL: CHALLENGES FOR AQUATIC ENVIRONMENTAL PROTECTION

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Introduction

Microplastic pollution represents a growing environmental concern due to its widespread occurrence, persistence, and potential ecological impacts in aquatic ecosystems. Although scientific research has considerably advanced the understanding of microplastic sources, distribution, and environmental fate, the translation of scientific evidence into effective regulatory frameworks remains insufficient. Current European legislation primarily addresses specific microplastic sources and plastic waste management, while diffuse emissions, cross-compartment transport, and environmental risk assessment remain inadequately addressed. Furthermore, the lack of harmonized sampling and analytical methodologies, consistent reporting standards, and scientifically established risk thresholds limits the integration of monitoring data into regulatory decision-making. A critical gap therefore exists between the increasing availability of environmental evidence and its practical application in comprehensive, science-based pollution control policies. This study aims to assess the European regulatory framework for microplastic pollution, identify key regulatory and monitoring gaps, and highlight priorities for strengthening environmental protection through harmonized monitoring and evidence-based policymaking.

Materials and methods

A structured review of scientific literature and European regulatory documents was conducted to assess existing policy frameworks addressing microplastic pollution. Scientific publications were identified through Scopus, Web of Science, ScienceDirect, and Google Scholar between October 2025 and March 2026, focusing on microplastic sources, environmental distribution, monitoring methodologies, and regulatory implications. Legislative documents were retrieved from official institutional sources, including EUR-Lex, the European Commission, the European Chemicals Agency (ECHA), and the European Environment Agency (EEA). Relevant ISO and ASTM standards were also considered. The analysis focused on regulatory scope, monitoring requirements, analytical standardization, and environmental risk assessment. Particular attention was given to identifying discrepancies between available scientific evidence and existing regulatory provisions, highlighting gaps that may limit effective microplastic pollution management in aquatic ecosystems.

Results and conclusions

The analysis identified several limitations in the European regulatory framework for microplastic pollution. Regulation (EU) 2023/2055 restricts intentionally added synthetic polymer microparticles, while Regulation (EU) 2025/2365 addresses plastic pellet losses. Directive (EU) 2024/3019 introduces microplastic monitoring provisions for urban wastewater and sewage sludge, whereas Commission Delegated Decision (EU) 2024/1441 establishes a harmonized analytical methodology for drinking water. Furthermore, Directive 2008/56/EC, complemented by Commission Decision (EU) 2017/848, addresses marine litter and micro-litter monitoring. Figure 1 illustrates the main sources and environmental distribution of microplastics alongside the relevant EU regulatory framework. Despite these developments, diffuse emissions from textile fibers, tire wear, and plastic fragmentation remain insufficiently controlled.



Figure 1 - Microplastic pollution in aquatic ecosystems: sources, environmental distribution, and EU regulatory frameworks.

Significant challenges persist regarding the harmonization of sampling and analytical methodologies, particularly across freshwater, marine, and sediment matrices. Differences in particle-size thresholds, polymer identification, and reporting units limit data comparability, while the lack of widely established, scientifically validated ecological risk thresholds constrains regulatory implementation. These findings highlight the need for an integrated regulatory approach extending beyond source-specific restrictions. Priorities include harmonized environmental monitoring, improved control of diffuse emissions, and the development of science-based risk assessment criteria to strengthen aquatic ecosystem protection.

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