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Editorial: Advances in the monitoring and assessment of marine microplastic contamination

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Editorial on the Research Topic

Advances in the monitoring and assessment of marine microplastic contamination

Environmental risks associated with marine plastic pollution, including microplastics (< 5 mm), are now recognized, prompting national and international efforts to mitigate their impacts. However, without fundamental baseline and long-term monitoring data as a starting point for comparison, it remains difficult to assess the local and regional needs and the effectiveness of these interventions. While microplastics are known to be pervasive across marine environments, even in remote and pristine regions, patterns on distribution and ecological impacts remain poorly quantified. Large-scale, long-term datasets are critical for tracking trends and informing policy, yet this research field continues to face significant methodological challenges, and the lack of standardized approaches hinders the development of comprehensive baselines. As a result, establishing robust monitoring frameworks remains the priority. This Research Topic reflects both the current state of the microplastics research field and strategies to address these challenges. The five contributing studies explore improvements in field sampling techniques and laboratory protocols, and, applying these, present baseline data on microplastic contamination levels across different marine environments and compartments.

One of the primary challenges in microplastic research is the risk of contamination during field sampling, e.g., from plastics associated with collection gear and field equipment —an issue that can rarely be completely eliminated in environmental studies. In this Research Topic, Todd et al. highlights this concern, emphasizing that while quality assurance and quality control (QA/QC) measures such as limits of detection and quantification are imperative to correct data, greater effort should be placed on minimizing or eliminating extraneous plastic contamination during sample collection itself. The study explores alternative, plastic-free field sampling techniques for water, sediment, and biota by adopting traditional materials such as metal, wood, silk and cork to replace plastic-based equipment. Results indicate that small modifications in field practices can significantly reduce extraneous contamination, offering a practical and sustainable approach to improving data reliability through best practices.

Addressing another recognised methodological challenge, Hoehn et al. focuses on the need to improve method harmonization to achieve data standardization. They aimed to replicate the sampling strategy from previous long-term microplastics assessments at sea surface to collect microplastics and other marine debris of coastal waters of the North Sea and applied Nile Red staining to enhance the identification of captured smaller-sized putative microplastics. The findings reveal microplastic concentrations to be significantly higher than previously reported for the North-East Atlantic and Scottish waters, emphasizing the need for continued methodological improvements in field collection and rapid identification of microplastics. Such improvements need to be implemented in tandem with harmonizations in processing and analytical procedures if we are to achieve data standardization and ensure data comparability across studies, an issue Bonita et al. addresses. This study evaluates methods for preparing 'control' sediment matrices for use in controlled experimental procedures (e.g., spike recovery tests to validate protocols used for separating microplastics from sediments) to assess microplastic impacts on tropical beaches. Findings indicate heating sediments at 550 °C for four hours is highly effective in generating a microplastic-free medium for controlled experiments. Applying this microplastic-free medium, they validate a stepwise separation technique, utilising density separation and oxidation, achieving > 99% processing efficiency of beach sediment samples, and provide practical recommendations for improving laboratory methodologies for microplastic monitoring of tropical beaches.

While microplastic research has expanded significantly since the early 2010s, the heterogeneous distribution of these ubiquitous contaminants necessitates extensive datasets to discern spatial and temporal patterns. Alongside methodological advancements, the studies in this Research Topic provide valuable data on the presence, abundance, and distribution of microplastics across multiple environments and compartments, including coastal and open waters, mangrove sediments and marine fish. In the coastal temperate waters of the North Sea, Hoehn et al. report concentrations of microplastics and other marine debris ranging from 857 to 25,462 particles per km², with no significant differences among sampling sites. Regionally, these numbers are found to be significantly higher compared to previous regional monitoring programs, yet global comparisons indicate they are relatively low. The study also highlights the presence of meso- and macroplastic filaments in samples, associating them with fishing gear and single-use plastics. Moving to China, Zhang et al. examines the role of mangrove ecosystems as microplastic sinks, demonstrating that mangrove sediments from Zhanjiang Bay contain 1.6× more microplastics than non-mangrove sediments from adjacent areas. The study also links enrichment patterns to human activities, underscoring the need for targeted conservation and pollution mitigation strategies in these susceptible coastal habitats. Finally, Boisen et al. investigates microplastic ingestion in three species of lanternfish from the northeast Pacific Ocean. Across species, up to 40% of fish contain microplastics, but proximity to riverine microplastic sources does not correlate with contamination levels. Instead, the study identifies oceanographic processes as a more significant role in driving the microplastic distribution in the region. They also identify species- and specimen-specific factors that may influence ingestion patterns, whereby actively feeding fish ingest more microplastics than passive feeders, and larger individuals contain higher microplastic loads. Overall, findings from Boisen et al. reveal that feeding strategy and body size are important predictors of microplastic ingestion in mesopelagic species.

These studies collectively advance the microplastic research field by tackling critical methodological challenges and offering new insights into contamination patterns across diverse marine matrices. By minimizing contamination risks through the adoption of plastic-free equipment and stringent QA/QC measures, researchers can enhance data reliability and reduce biases in field sampling, laboratory processing and experimental designs. Furthermore, findings show that harmonization of microplastic collection and separation will improve comparability across studies, particularly those focusing on long-term monitoring and baseline assessments. This Research Topic also highlights the influence of oceanographic processes (e.g., mangroves as key microplastic sinks), species-specific biological factors (e.g., feeding strategy and body size) and human activities on microplastic distribution, underscoring the need for targeted conservation and pollution mitigation efforts. Together, these studies contribute to the ongoing effort to establish systematic and harmonized baselines for microplastics contamination, ensuring that scientific research continues to provide accurate data to inform policy and guide targeted interventions to mitigate plastic pollution in marine ecosystems.

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