

# MICROPLASTICS IN MARINE SEDIMENTS: EFFECTS ON MICROBIAL STRUCTURE AND FUNCTION REVEALED BY A FLOWTHROUGH REACTOR EXPERIMENT

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## Introduction and Research Question

- Microplastics (MPs) are ubiquitous in marine environments posing a potential threat to marine life.
- Microbes (i.e., microalgae, bacteria, archaea) form biofilms around MPs, a process called *biofouling*;
- Biofouling increases settling and sedimentation rates of MPs (Kaiser et al., 2017; Ziervogel et al. 2024) (Fig 1).
- Little is known about microbial interactions with MPs in sediments (Ladewig et al., 2024).

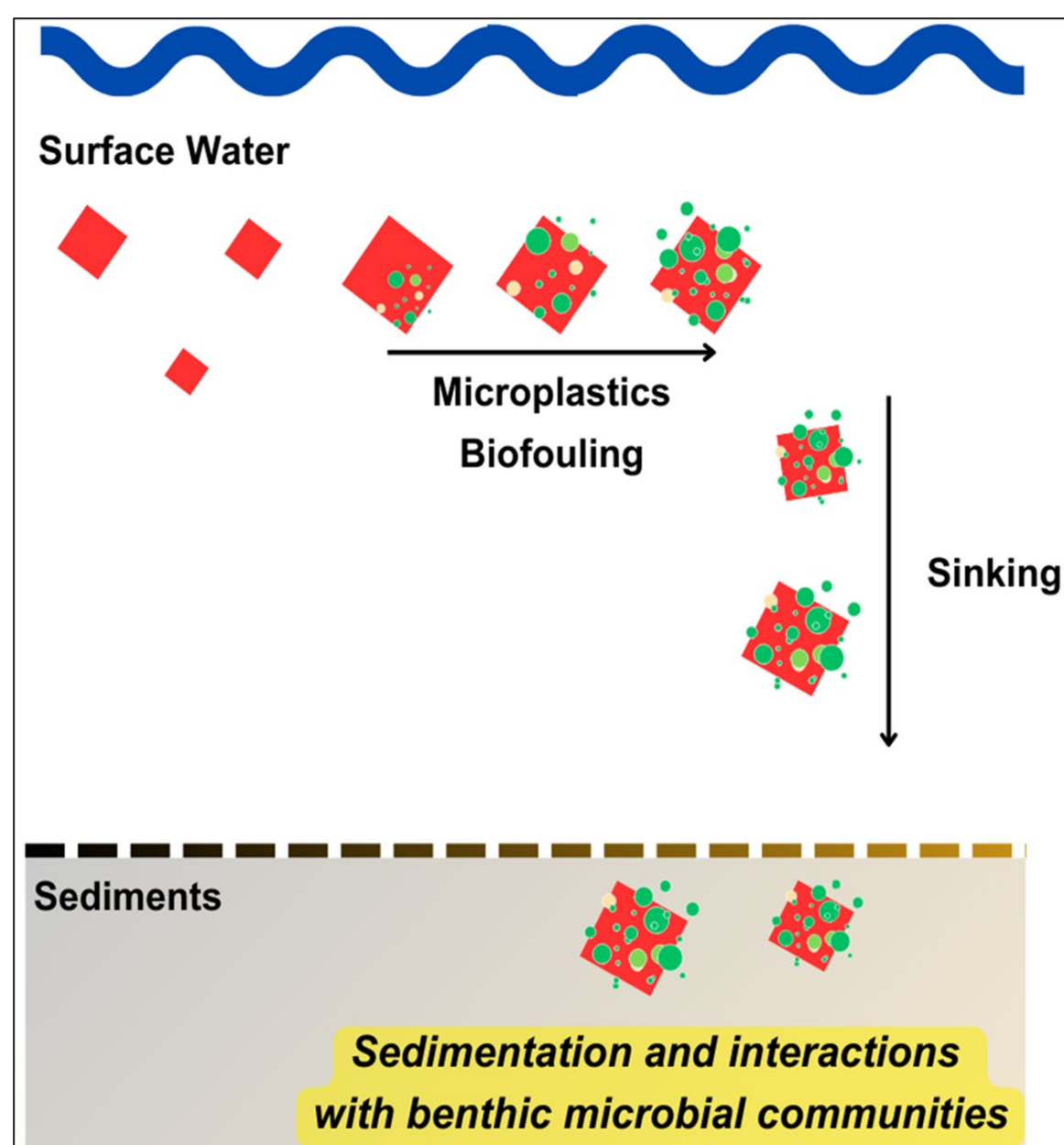


Fig 1. Surface water MPs are colonized by microbes, leading to their sinking and accumulation in marine sediments.

### Research Question:

**Do sedimented MPs enhance bacterial cell growth and enzyme activities in sediments?**

- Heterotrophic microbes, including those that colonize and utilize MPs as carbon source, require digestive enzymes to access and degrade complex organic matter.
- Enzymes operate outside the cell; their potential activities can be measured using different fluorescently labeled substrates that represent substrates present in the environment (Hoppe, 1983).

## Experimental Setup & Methodology

- MPs from PE shopping bags were incubated in surface seawater for two weeks (*biofouling experiment*), then used as amendments in sediment incubations.
- Sediment incubations were set up in triplicates and incubated for 14 days in flowthrough reactors (Fig. 2); two treatments: Unamended sediments (no MPs control); sediment with biofouled MPs.
- Samples were taken at Days 2, 7 and 14 from sediments and MPs (subsamples from sediments with MPs were separated into sediments and MPs).
- Samples were analyzed for bacterial cell abundance (Flowcytometry), potential enzyme activity (enzyme assays with 8 different substrates) and community composition (16S rRNA sequencing).

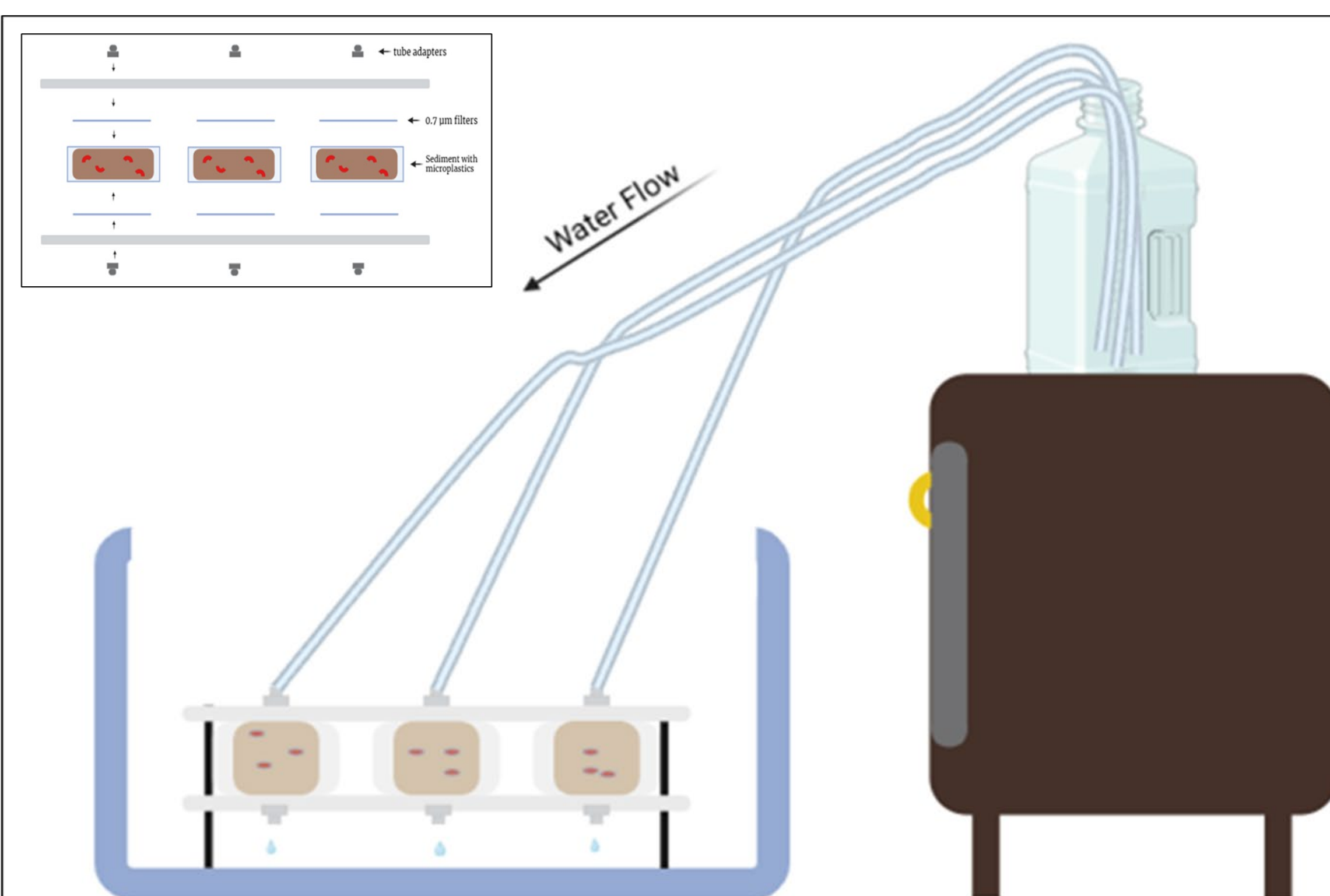
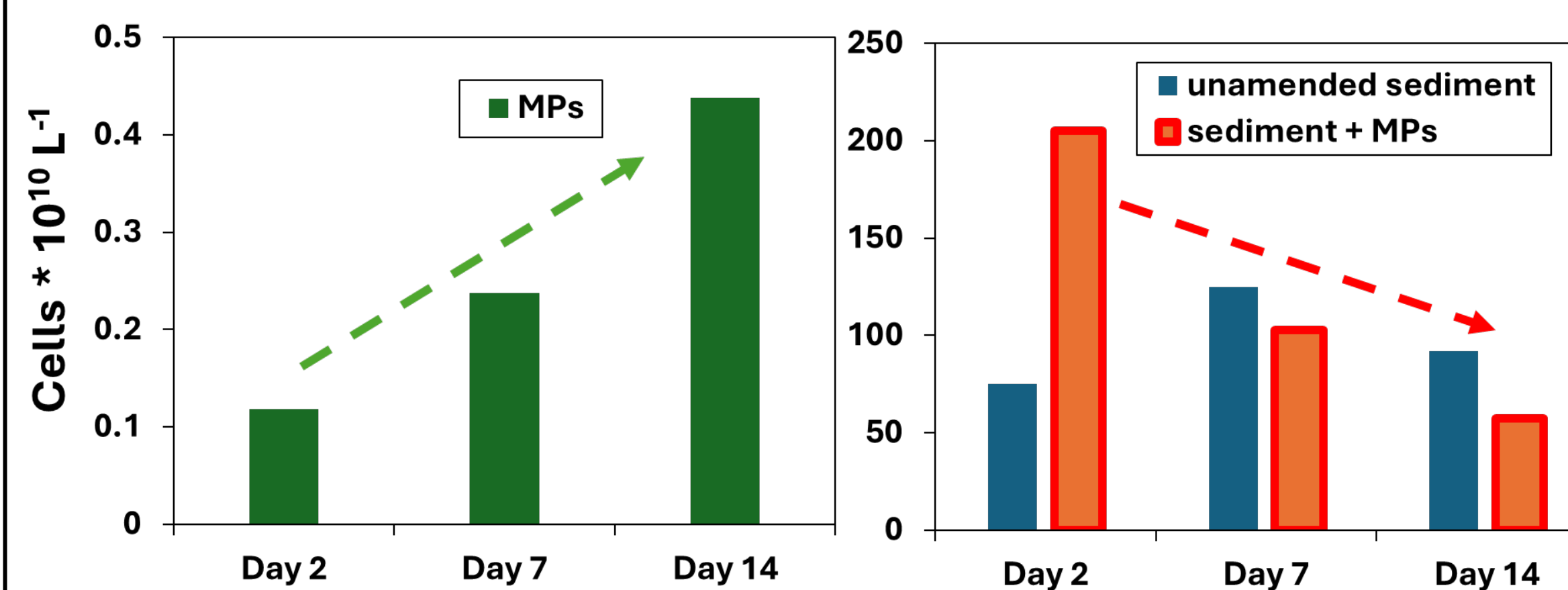


Fig. 2: Schematic of the flowthrough system; filtered artificial seawater (Sea salts, Millipore Sigma) was pumped through replicate reactor blocks (insert) containing sediments with and without MPs.

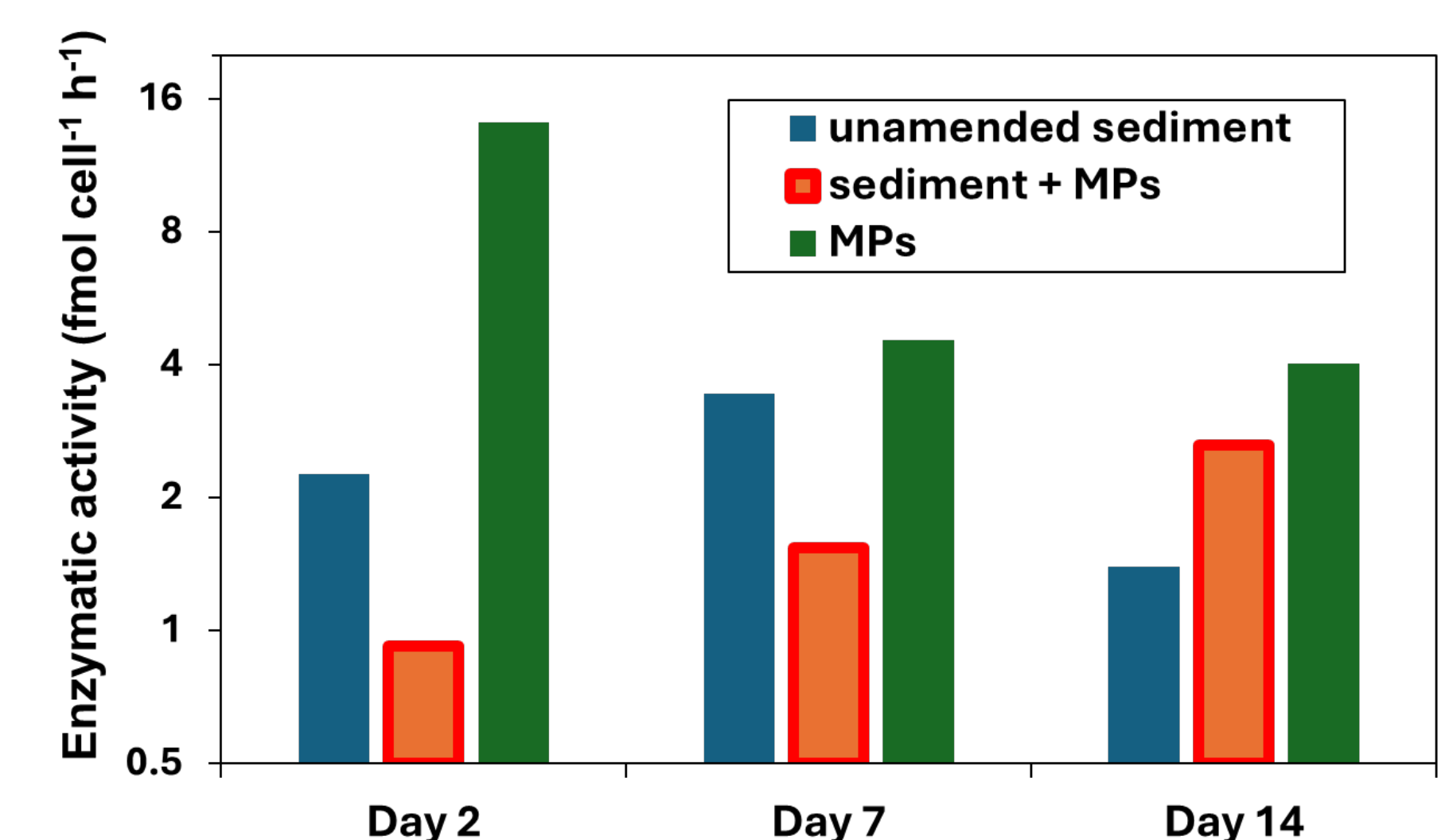
## Results

### MPs are rapidly colonized in sediments



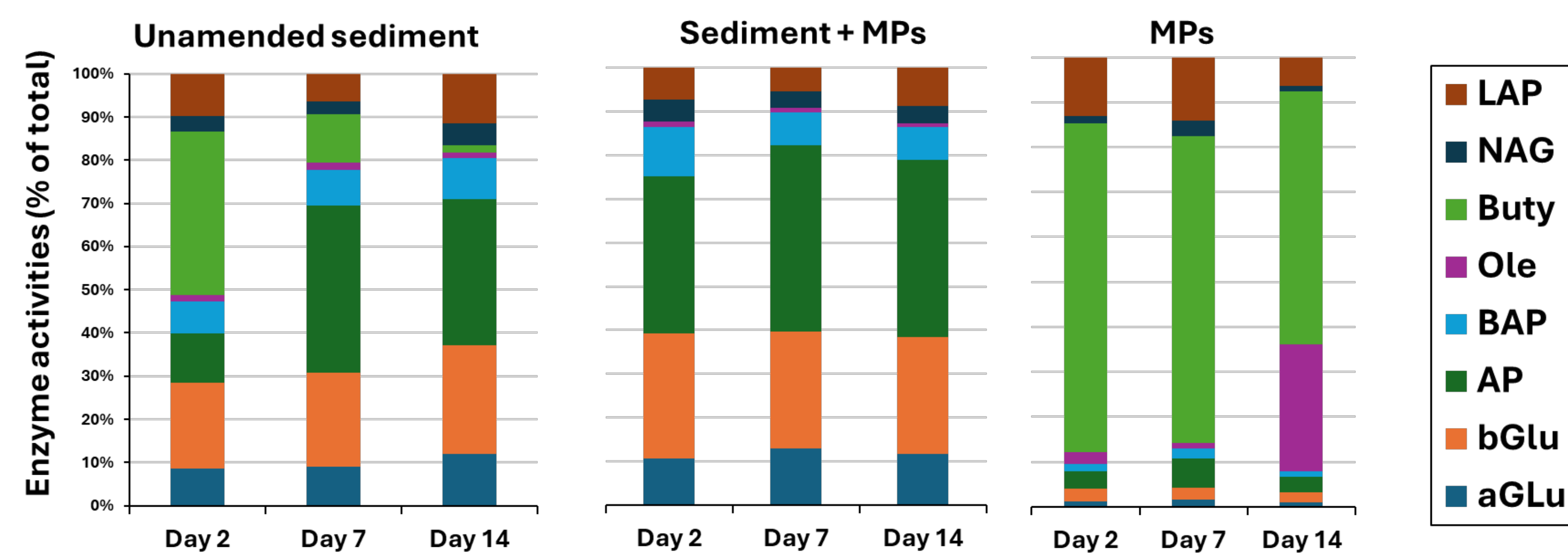
- Average cell abundance on isolated MPs increase over time, indicating colonization of MPs from surrounding sediments
- Cell growth may also contribute to increasing cell numbers on MPs.

### Potential enzyme activities (sum of 8 enzymes)



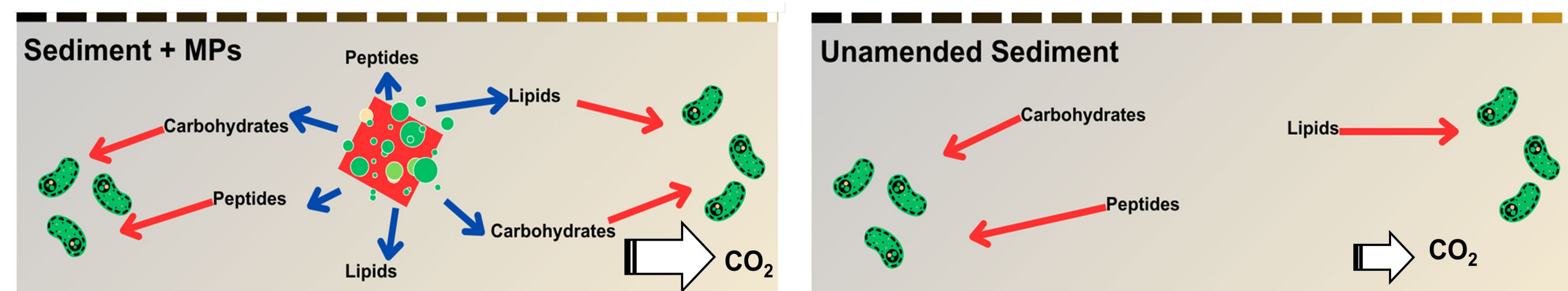
- Highest rates on isolated MPs, decreased over time: → potential shift in community composition (tbd).
- Increased activity in sediment + MPs: → potential stimulation of microbes not attached with MPs

### Distinct enzyme patterns on MPs



- LAP: peptidases; NAG: chitinases; Buty: esterases (butyrate: C<sub>3</sub>H<sub>7</sub>COOH); Ole: esterases (oleate: C<sub>18</sub>H<sub>34</sub>O<sub>2</sub>); BAP & AP: phosphatases; bGlu & aGlu: glucosidases;
- Ole dominate activities on MPs: → potential hydrocarbon breakdown.

## Conclusions



- Microbes colonize MPs in sediments → enzymatic breakdown of plastic components;
- Microbes attached to MPs produce exopolymeric substances (EPS: carbohydrates, peptides, lipids) to form biofilms and as plastic degradation byproducts;
- EPS serves as substrates for microbes not directly involved with plastic degradation ('secondary degraders'), enhancing elemental cycles and carbon respiration in sediment + MPs relative to unamended sediments.

**Next steps:** Analyze microbial community composition in sediments and MPs → What fraction of the community is colonizing MPs (specialists vs. generalists)? What is their role in biogeochemical cycles?

## What happens at the surface water?

Attend the **oral presentation**: *Marine Plastisphere Structure and Function: Insights from a flowthrough experiment on Microplastics in the Water Column* by Astrid Zapata-De Jesus on 30/03/2025 at 5:30PM, Room W205CD

## Acknowledgments and References

- NSF Research Experiences for Undergraduates (REU) at the University of New Hampshire *Sensors in Earth, Oceans, and Space Science: How We Observe Our Planet* (#2244092); **ASLO Multicultural Program 2025**
- References: Kaiser et al. (2017), *Environmental Research Letters*, 12(12), 124003; Ladewig et al. (2024), *Scientific reports*, 14(1), 17963. <https://doi.org/10.1038/s41598-024-68766-0>; Hoppe (1983), *Marine Ecology Progress Series*, 11, 299-308; Ziervogel et al. (2024) *Marine Chemistry* 262, 104395