Micro- and Nanoplastics (MNPs) in Sediment: Considerations for Risk Assessment

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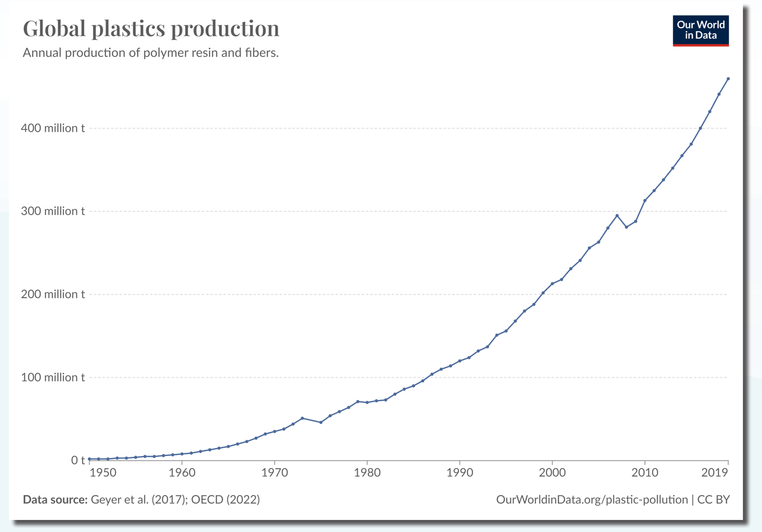
MNP Sources and Characteristics in Environmental Media

MNPs: A growing concern

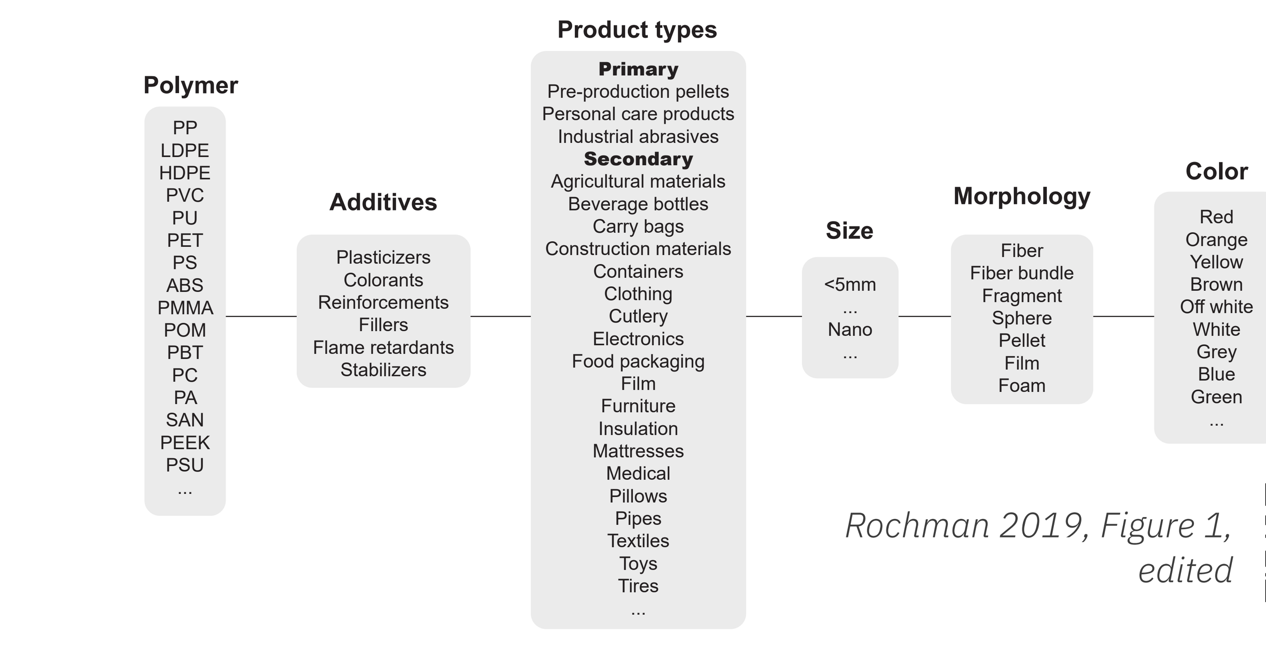
Plastic production has risen dramatically since the 1970s, with Bakelite (1909) marking the first fully synthetic plastic.



Our World in Data

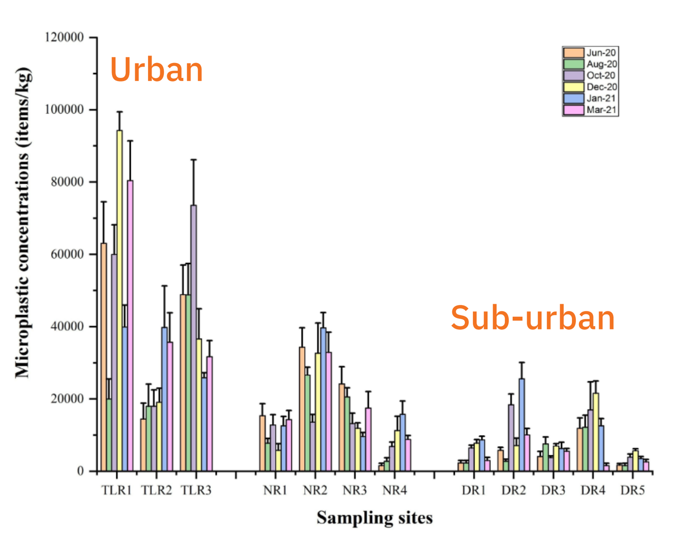
Diverse characteristics of MNPs present challenges

MNPs are derived from a wide range of products and materials. Urban and agricultural runoff, wastewater treatment plant discharge, and industrial activities are among the sources of MNPs to the environment. Chemical and physical characteristics of MNPs vary widely, complicating their assessment in sediment, water, and biota. This variability affects sampling protocols, transport analysis, and risk evaluation methods.



Rochman 2019, Figure 1, edited

MNP concentrations higher in more urbanized areas

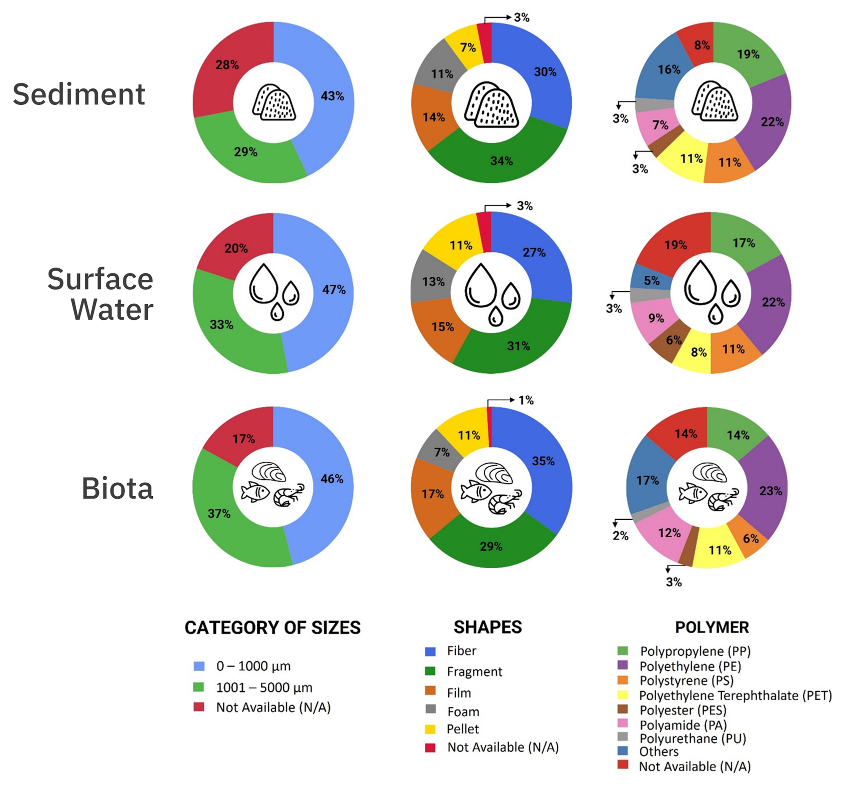


Since MNPs are derived from anthropogenic products and activities, it is not surprising that MNP concentrations in environmental media correlate strongly with urbanization levels. Studies by Duong (2023) and Martin (2017) show elevated concentrations in urban areas and nearshore fisheries compared to remote locations.

Duong 2023, Figure 2

Distribution across environmental media

Diversity in plastic sources results in diverse characteristics of MNPs in environmental media. Ali (2024) summarized MNP characteristics in sediment, surface water, biota, and other media based on a literature review of 100+ studies from Asia. Those findings are captured in Figures 6–8 of Ali (2024) presented below.



Despite diverse characteristics (size, shape, material composition) within each environmental medium, the distribution of MNPs across media is surprisingly consistent.

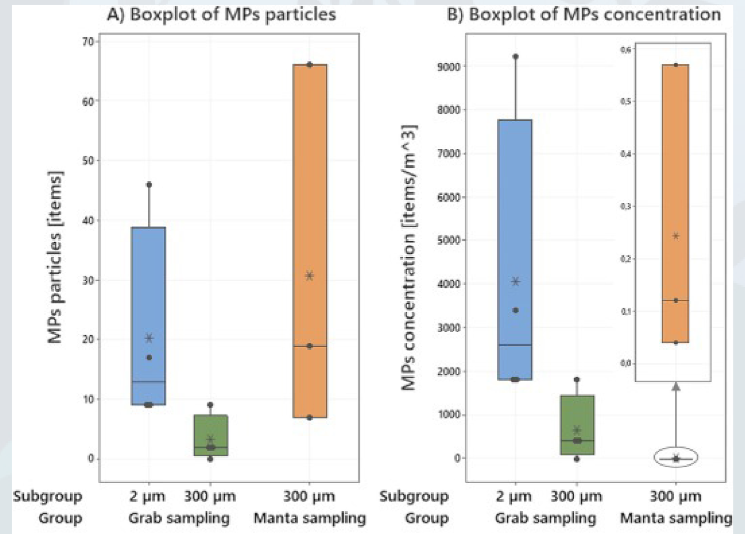
Ali 2024, Figures 6–8 combined

MNP Sampling and Measurement Considerations

Sampling methods, including device and filter size

Device selection and separation methodology significantly influence results. Filter and sieve opening sizes are critical parameters that directly affect the particle size range captured in samples.

The figure to the right illustrates the difference in results using different surface water sampling approaches and filter sizes.



Poli 2024, Figure 1A/B

Physical Methods
- Visual analysis (microscopy)
- Laser diffraction particle analysis
- Dynamic light scattering

Quantitation
- Mass concentration
- Quantitative concentration (number of particles)

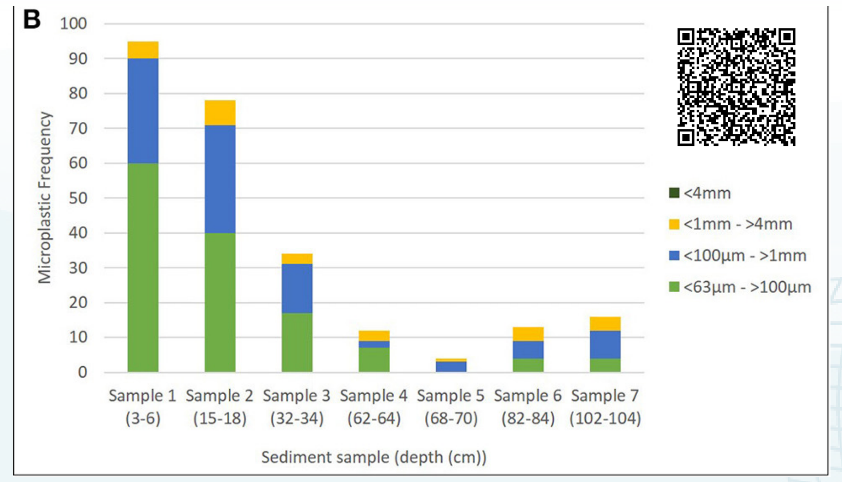
Chemical Methods
- SEM-EDX
- FTIR spectroscopy
- Raman spectroscopy
- Thermal analysis
- Mass spectrometry

Huang 2023

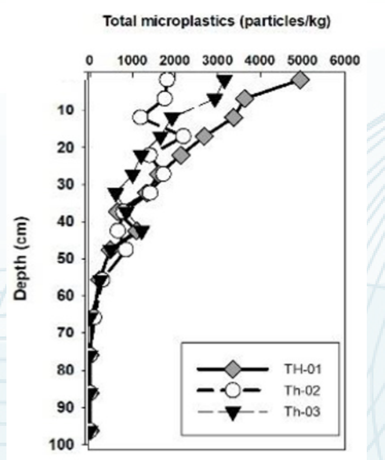
Huang (2023) discusses the range of physical and chemical approaches for characterizing and identifying MNPs in environmental media.

Sample interval

MNPs typically show higher concentrations in shallower sediments due to their recent introduction into the environment. Willis (2017) and Dung (2021) demonstrate this vertical distribution pattern in urban estuaries and mangrove forests, respectively. **This is relevant to risk assessment as MNPs may be present in biologically active sediment depths and therefore available for uptake by biota.**

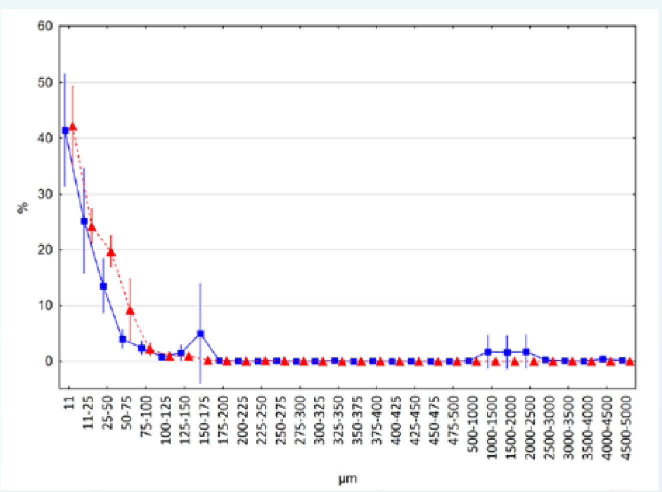


Willis 2017, Figure 3B



Dung 2021, Figure 2

Particle size distribution



Finer particles (<100 µm) are most common in MNP populations, and the majority of MNPs are <1 mm.

This size distribution, documented by Willis (2017) and Lorenz (2020) (left) in sediment and surface water, should inform sampling methodology and filter selection.

Lorenz 2020, Figure 6

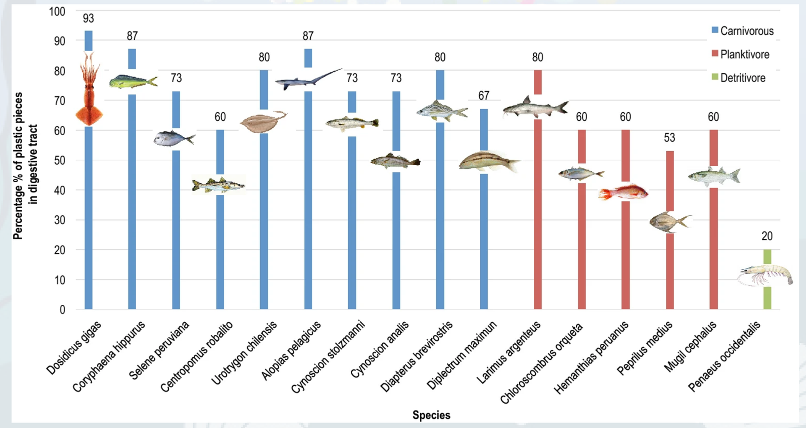
Risk Assessment Considerations

Risk assessment framework

Assessment of MNP risk requires developing conceptual site models, including identifying potential receptors and exposure pathways. The potential role of MNPs in contributing to traditional chemical risk is unclear.

Research has demonstrated MNP uptake across all trophic levels and feeding strategies (right). Species-specific factors that may impact MNP uptake and toxicity include:

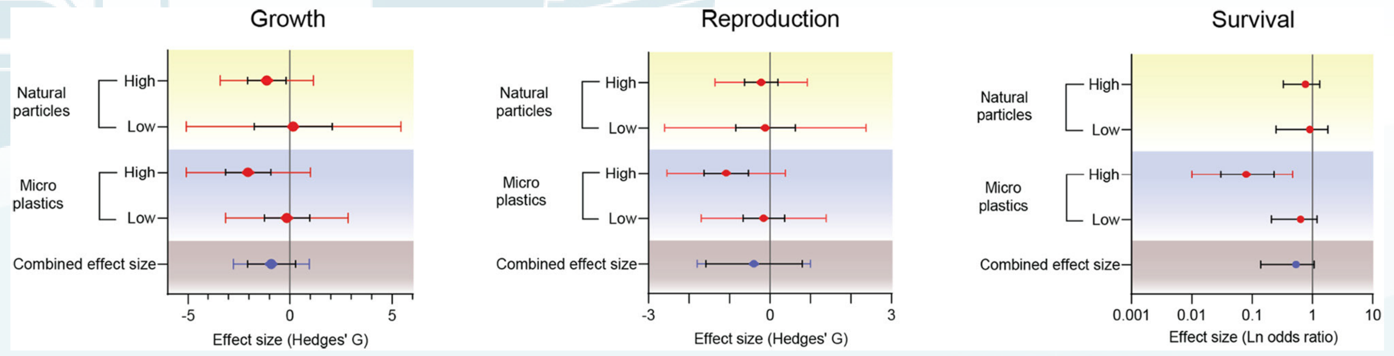
- Home range
- Surface water ingestion or filtration
- Close contact with sediment or bottom feeding
- Consumption of prey with high MNP levels



Alfaro-Nunez 2021, Figure 3

Individual and population-level effects

Current data on ecological impacts show variable results. Meta-analyses indicate that higher MNP concentrations may cause more severe negative effects on growth, reproduction, and survival compared to natural particles (below).

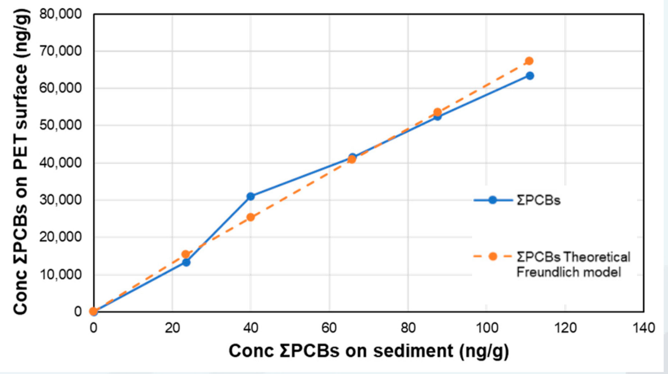


Waldschlager 2022, Figure 3

Role of MNPs on fate and transport of other contaminants

MNPs influence the fate and transport of contaminants through sorption. Such contaminants may include:

- Metals (Lead, chromium, zinc, copper, nickel, etc.)
- Radioactive contaminants such as uranium
- PCBs (right) and other hydrophobic organic contaminants.



Sorption effectiveness varies by polymer type and environmental conditions (pH, salinity, organic matter). MNP–contaminant interactions may create synergistic effects.

Llorca 2020, Figure 1C

Conclusion

Microplastics (MNPs) are pervasive in the environment and are a growing global concern. International efforts to regulate plastic waste are underway, yet the biological and ecological impacts of MNPs remain poorly understood. Found in sediments and surface waters, MNPs contribute to environmental risks through mechanisms like contaminant sorption and bio-uptake.

This poster highlights key variables for assessing MNPs in sediments, emphasizing the need for **tailored characterization methods**, particularly in urban or high-MNP areas near waste sources. **Risk evaluations should follow best practices, incorporating multiple lines of evidence to understand the complexity of MNPs in environmental media and the resulting impacts on ecological receptors.**

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