GAP Analysis report on the environmental impacts of plastic food packaging litter

This report serves as a foundation for further research within the STOPP project, guiding experimental studies and informing policy recommendations. Its findings should be used to foster collaboration between researchers, policymakers, and industry stakeholders to develop sustainable packaging alternatives and improve waste management strategies.

CONTENT

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1. Introduction

The present report summarises the findings of the GAP analysis conducted within the STOPP project. The objective of this task is to assess and quantify the environmental impacts of plastic food packaging (PFP) litter across three ecosystems: marine, terrestrial, and freshwater. This analysis aims to identify existing knowledge gaps and provide a foundation for future experimental research on the fate and effects of PFP in the environment.

Plastic food packaging plays a crucial role in modern food distribution, preserving freshness and reducing waste. However, its widespread use has led to significant environmental concerns due to its disposal and degradation processes. The presence of macro-, meso-, micro-, and nanoplastics in various ecosystems contributes to pollution, posing potential risks to biodiversity, food chains, and ecosystem stability. Despite the abundance of research on plastic pollution, there is a notable lack of studies specifically addressing the environmental consequences of PFP litter, highlighting the need for a comprehensive analysis to bridge existing knowledge gaps.

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2. Methodology

A systematic literature review was performed using Web of Science, Scopus, and ProQuest databases. The search focused on scientific studies addressing the occurrence, toxicity, bioaccumulation, and ecosystem-level effects of macro-, meso-, micro-, and nanoplastics derived from PFP. The screening process resulted in a final selection of 327 relevant articles.

The selection process involved multiple steps, including keyword refinement and exclusion criteria to ensure relevance. The reviewed studies were categorised based on their focus areas: pollution occurrence, toxicological effects, and environmental consequences. In addition, the literature review considered life cycle assessments (LCA) of PFP materials to understand their broader environmental footprint. By synthesising these sources, the report aims to identify key gaps in the existing body of knowledge and suggest priority research areas for further investigation.

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3. Key Findings

The analysis identified three major knowledge gaps in the current understanding of PFP litter impacts:

- Lack of Source Attribution: Most studies fail to specify the origin of the plastic pollution, making it difficult to assess the contribution of PFP to total plastic litter. This lack of traceability hinders the development of targeted policies and mitigation strategies.

- Limited Research on Toxicity and Bioaccumulation: The majority of toxicity studies focus on higher trophic organisms (e.g., fish), with little research on lower trophic organisms (e.g., plankton, aquatic biofilms). Understanding bioaccumulation patterns at different levels of the food web is crucial for assessing the full extent of PFP's impact.

- Absence of Studies on Aged and Recycled PFP: The environmental behaviour of degraded or recycled PFP remains largely unexplored, despite its prevalence in real-world conditions. The degradation process alters the physicochemical properties of plastics, influencing their toxicity and interaction with organisms.

Additionally, while research on marine plastic pollution is relatively abundant, there is a noticeable gap in studies investigating PFP litter in terrestrial and freshwater environments. Since waste management and degradation processes differ across ecosystems, more research is needed to evaluate the specific effects of PFP in non-marine settings.

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4. Summary of Knowledge GAPs

The following table summarises the key findings and research gaps:

Category	Findings	Identified Gaps
PFP Litter Occurrence	83 studies reported on the presence of PFP-derived plastics in the environment.	Limited data on the origins of plastic particles, making it difficult to estimate the PFP contribution to pollution.
Toxicity and Bioaccumulation	97 studies focused on the release of toxic compounds from PFP.	Few studies on the impact of PFP-derived micro- and nanoplastics on lower trophic organisms.
Environmental Effects	20 review papers and 39 LCA studies examined PFP environmental impacts.	Lack of studies addressing aged and recycled PFP plastics.
Ecosystem-level Impacts	Most studies focused on marine environments.	Limited research on PFP litter in terrestrial and freshwater ecosystems.
Degradation and Transformation	Some studies examined the breakdown of plastics in controlled conditions.	Insufficient data on the real-world degradation of PFP under varying environmental conditions.
Human and Wildlife Exposure	Research highlights ingestion and entanglement risks in marine life.	Few studies investigate human exposure risks through the food chain or air.

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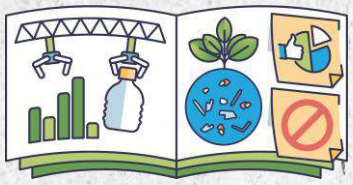
5. Recommendations for Future Research

To address the identified knowledge gaps, the following research directions are recommended:

Improve source attribution methodologies to differentiate PFP-derived plastic from other sources. Techniques such as chemical fingerprinting and stable isotope analysis could enhance traceability.

Expand toxicity and bioaccumulation studies to include lower trophic organisms and broader environmental conditions. Investigations should also consider seasonal and geographical variations in PFP contamination.



Investigate the environmental fate and effects of aged and recycled PFP plastics. Studies should assess how environmental weathering alters the toxicity and interaction of plastics with ecosystems.

Enhance monitoring efforts in terrestrial and freshwater ecosystems to obtain a more comprehensive understanding of PFP pollution. Standardised sampling protocols and global monitoring networks would provide more reliable data.

Conduct longitudinal studies to assess long-term accumulation and potential chronic effects of PFP-derived micro- and nanoplastics in different ecosystems.

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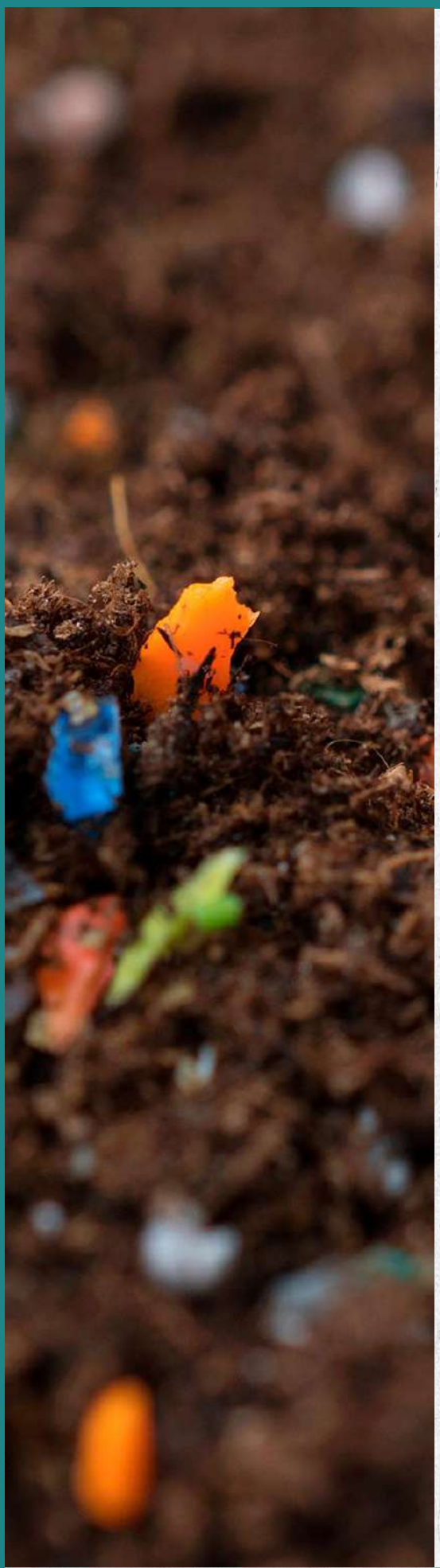

6. Conclusion

This GAP analysis highlights critical deficiencies in current research on the environmental impacts of plastic food packaging litter. Addressing these gaps is essential to develop effective mitigation strategies and regulatory frameworks for reducing PFP pollution and its adverse effects on ecosystems.

The lack of source-specific studies on PFP means that current regulations and mitigation strategies may be inadequate. Future studies should prioritise targeted assessments of PFP litter impacts across diverse environmental settings. By adopting interdisciplinary approaches and innovative research methodologies, the scientific community can enhance the understanding of PFP pollution and guide policy development towards more sustainable packaging solutions.

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