Development of an *in situ* method for the removal of microplastics from the aquatic environment

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INTRODUCTION

Microplastics (plastic particles from 1 to 1000 μm) are currently one of the most widespread pollutants in the aquatic environment and can have serious direct and indirect effects on biota and the entire ecosystem (Garcés-Ordóñez et al., 2022). So far, the focus has mainly been on developing methods to prevent microplastics from entering the environment, and most of the methods researched have been for the removal of microplastics from wastewater. However, many microplastics enter the aquatic environment through many other non-point sources (e.g. runoff, wind deposition from construction sites and urban traffic, or environmental degradation of larger plastic pieces (Yang et al., 2023)), so methods that could be used for direct *in situ* removal of microplastics from the environment are urgently needed. Several studies have already confirmed the adhesion potential of aquatic macrophytes towards microplastics (reviewed in Kalčíková et al. (2023)), so **phytoremediation** could be one of the possible methods, which is also simple, cost-effective, and environmentally friendly.

Microplastics
Low-density polyethylene (LD-PE)
149 ± 75 μm

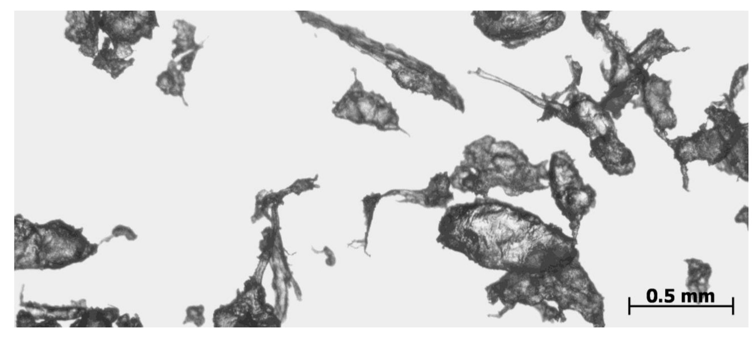


Figure 1: LD-PE microplastics under the optical microscope.

METHODS

Aim: to invrstigate the adhesion mechanisms between LD-PE microplastics (Figure 1) and floating macrophyte *Lemna minor* in order to develop a possible phytoremdiation method for the *in situ* removal of microplastics from aquatic ecosystems.

- Determination of the number of adhered microplastics over time (after 24 h, 72 h, 120 h, and 168 h) under static conditions and with slow water movement.
- Determination of the number of adhered microplastics by different amount of biomass.
- Fitting experimental data with the adsorption isotherm models.
- Performing phytoremediation experiment under the controlled laboratory conditions (Figure 2).

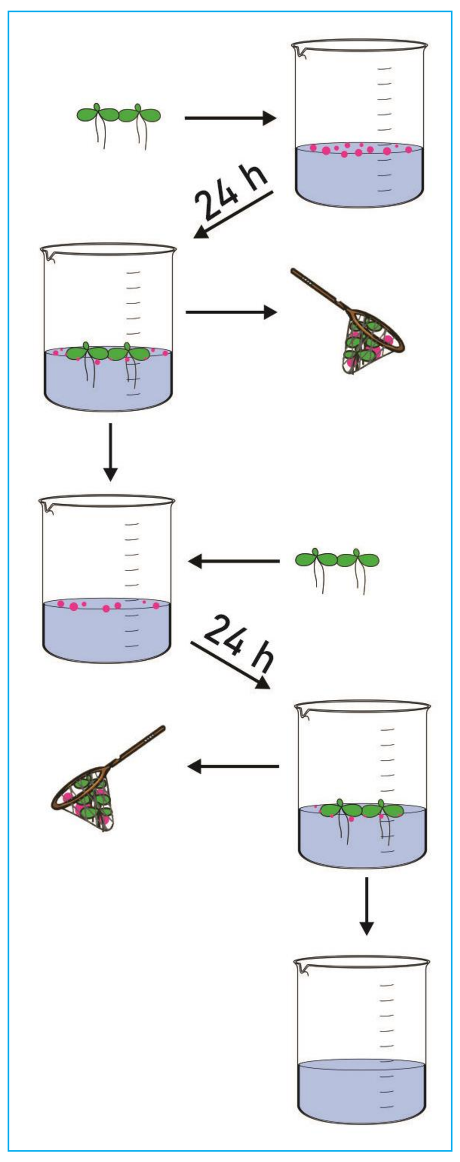


Figure 2:Procedure for the phytoremediation experiment.

RESULTS

The number of adhered microplastics over time

Table 1: The number of adhered microplastics per plant biomass after 24 h, 72 h, 120 h, and 168 h under the static regime and with water movement.

	Time (h)	Number of adhered microplastics per plant mass (particles/mg)	
		Static regime	With water movement
MAX.	24	2.8 ± 1.1	3.7 ± 1.7
	72	1.2 ± 0.3	2.2 ± 2.2
	120	1.1 ± 0.7	1.7 ± 0.5
	168	0.8 ± 0.2	0.8 ± 0.5

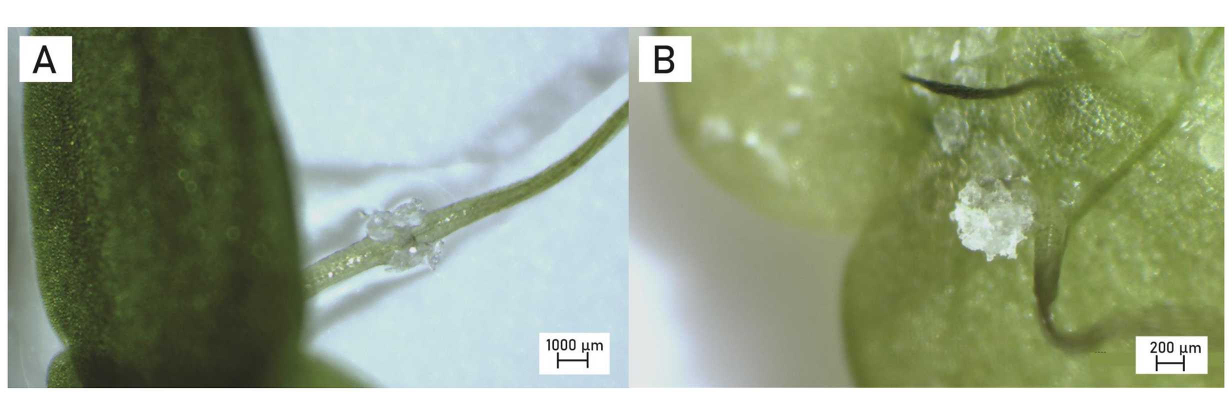


Figure 3: LD-PE microplastics adhered to the root (A) and frond (B) of *Lemna minor.*

DISCUSSION

The number of adhered microplastics by different amount of biomass

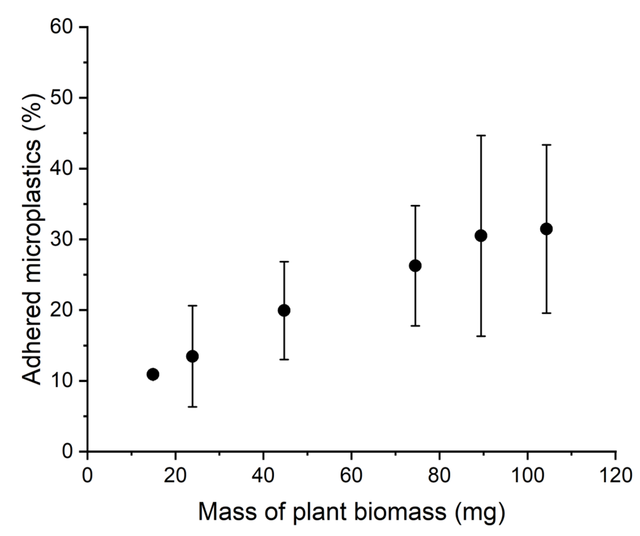


Figure 4: The precentage of adhered microplastics by mass of plant.

Adsorption isotherm models

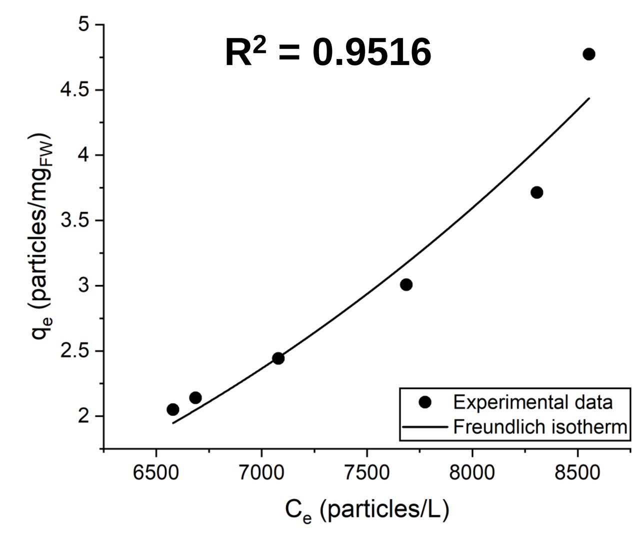
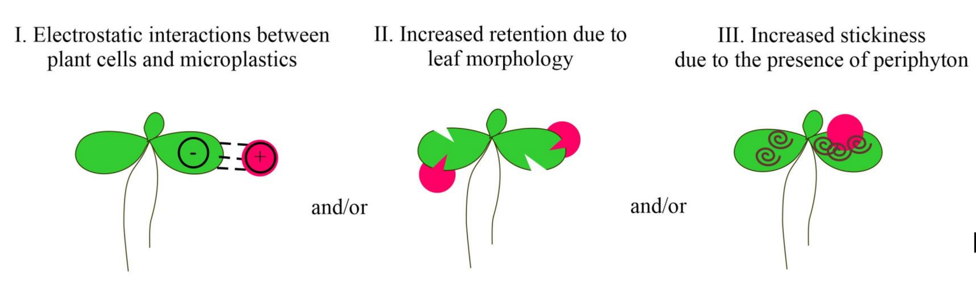


Figure 5: Fitting experimental data to the Freundlich adsorption isotherm model.

Mechanisms of interaction



Kalčíková, 2020

Figure 6: Possible mechanisms of interaction between microplastics and aquatic plants.

Phytoremediation experiment

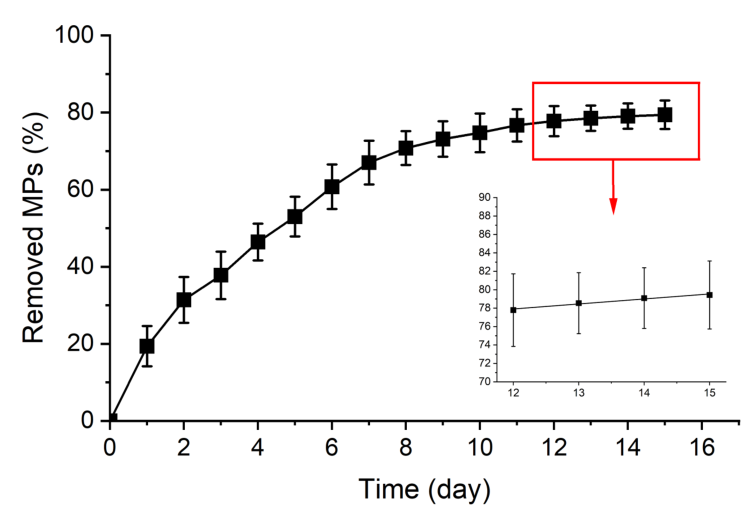


Figure 7: Removal of microplastics with time during the phytoremediation experiment.

Removal rate = 1 particle/(mg·day)

100% removal → 53 days

CONCLUSIONS

The results of this study show that **microplastics adhere quickly to aquatic macrophytes.** This is a promising result, and aquatic plants could be used for the actual **removal of microplastics** and could also serve as **bioindicators** for the detection of areas contaminated with microplastics (Rozman and Kalčíková, 2022). Nevertheless, research into the interactions between microplastics and aquatic plants is still at a very early stage. Therefore, these mechanisms need to be further investigated in real environments, as the interactions could be influenced by many environmental factors that cannot be taken into account in laboratory studies (e.g., strong weathering events, other pollutants, feeding on a contaminated biomass). In addition, for the successful development of a phytoremediation method, limitations regarding the invasiveness of the plants and the correct disposal of the contaminated plant biomass should be carefully considered.

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