

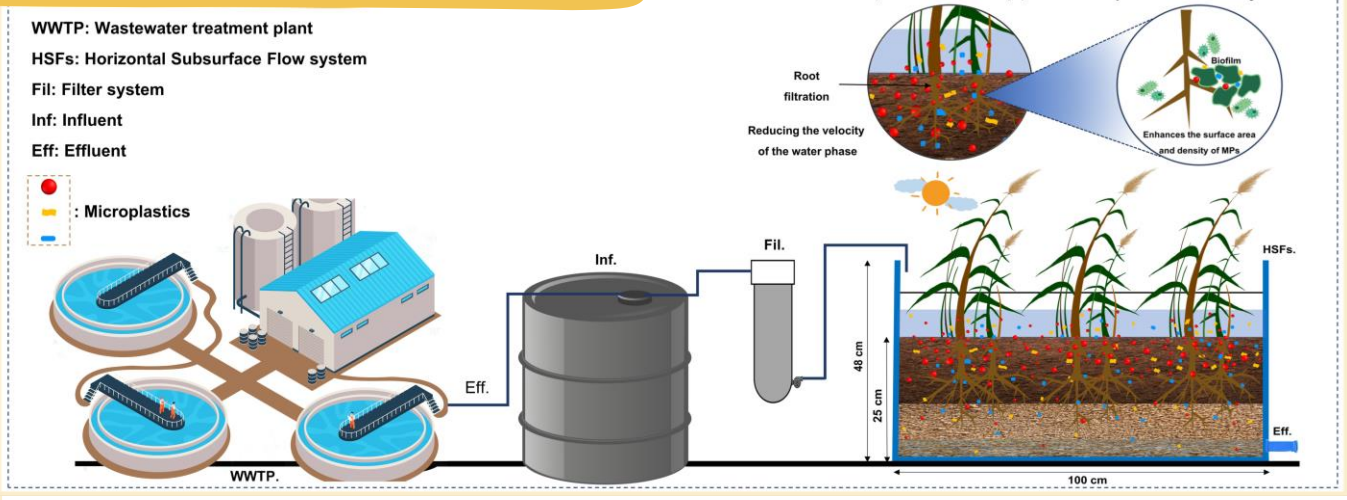
Performance of bioretention systems by umbrella plant (*Cyperus alternifolius* L.) and common reed (*Phragmites australis*) for removal of microplastics

Piyarat Vijuksungsih, Tunlawit Satapanajaru, Kanitchanok Muangkaew, Rattana Boonprasert

Central Laboratory and Greenhouse Complex, Research and Academic Service Center, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University

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Graphical Summaries



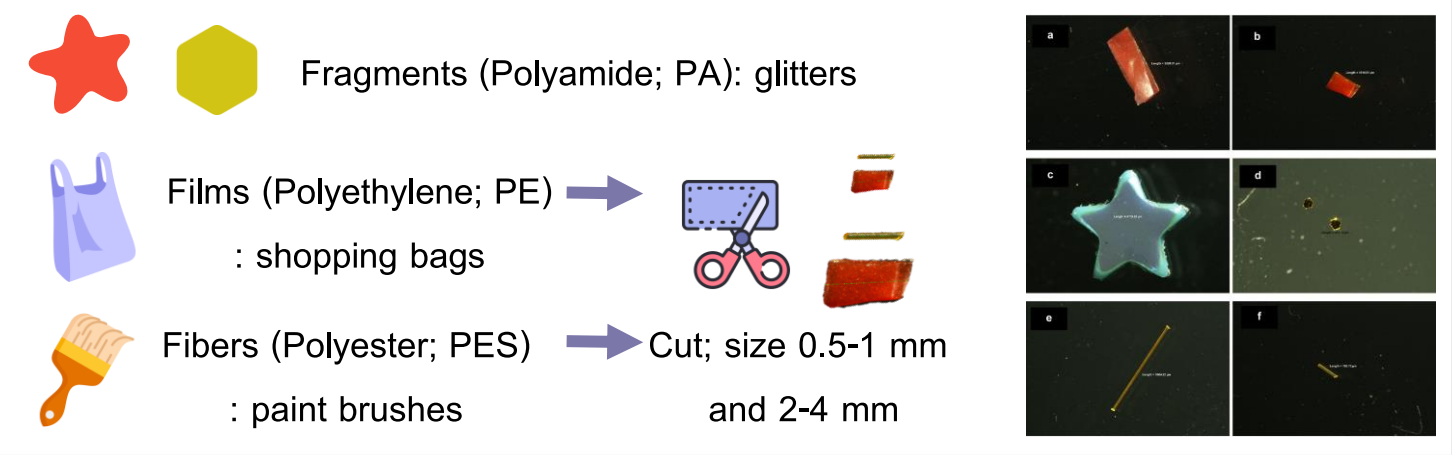
the MP retention process to a greater extent through physical filtration, substrate ratio, plant roots, and biofilms on the roots. The results showed that the common reed at a 3:2:9 ratio (gravel: sand: soil) had the highest relative height growth rate (RHGR) ($1.8 \text{ mm cm}^{-1} \text{ week}^{-1}$) and reduced the number of MPs, with an average removal efficiency of 95.45% for sizes $>1000 \mu\text{m}$, 89.21% for sizes $500\text{--}1000 \mu\text{m}$, and 44.16% for sizes $<500 \mu\text{m}$. Our results suggest that plant bioretention is an effective treatment for removing MPs from wastewater.

Experimental design

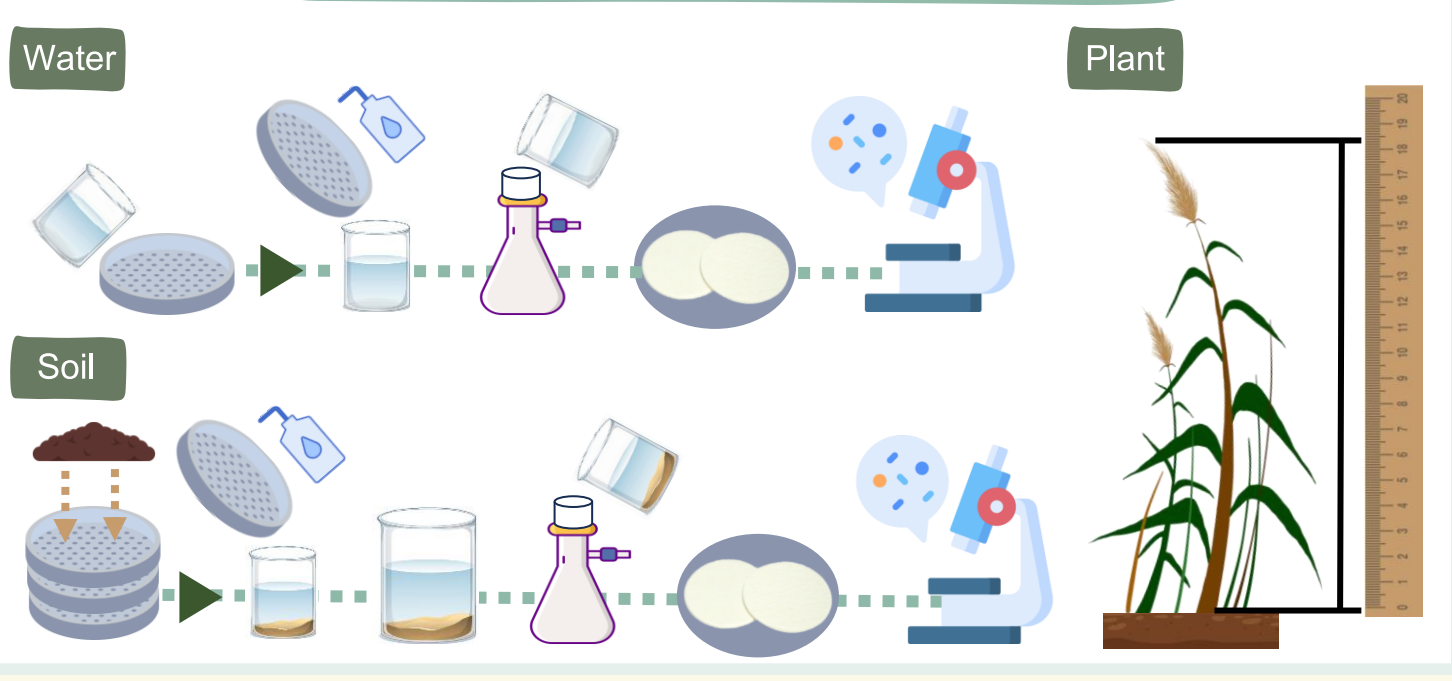


The Horizontal Subsurface Flow system (HSFs) microcosms were constructed using polypropylene ($50 \times 100 \times 48 \text{ cm}$). All microcosms were filled with filter substrates (gravel: sand: soil) at ratios of 1:3:9, 2:3:8, and 3:2:9 (bottom-up).

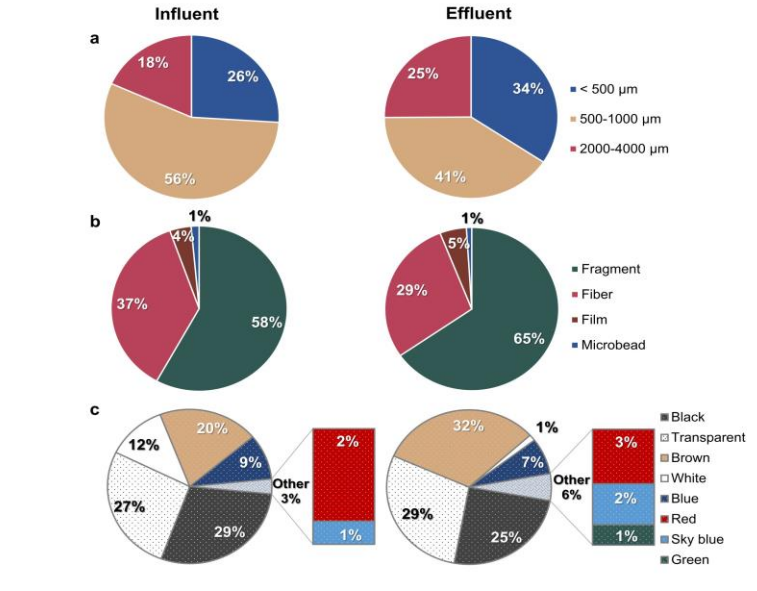
Preparation of MPs



Sample collection and analysis



Results



Our results show that MP size, shape, and color distribution within the Dindaeng Water Environment Control Plant, which is not designed for microplastic removal (with a removal efficiency of 37.01%), are factors that release MPs into the environment. The MPs release rate of the treatment plant into the natural environment was 105×10^3 pcs/capita/day.

Fig. 1. MPs characteristics in wastewater from the Dindaeng WWTP.

Domestic wastewater is one of the main sources of microplastic (MP) contamination in aquatic environments; however, most wastewater treatment plants (WWTPs) have not been designed to remove MPs. In this study, the release rate of MPs in the treated water from a WWTP into the river was estimated to be approximately 105×10^3 pcs/capita/day. The of this study was to evaluate the performance of bioretention systems using the umbrella plant (*Cyperus alternifolius* L.) and common reed (*Phragmites australis*) for MP removal. After 17 weeks, the common reed root system and substrate influence

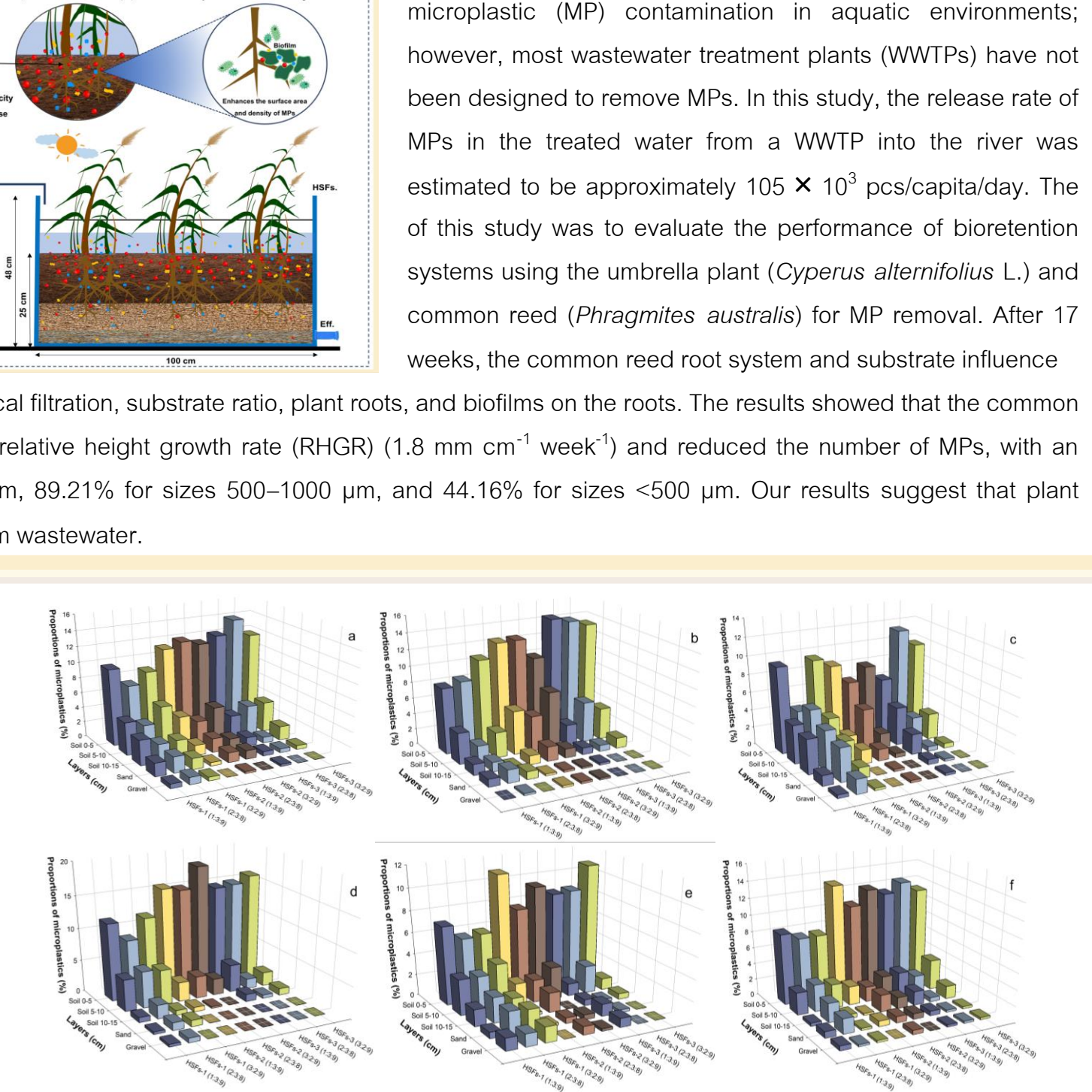


Fig. 2. Horizontal distribution of MPs in the substrate at the end of the experiment.

The horizontal distribution of MPs in bioretention systems (Fig. 2) can ensure efficient removal. No MPs were detected in the effluent, which were mainly retained in the 0–10 cm segments after running for 17 weeks.

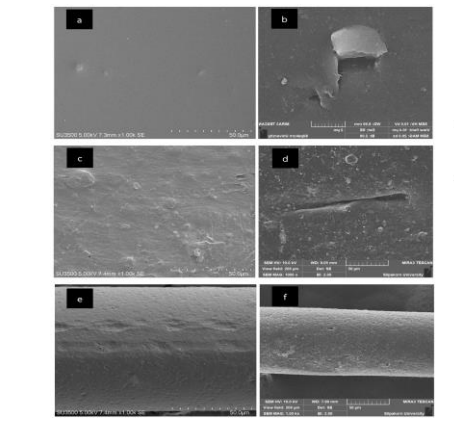


Fig. 3. SEM images of surface on MPs.

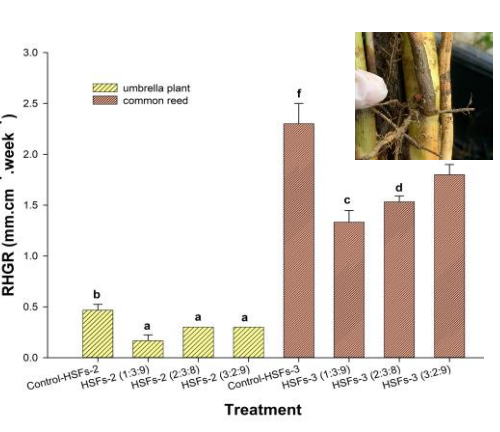


Fig. 4. Relative height growth rate (RHGR).

Before the experiment, surface structure of the film (a), fragments (c), and fibers (e) reveal smooth and flat. The end of the experiment, cracks and tears are observed on the fragments (d), cracks and holes on the fibers (f).

The combined action of the common reed root system and the substrate influences the MP retention process to a great extent through physical filtration, substrate ratio, plant roots, and biofilms on the root. While the accumulation of MPs on roots or root hairs will inevitably affect plants, in the HSFs-3 at a ratio of 3:2:9, Fig. 4 the highest efficiency for retention of MPs and the highest RHGR were observed.

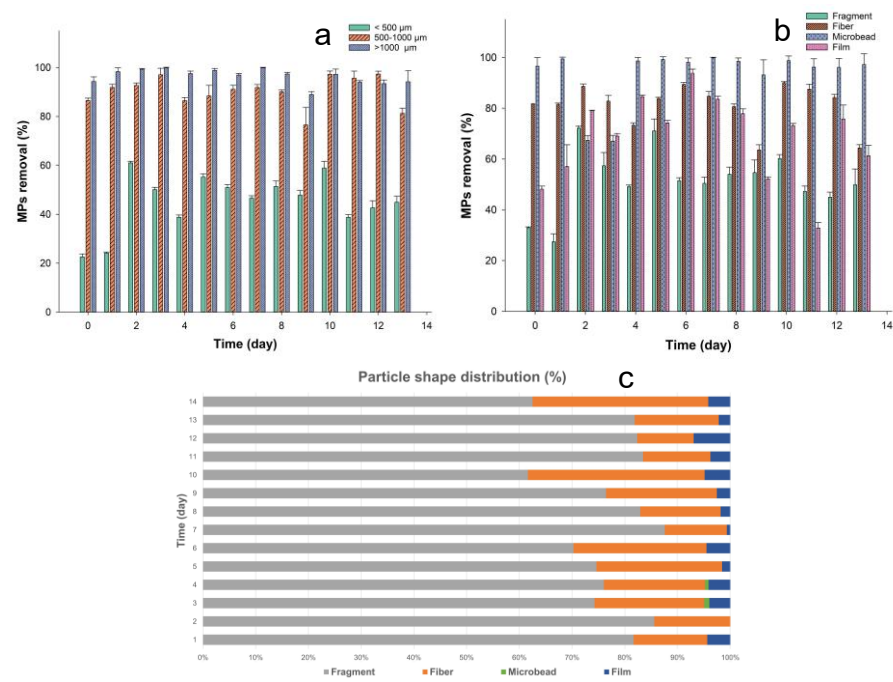


Fig. 5. MPs removal efficiency of WWTPs by HSFs-3 (ratio 3:2:9) treatment: size (a); shape (b) and distribution of particle shaps (c).

The HSFs-3 was applied to real wastewater at a 3:2:9 ratio (Fig. 5), with an average efficiency of 62.89% and 95.45% for sizes $>1000 \mu\text{m}$, 89.21% for sizes $500\text{--}1000 \mu\text{m}$, and 44.16% for sizes $<500 \mu\text{m}$. The highest average microbead removal efficiency was 95.24%. Our results suggest that HSFs could be an effective treatment for removing MPs from wastewater and a good barrier for MPs from entering the environment.