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Microplastic–Microalgae Interactions: Effects on Nutrient Uptake and Growth of *Chlorella vulgaris*

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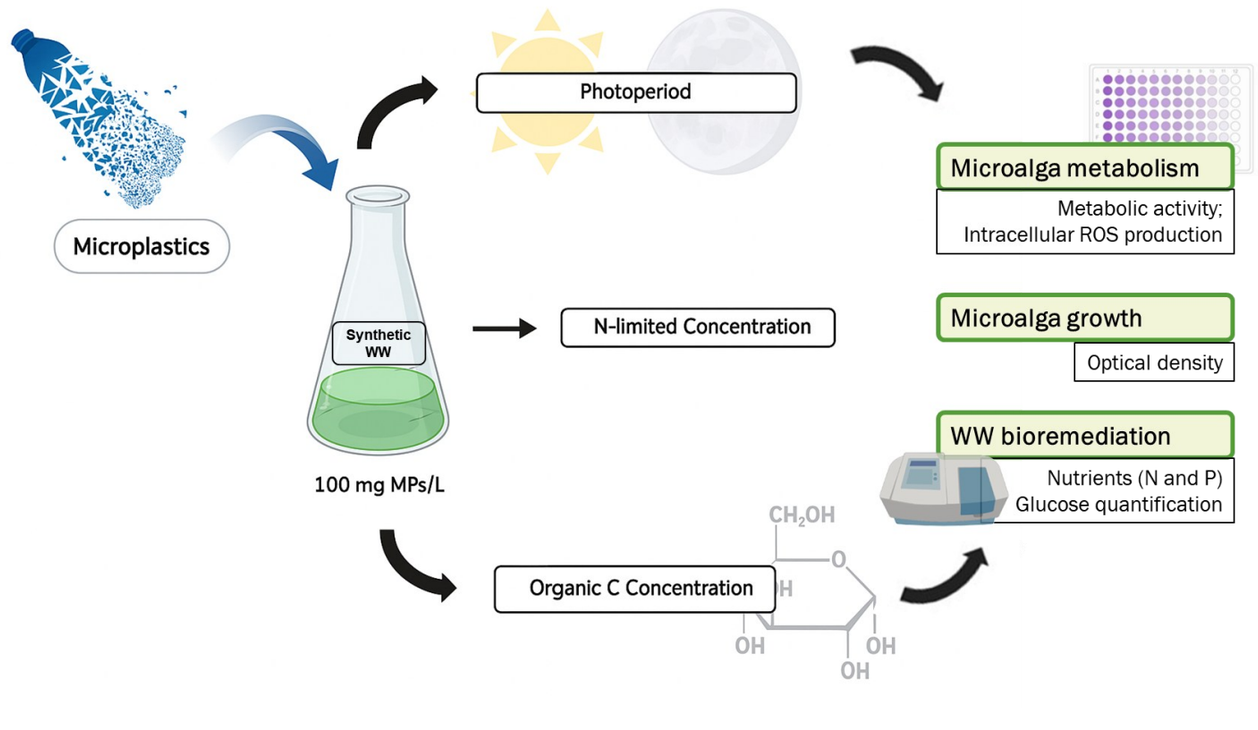
INTRODUCTION & AIM

Microplastics (MPs) are pervasive contaminants in wastewater (WW), where conventional treatments fail to effectively remove them, contributing to environmental pollution and aquatic ecosystems risks[1]. As a solution, microalgae-based systems offer a sustainable and multifunctional alternative with efficient nutrient removal and valuable biomass production, for a high biotechnological interest[1]. However, their performance in MP-contaminated environments remains poorly understood, especially in WW systems.

Evaluate the **physiological responses and bioremediation efficiency** of *C. vulgaris* exposed to five common MPs, namely **polypropylene (PP), polystyrene (PS), polyamide (PA), low-density polyethylene (LDPE), and high-density polyethylene (HDPE)**, under different synthetic WW conditions: nitrogen and organic carbon availability and photoperiod regimes (12/12 h light/dark *versus* continuous light - 24 h light).

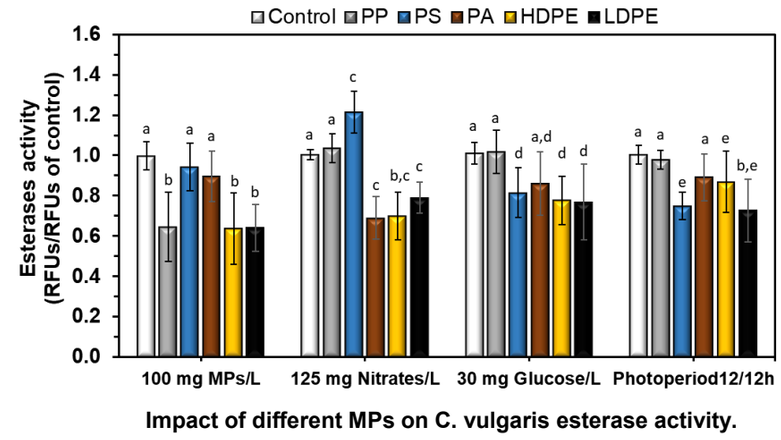
METHODS



RESULTS & DISCUSSION

SWW conditions **strongly modulated** the MPs impact

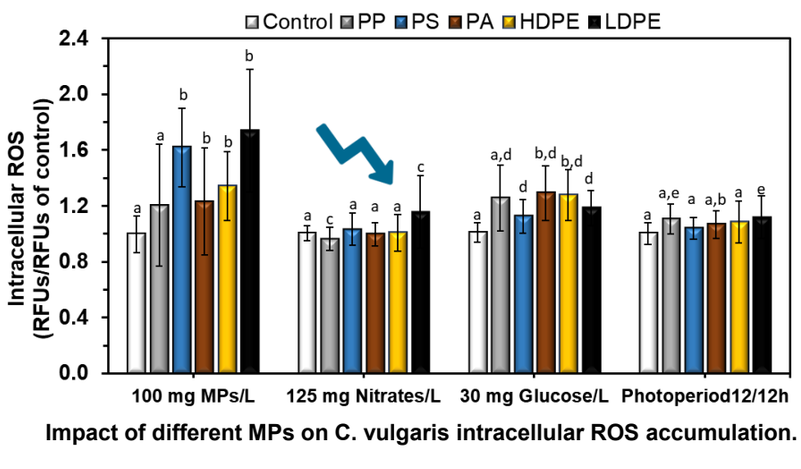
showing high variability in metabolic response.



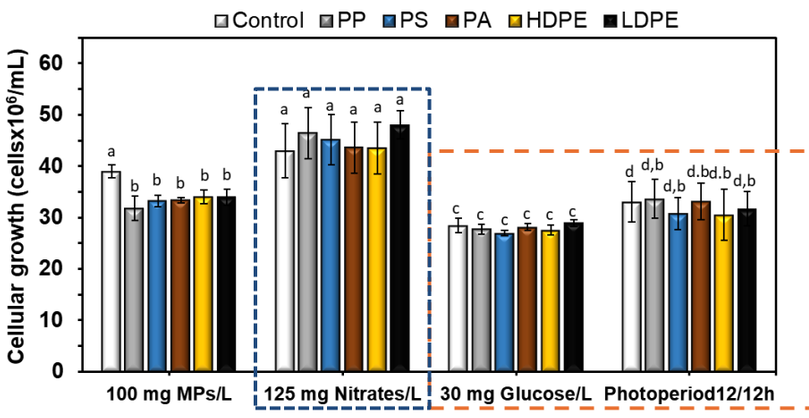
Impact of different MPs on C. vulgaris esterase activity.

Changing SWW conditions

decreased intracellular ROS levels compared to 100 mg MPs/L



Impact of different MPs on C. vulgaris intracellular ROS accumulation.



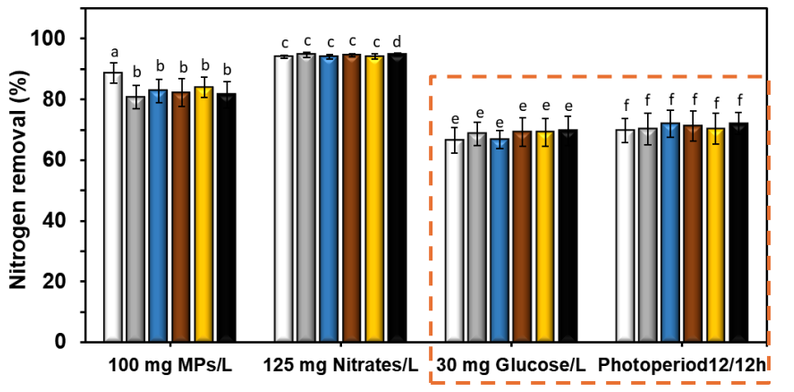
Microalga growth after 168 h under different experimental conditions, in the presence of 100 mg MPs/L.

N-limitation → **promoted** a **higher** growth and biomass production.

Carbon limitation → inhibited *C. vulgaris* growth by **27 %**.

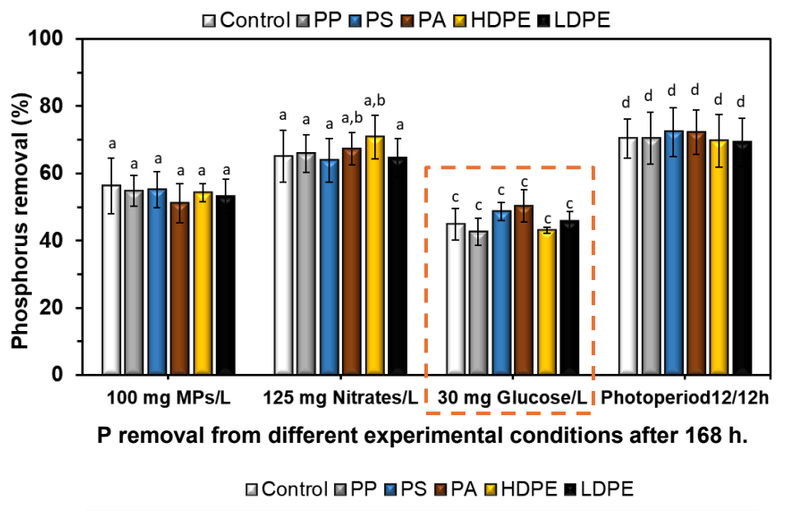
N-limitation → a N removal up to **94 %**

Inhibited N removal up to **25 %**



N removal from different experimental conditions after 168 h.

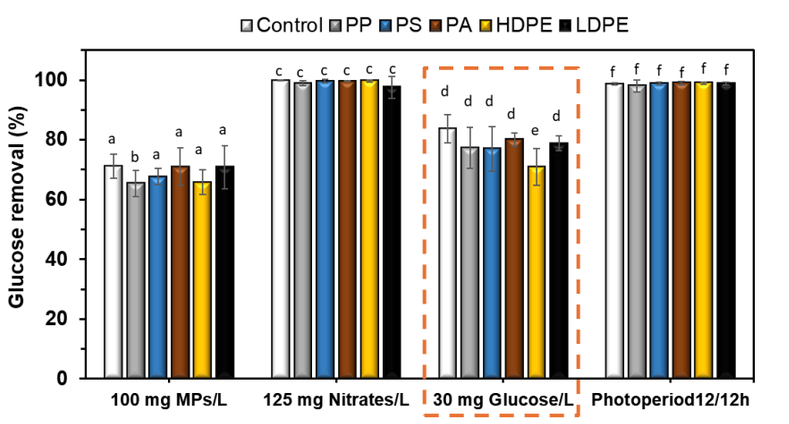
N-limitation and 12h/12h photoperiod → P and glucose removal efficiency **remained high** across all MPs



P removal from different experimental conditions after 168 h.

→ P removal was inhibited by **~20 %**.

→ **Strong negative impact** on metabolism, growth, and bioremediation.



Glucose removal from different experimental conditions after 168 h.

Glucose availability was critical for sustaining **antioxidant defenses and repair mechanisms under MP stress**.

CONCLUSIONs

- ✓ MPs are strongly influenced by WW composition and environmental conditions, with a wide heterogeneity of response by microalgal cells.
- ✓ C-limitation is the most critical stress condition, compromising the microalga performance.
- ✓ N-limited environment promotes microalgal adaptive response.
- ✓ *C. vulgaris* resists MP stress, reinforcing its potential for efficient and eco-friendly WW treatment systems.

REFERENCES

[1] Sousa, P.M.S. et al., Microalgae for microplastic removal from water and wastewater: a review. Environmental Chemistry Letters, 2025, 23, 611–648.