Treatability of Microplastics by Urban Stormwater Controls

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Presentation Outline

- Research Objectives
- Background
- Research Methodology
- Results & Discussions
- Conclusions & Recommendations
- References
- Acknowledgments

Research Objectives

- **Analyzed Microplastic Distribution:** Assessed the distribution of MPs in SW retention ponds, with a focus on how different land use types influence their presence.
- **Developed Detection Methods:** Established and refined analytical techniques for the detection and identification of MPs in environmental samples.
- **Quantified Size Distribution:** Examined and quantified the size distribution of MPs in stormwater retention ponds to inform future design and management of stormwater infrastructure.
- **Evaluated Bioretention Systems Effectiveness:** Investigated the efficacy of field-installed bioretention systems as a physical treatment method for removing MPs from urban stormwater runoff, providing insights for sustainable design improvements.

Background: MPs Abundance and Toxicity

- Plastics are everywhere and so now Microplastics (MPs)!
- According to the scientific community, microplastics are tiny plastic particles with a diameter of 0.001mm – 5 mm (sometimes less than a hair, 0.05 mm).
- Have negative effects on ecosystems and human health.
- Can adsorb pollutants on their surface, such as heavy metals, PCBs, and PAHs.
- Can change swimming and feeding behaviors of various species.
- Can be ingested by air and other organisms, and potentially induce chronic diseases.

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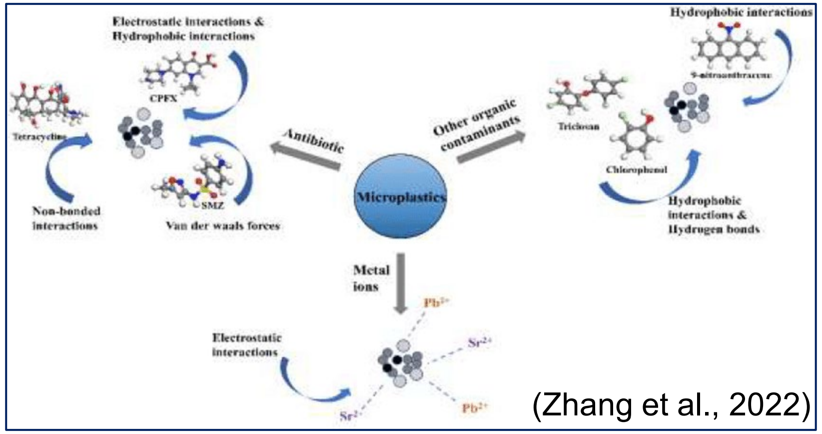
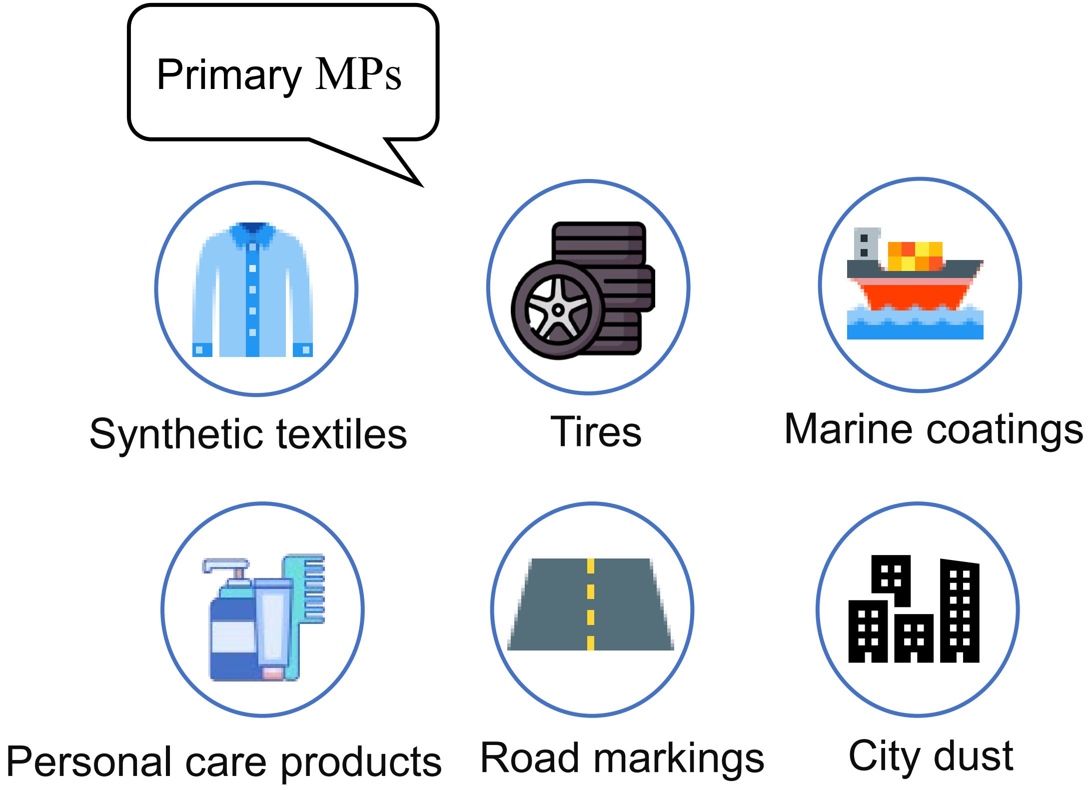
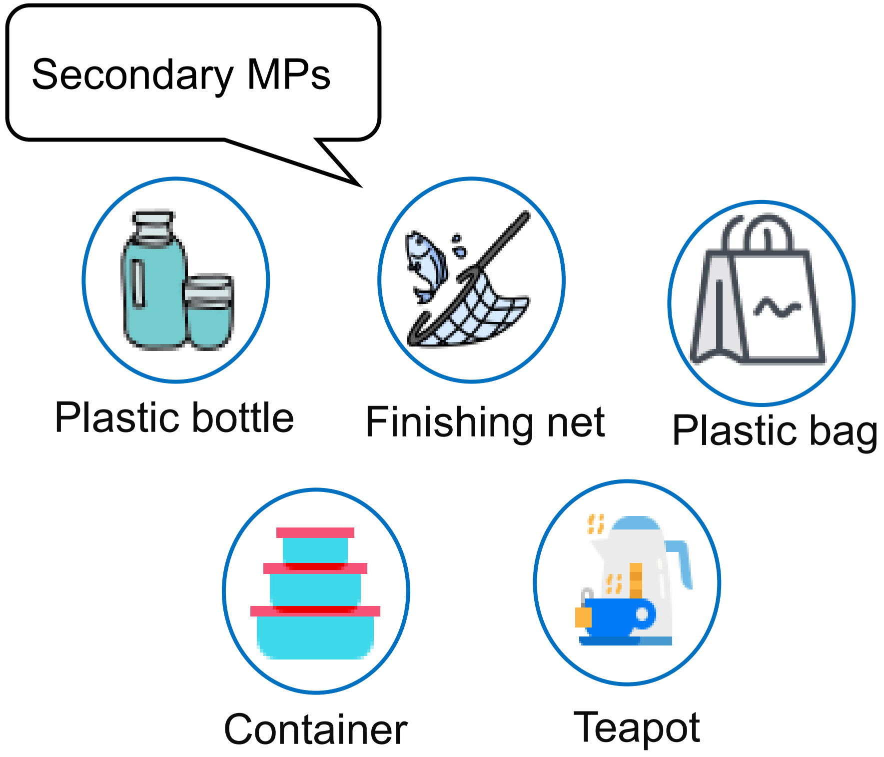


(Zhang et al., 2022)

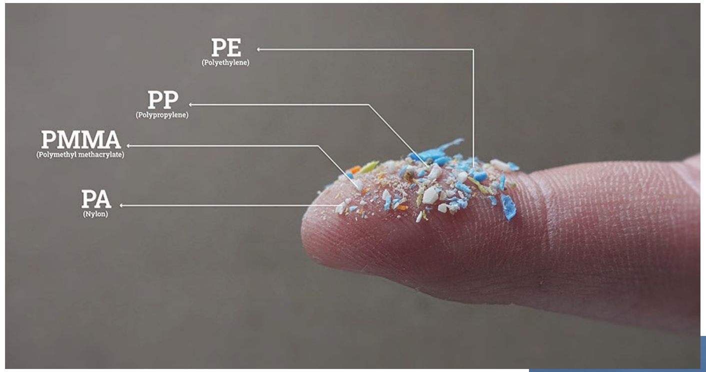
Background: Types of MPs

- MPs are of two types: 1. Primary 2. Secondary





Background: Chemical Composition of MPs



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Common MPs Types

- Polyethylene (PE)
- Polypropylene (PP)
- Polyethylene Terephthalate (PET)
- Polystyrene (PS)
- Polyvinyl Chloride (PVC)
- Nylon

Common Shapes

- Fiber
- Film
- Fragment
- Foam
- Pellet

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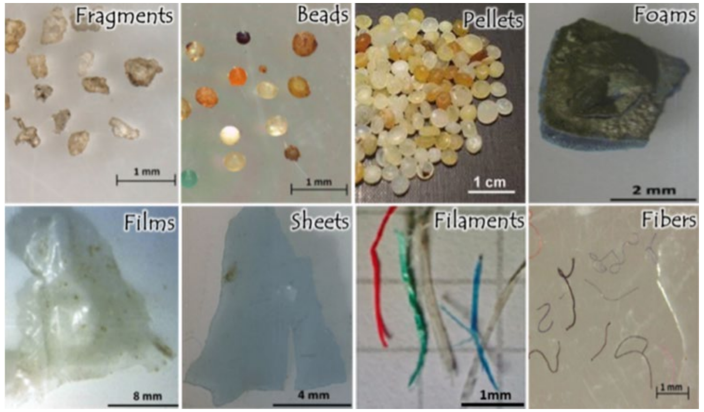
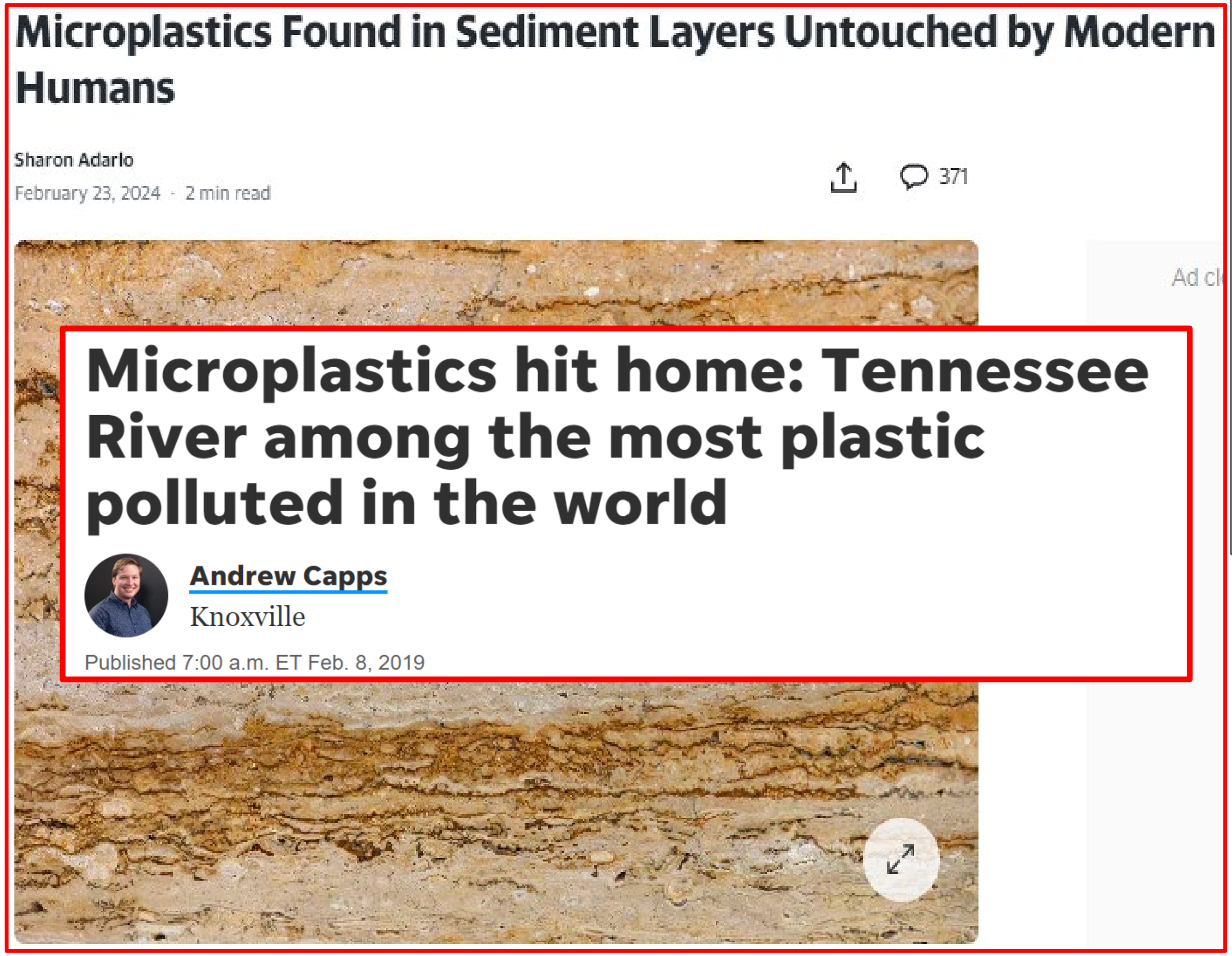
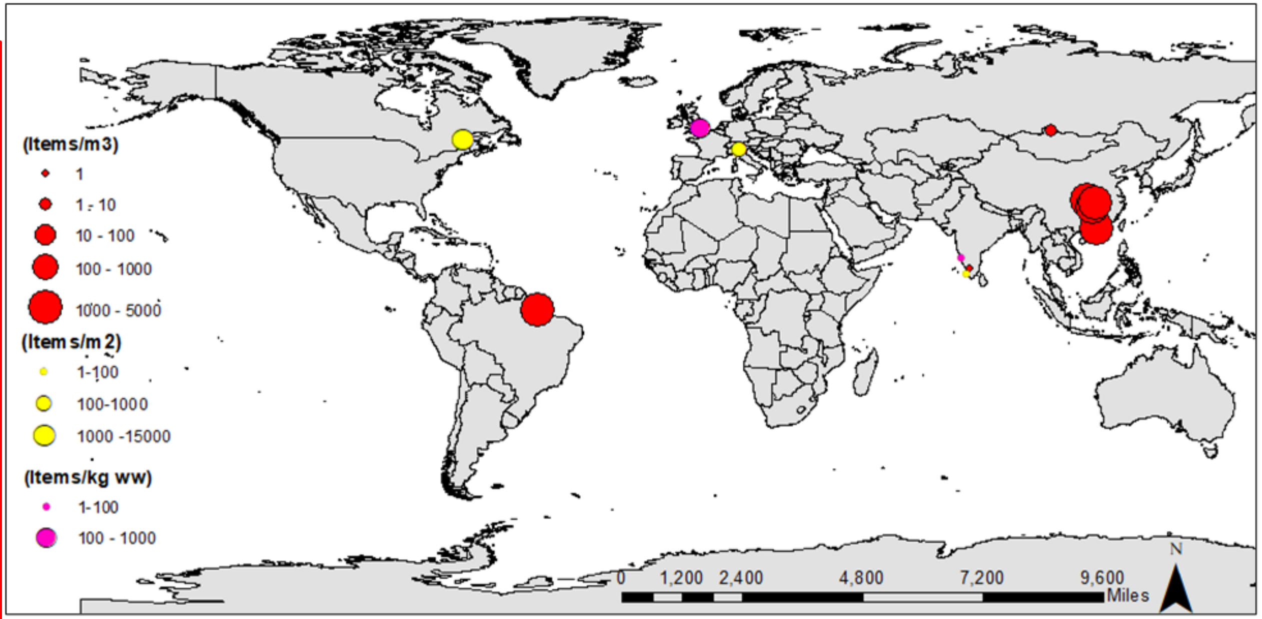
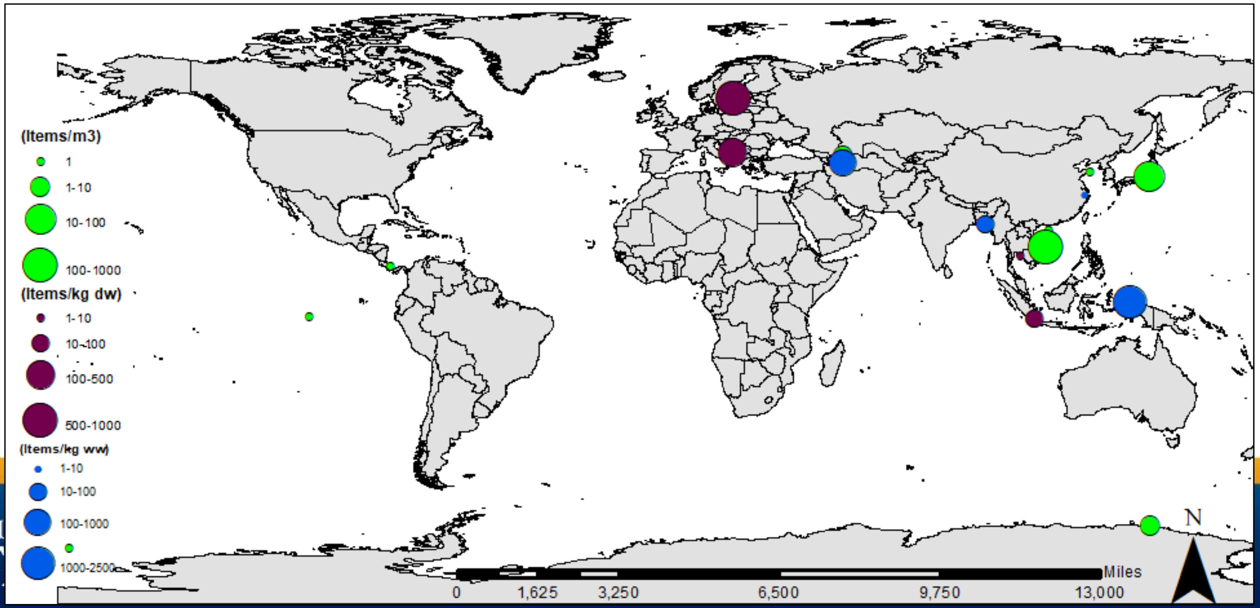


MPs Abundance





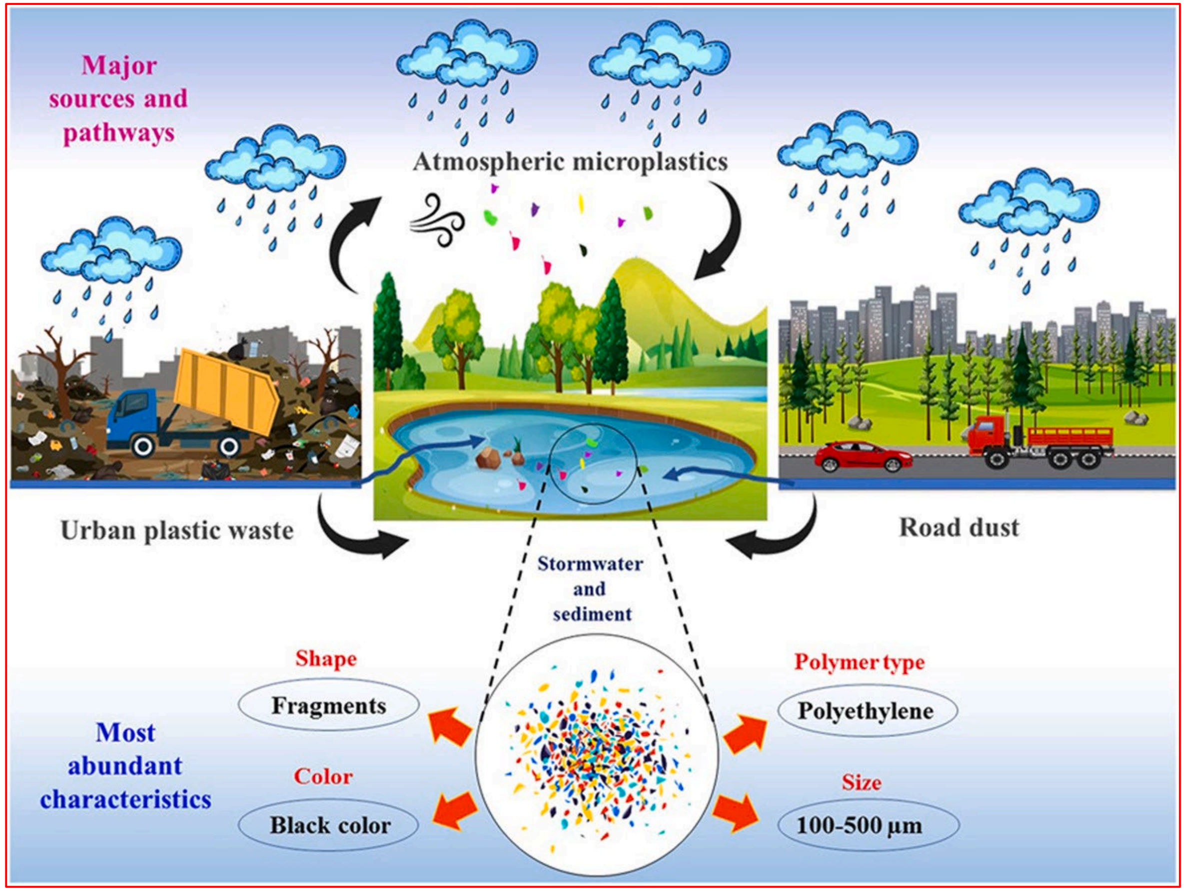


MPs in Urban Stormwater Environments

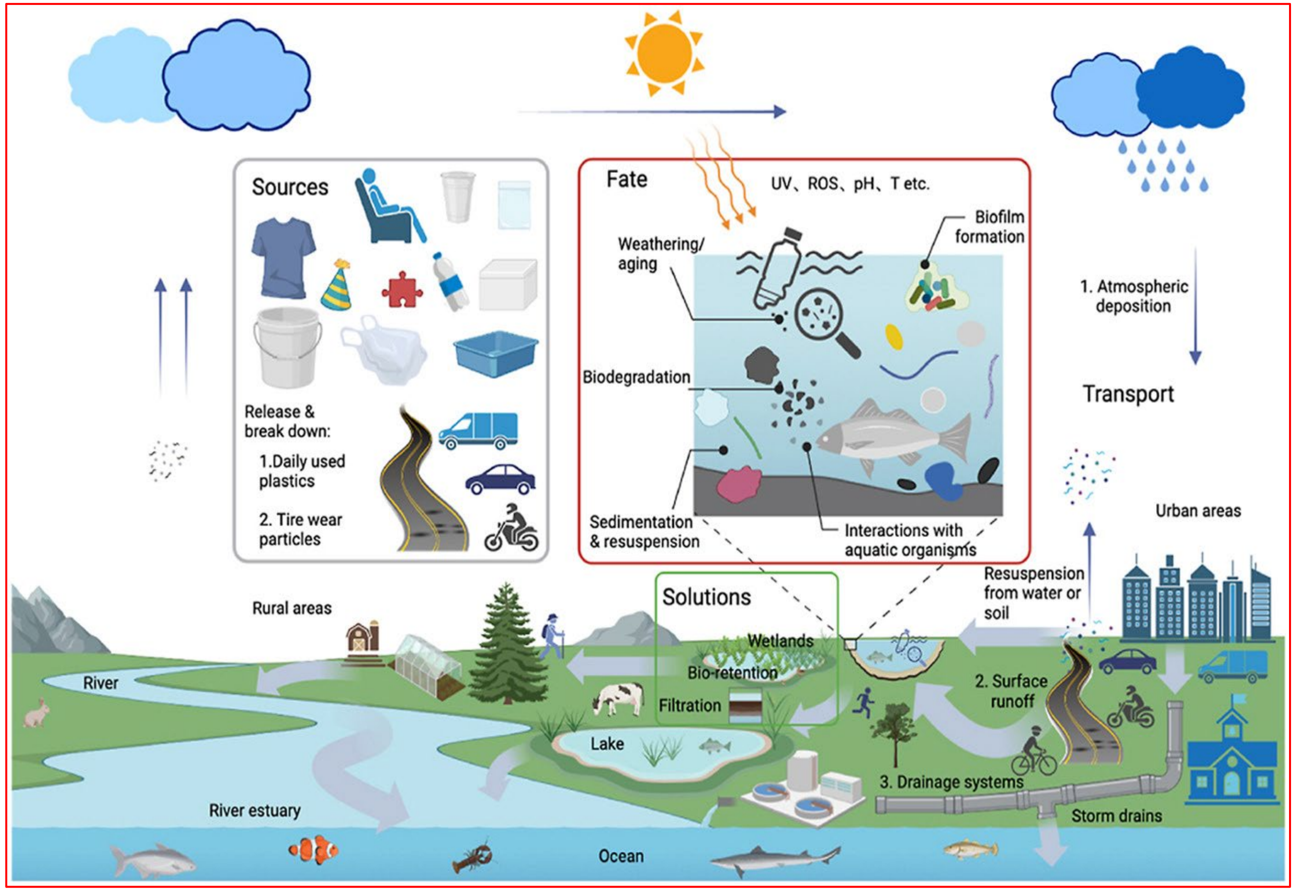
- **Urban Stormwater Controls** are strategies and practices implemented to **manage** the **quantity** and **quality** of **stormwater runoff** in urban areas.
- **Stormwater** (SW) **Retention Ponds** play a critical role in managing urban runoff by **allowing suspended solids to settle** before water is discharge into the environment or storm sewers.
- **Bioretention Systems**, a form of green stormwater infrastructure, provide a sustainable solution for **controlling stormwater overflow**. They also serve as a control mechanisms for other pollutants, such as PCBs, and PAHs.
- MPs can disrupt urban stormwater ecosystems by affecting soil stability, microbiomes, and water resources.
- Understanding **how different land use types influence the distribution of MPs** in **urban stormwater systems** is crucial for the future design and management of stormwater infrastructure. By studying MPs concentrations and their sources, we can develop more **targeted** and **effective strategies** to **reduce contamination** and **enhance** the **resilience** of urban water systems.

MPs in Urban Stormwater Environments

- MPs cycle in Urban Stormwater Sediments and Runoff



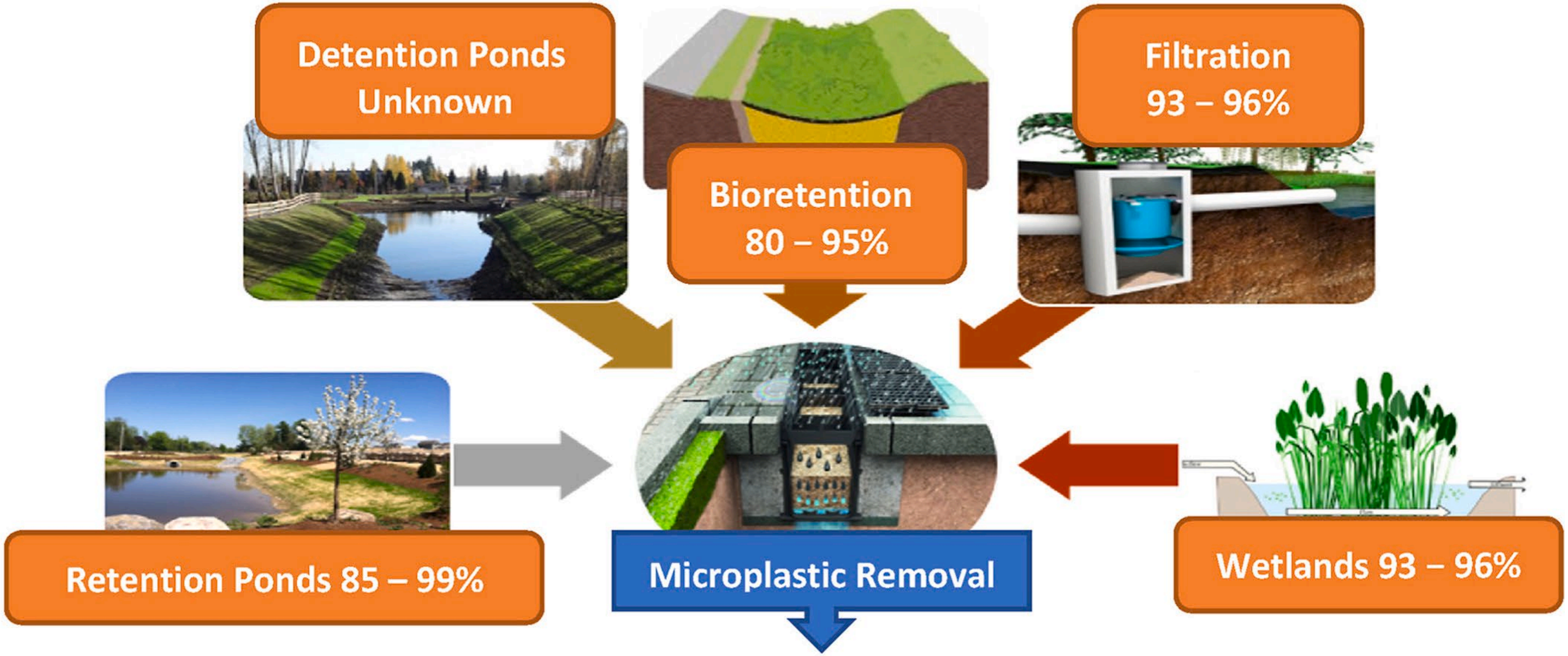
(Sewandi et al., 2024)



(Wei et al., 2023)

Removal Techniques of MPs

- MPs removal from Urban Stormwater Environments

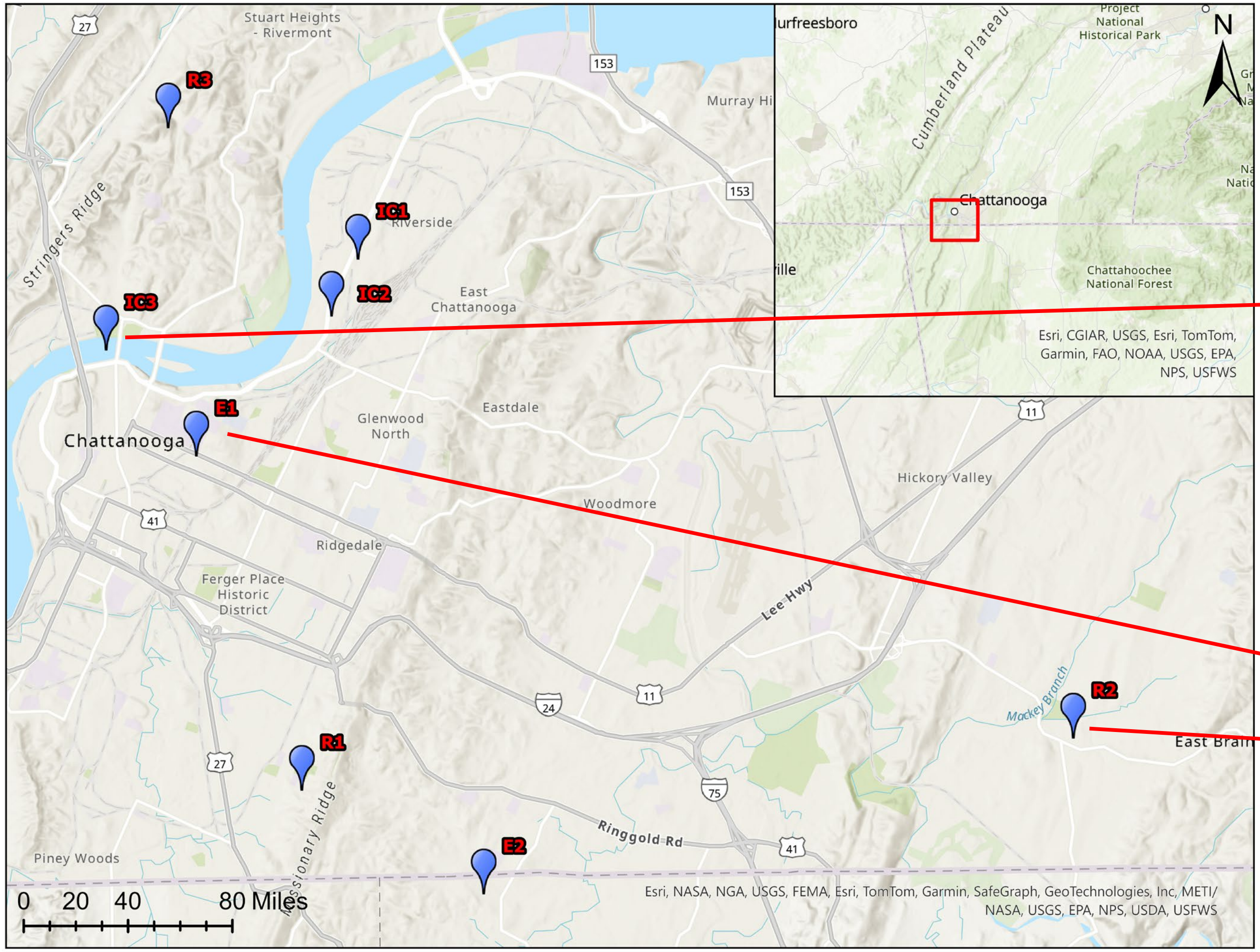


(Stang et al., 2022)

Methodology: Study Sites

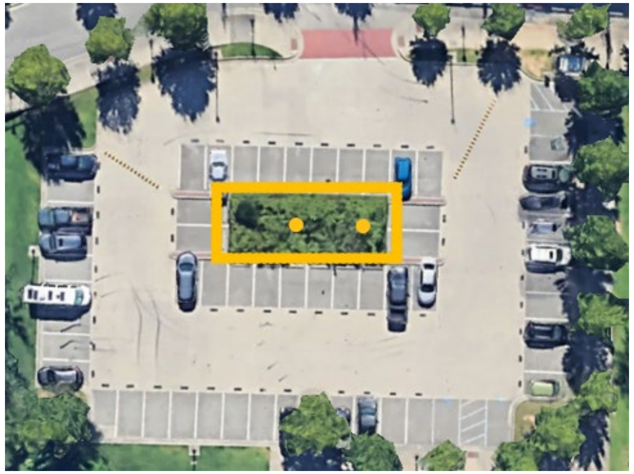
Stormwater Retention Ponds	East Lake	R1	Residential Area
	Heritage Park	R2	
	Memorial Duck Pond	R3	
	EMCS Building	E1	Educational Areas
	East Ridge High School	E2	
	Amnicola High Pond	IC1	Light Industry, Commercial, and Highways
	Curtain Pole Pond	IC2	
	Renaissance	IC3	
Bioretention Systems	Warner Park	S1 S2	
	Renaissance Park	S3 S4	

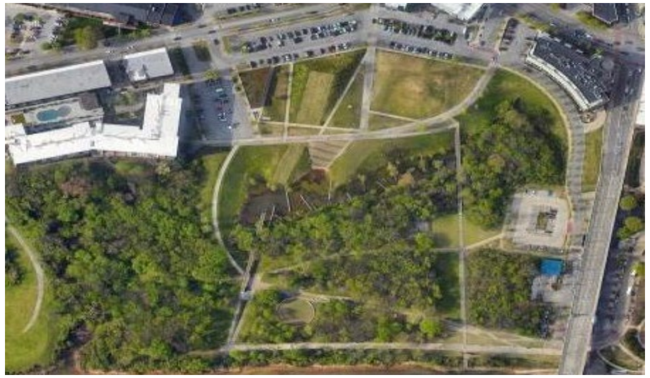
Methodology: Study Sites



Methodology: Field Samplings (SW Retention Pond)

Methodology: Field Samplings (Bioretention Cell)

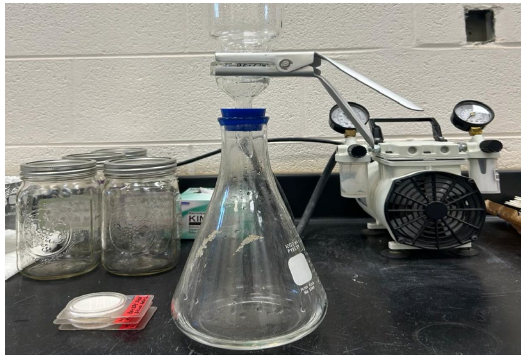


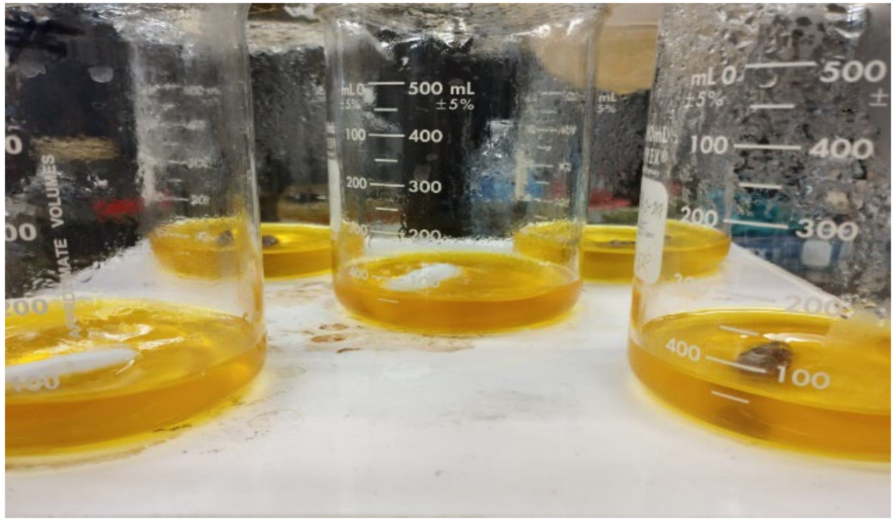


Methodology: Laboratory Procedures

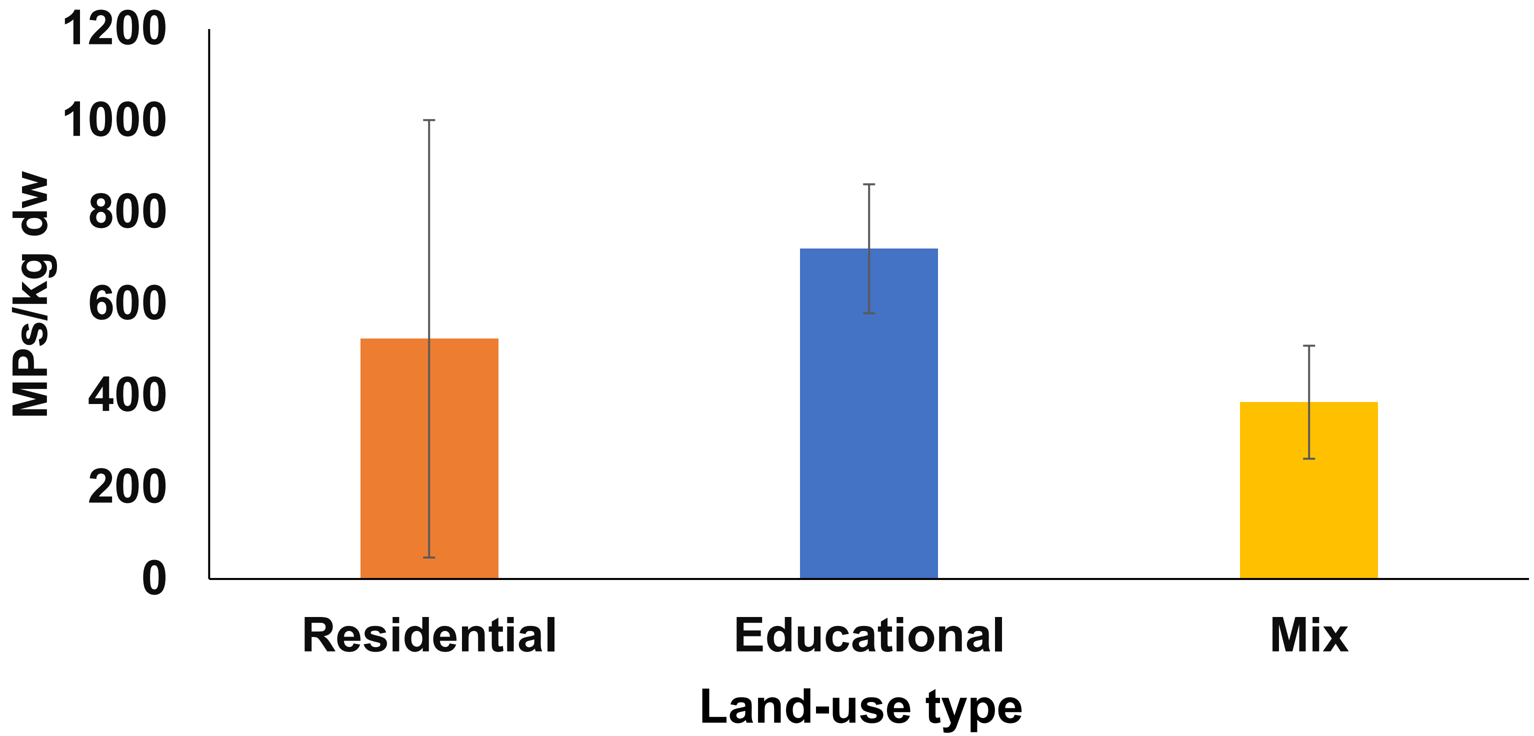
Laboratory Analysis

- Density Separation
- Oxidative Digestion and Filtration
- Optical Microscope Analysis, Nile Red and Fluorescence Analysis





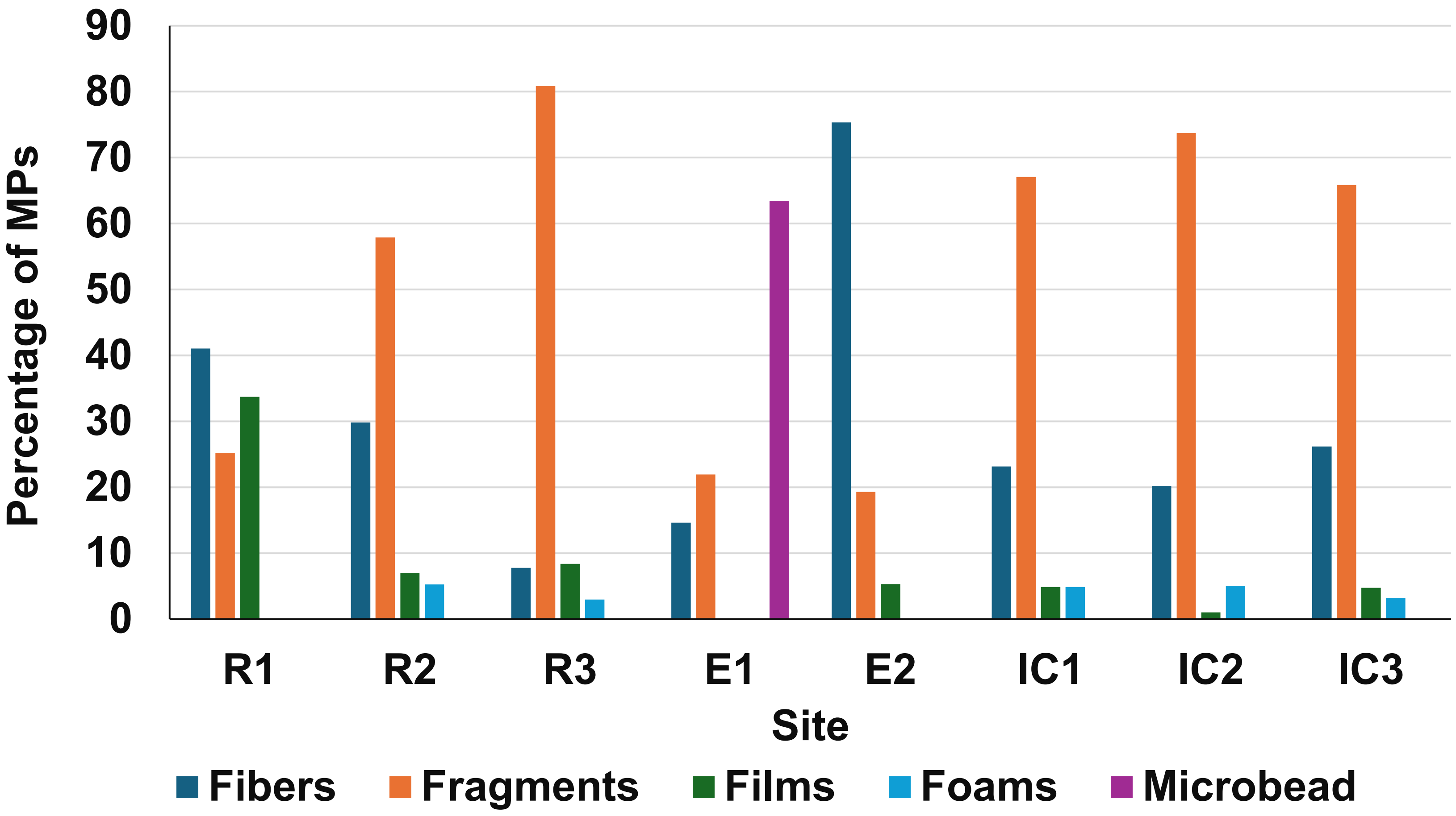
Results & Discussions: MPs Distribution in SW Retention Pond



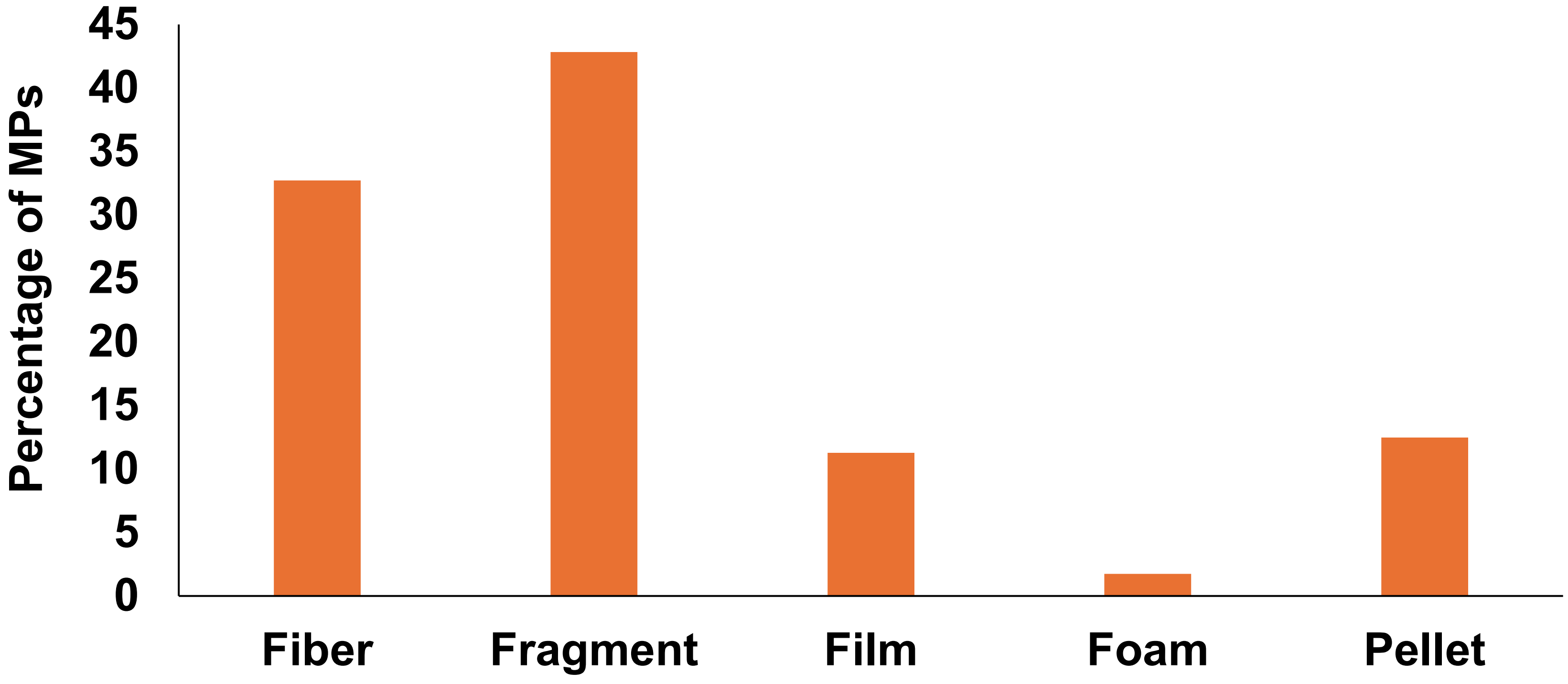
Major Sources:

- Residential areas: personal care products, synthetic textiles, plastic food package, etc.
- Educational areas: laboratory materials, plastic dishes, pipettes, vehicles tires, and road paints, etc.
- Light Industry, Commercial and Highways areas: nurdles, manufacturing residues, packaging materials, and construction materials, etc.

Results & Discussions: MPs Distribution (Morphology)

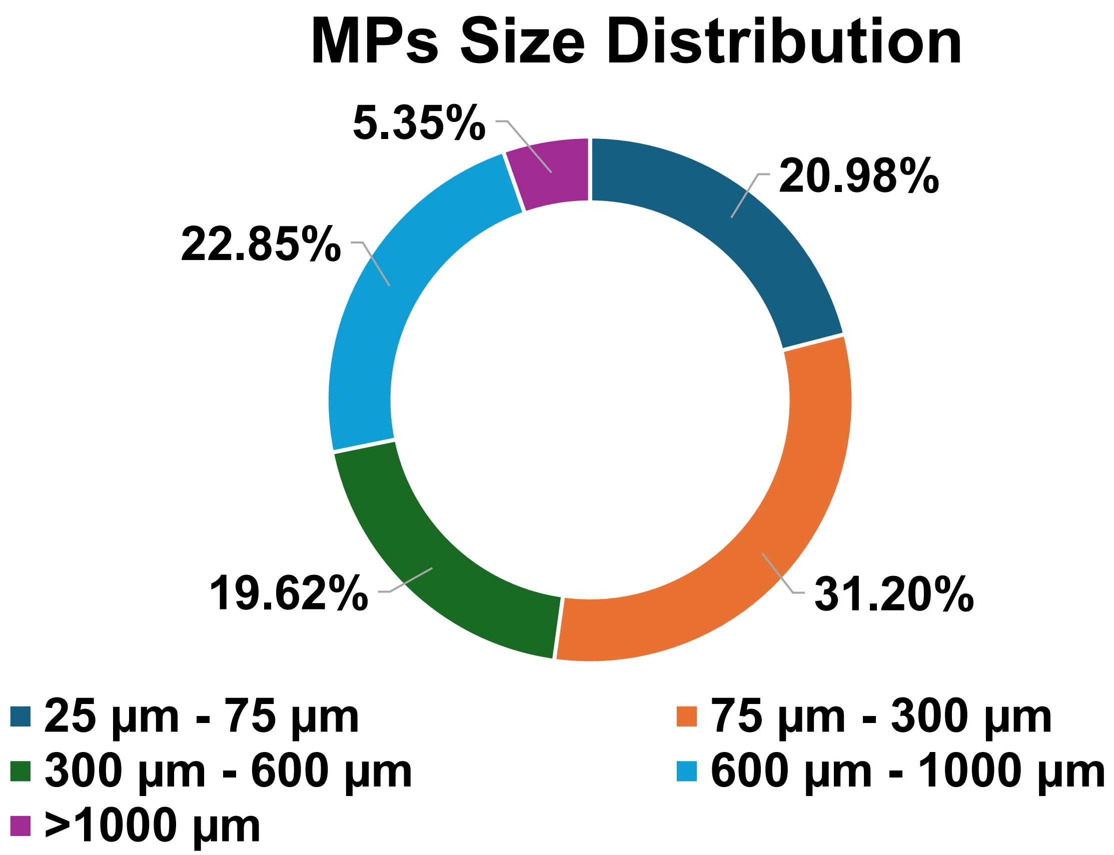


Results & Discussions: MPs Distribution (Morphology)



- Five types - fibers, fragments, films, foams, and microbeads.
- Majority MPs (~75%) – Fragments & fibers.

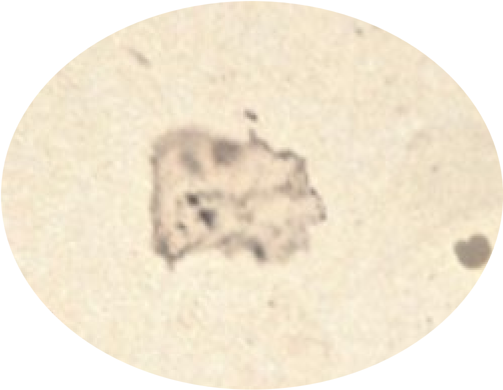
Results & Discussions: Size Distribution of MPs



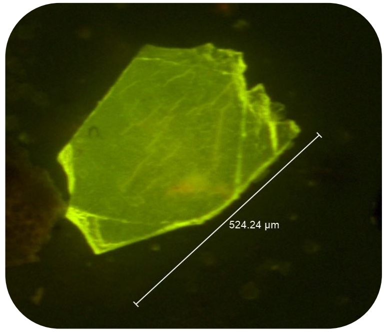
- More than 30% of microplastics were in the 75–300 µm range, making it the dominant size. In contrast, larger microplastics (>1 mm) accounted for 5.35% of the total.

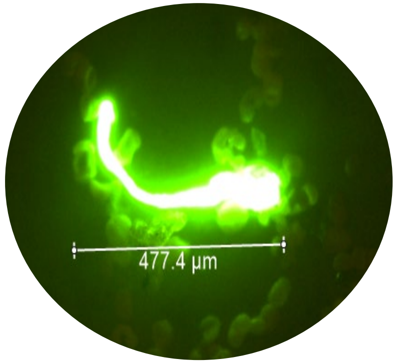
Detection and Identification of MPs

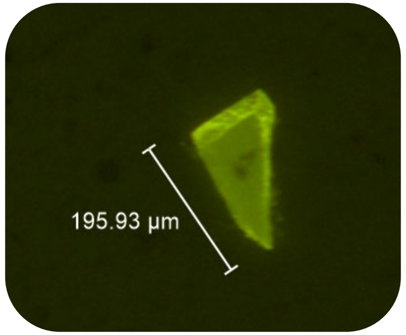
Optical Microscope

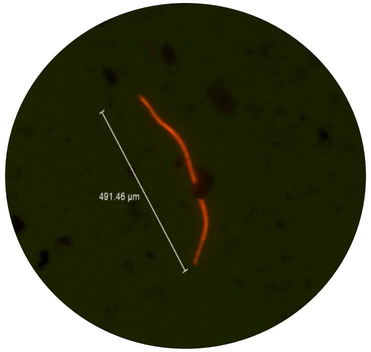


Fluorescence Microscope

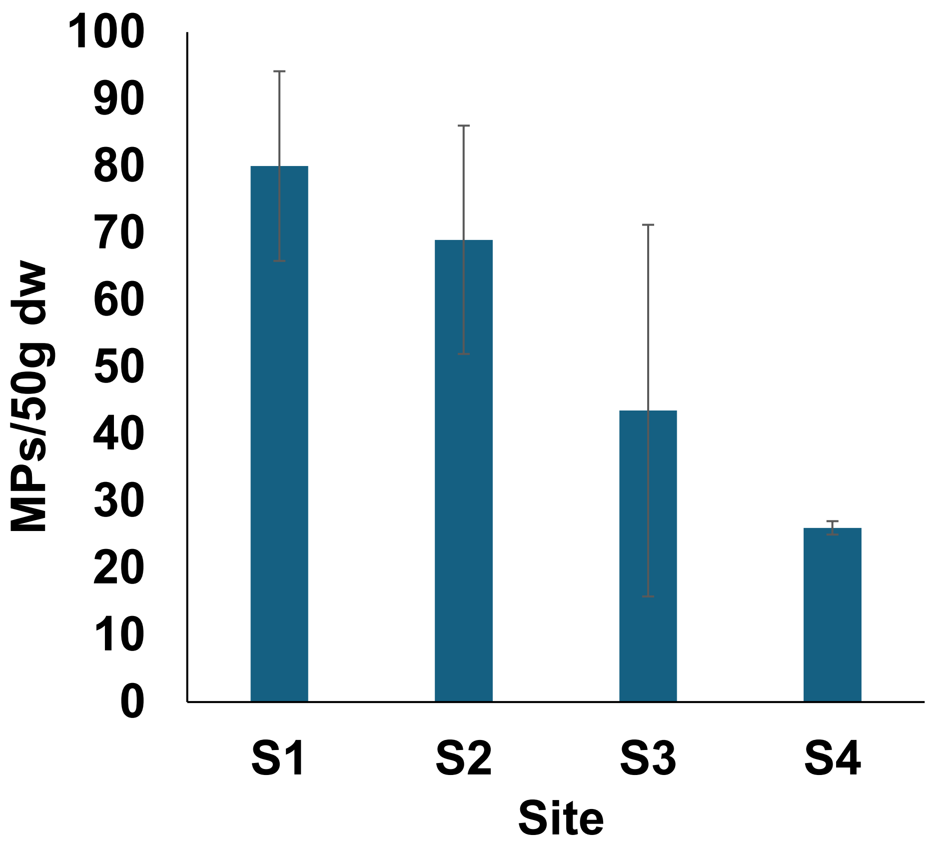


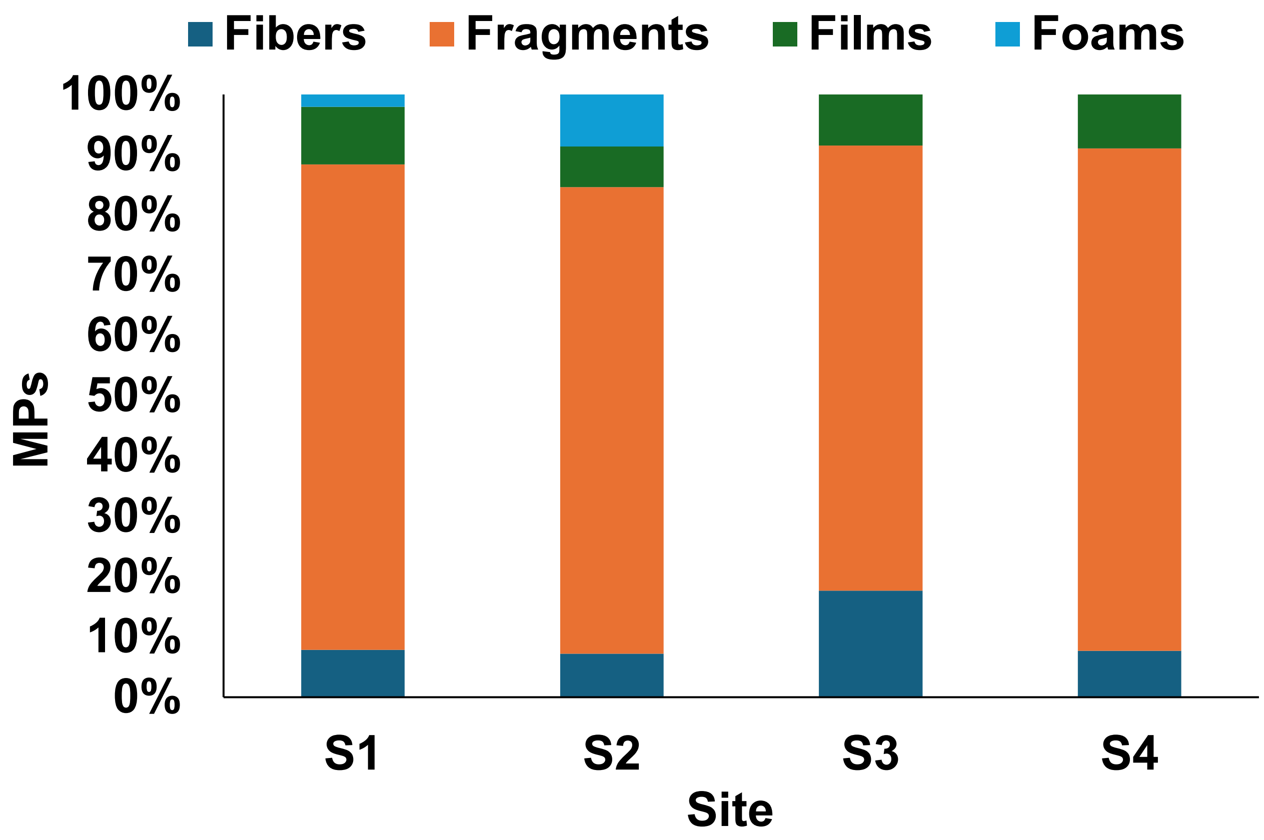






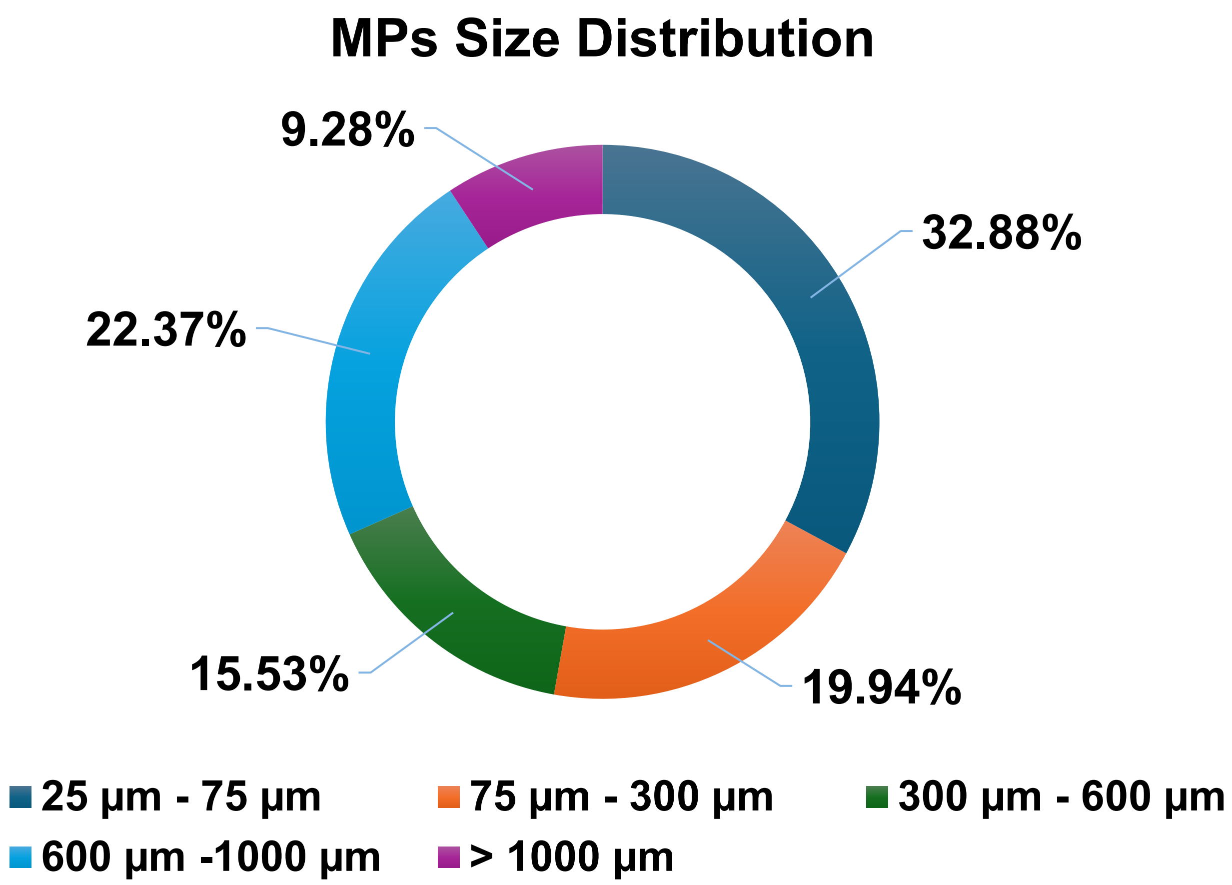
Results & Discussions: MPs Retention using Bioretention Cells

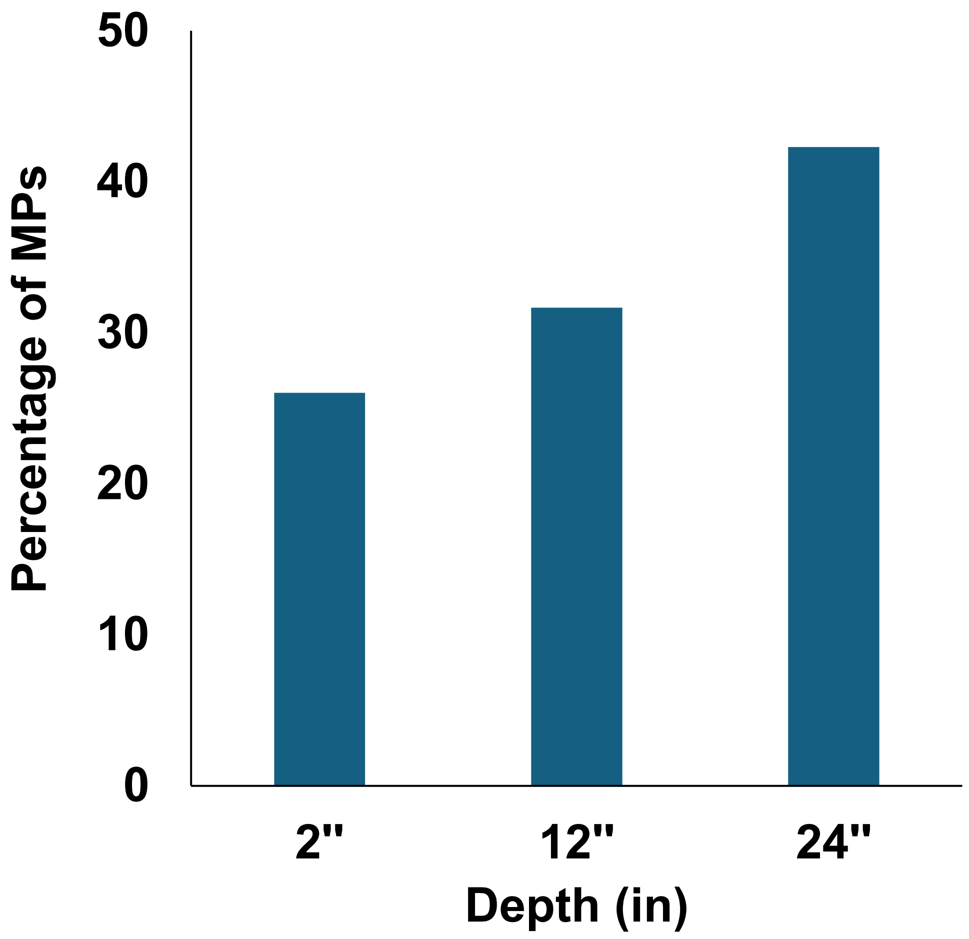




- In Renaissance Park BRS, the mean MPs concentration was approximately 75 items per 50g of dried soil, while in Warner Park BRS, it was around 35 items per 50g.

Results & Discussions: Size Distribution of MPs





Conclusions & Recommendations

- Microplastics were prevalent in all sediment samples.
- Fibers, films, foams, and fragments were common MPs types, with fragments being predominant in stormwater retention ponds.
- In various stormwater retention ponds samples, more than 30% of MPs were within the 75 µm – 300 µm range, highlighting targeted treatment ability of MPs by ponds and/or dominant MPs pollution in the Chattanooga area.
- The findings suggested that Bioretention cells offer sustainable mitigation strategies for MPs removal.
- Future work should be on creating a MPs database for various urban water systems and identifying critical sources of MPs pollution to develop targeted mitigation strategies.
- Sustainable plastic mitigation campaigns (**4R's:** Reduce, Reuse, Recycle, and Recover) to enhance public awareness may be the best startergy to limit future MPs pollution.

Results & Discussions

- A higher concentration of MPs was observed at a depth of 24 inches in the biofiltration media of the BRS.

- While runoff is believed to be major source of MPs in bioretention media, initial contamination of media during construction may also be a part.

- Primary source of MPs include vehicle tires and rubberized asphalt.

- The majority of MPs were within the 25–75 μm size range, indicating retention of smaller particles, while the size fraction >1000 μm contained the fewest MPs.

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