Bioremediation of Nanoplastics Using Mycelium Paddy Biopods and Plants

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Abstract

With plastic production and pollution surging, increasing concentrations of nanoplastics have accumulated in the environment. This concentration of nanoplastics poses a danger to both agricultural processes and human life. Therefore, investigating nanoplastics and their impacts on plants and the potential of bioremediation techniques remains paramount. More specifically, this investigation explores the efficacy of mycelium paddy 'Biopods' in bioremediation. By comparing two different plants (monocot: *O. sativa*; eudicot: *N. benthamiana*), the effectiveness of fungi and plant tissue in the absorption of two hydroponically-delivered polystyrene nanoplastics (20 nm Nile red, 30 nm yellow-green fluorophore) were evaluated over the course of 7 days. Our overall results demonstrated a higher fluorescence intensity for the nile red nanoplastic treatment in mycelium, wood, and root tissue for both plants, relative to control. Whereas, *O. sativa* did not yield significant higher fluorescence for any tissue type with the yellow-green nanoplastic. Future work will include confocal imaging to increase detection sensitivity of fluorescent nanoplastics in both Biopod and plant tissue.

Background

Environmental stressors as well as increased industrial productivity have led to developments in plastic pollution, as well as an increased concentration of nanoplastics in the environment, threatening organic life, especially agriculturally relevant plants[2,3]. Use of fungi in bioremediation of water has demonstrated exceptional promise[1]. Our project investigated the use of mycelium column Biopods housing two different plants in bioremediation. By drawing from existing work, our mycelium paddies parallel Biopods, which have already demonstrated the effectiveness of paired fungal and plant bioremediation in natural environments.

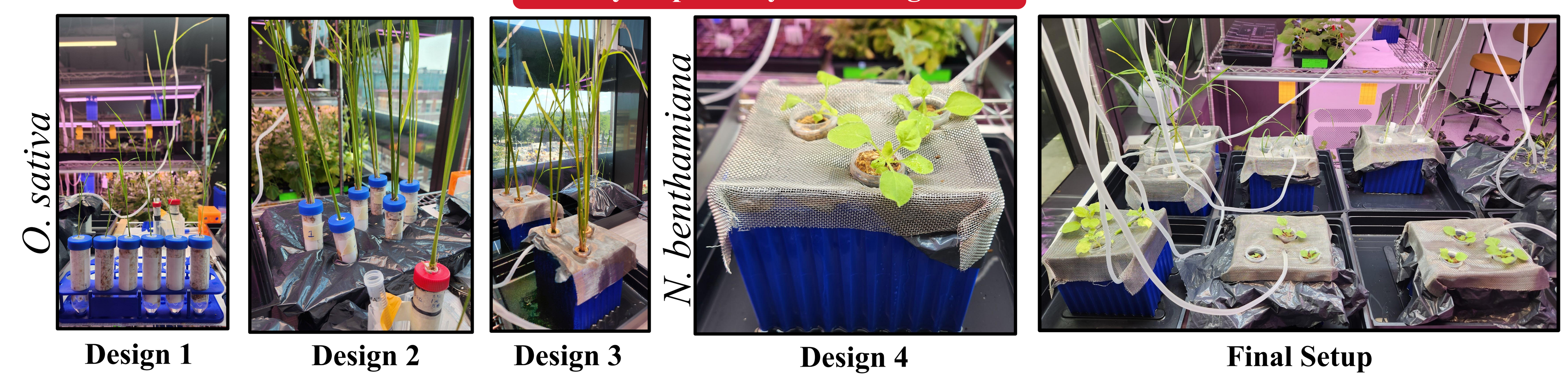
Hypotheses:

- The mycelium paddies will absorb both nanoplastics from the hydroponic system.
- Both *O. sativa* and *N. benthamiana* will uptake both nanoplastics.

Figure 1. Deployed Biopods in Providence River[1]

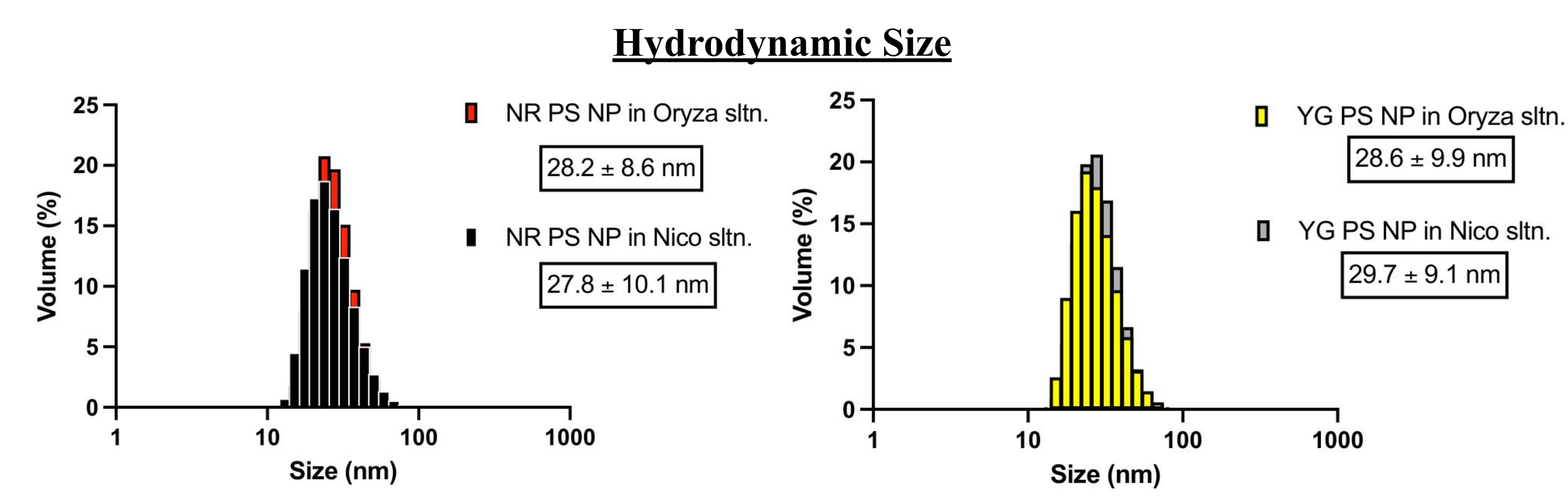
Experimental Methods

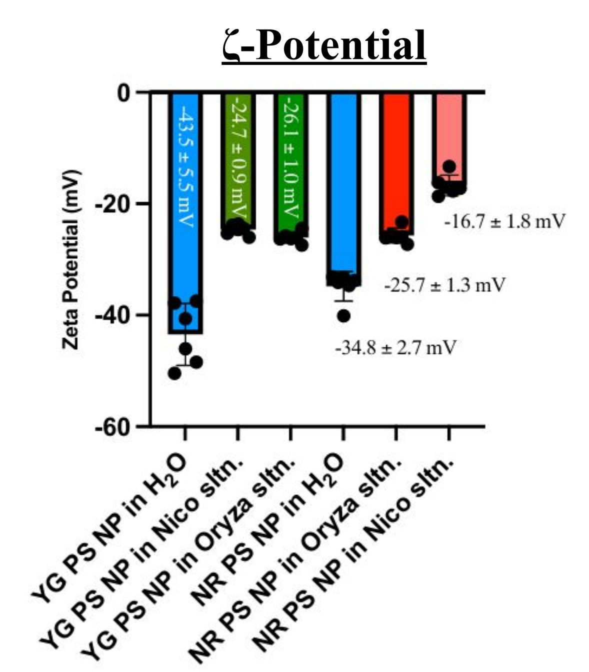
Hydroponic System Designs



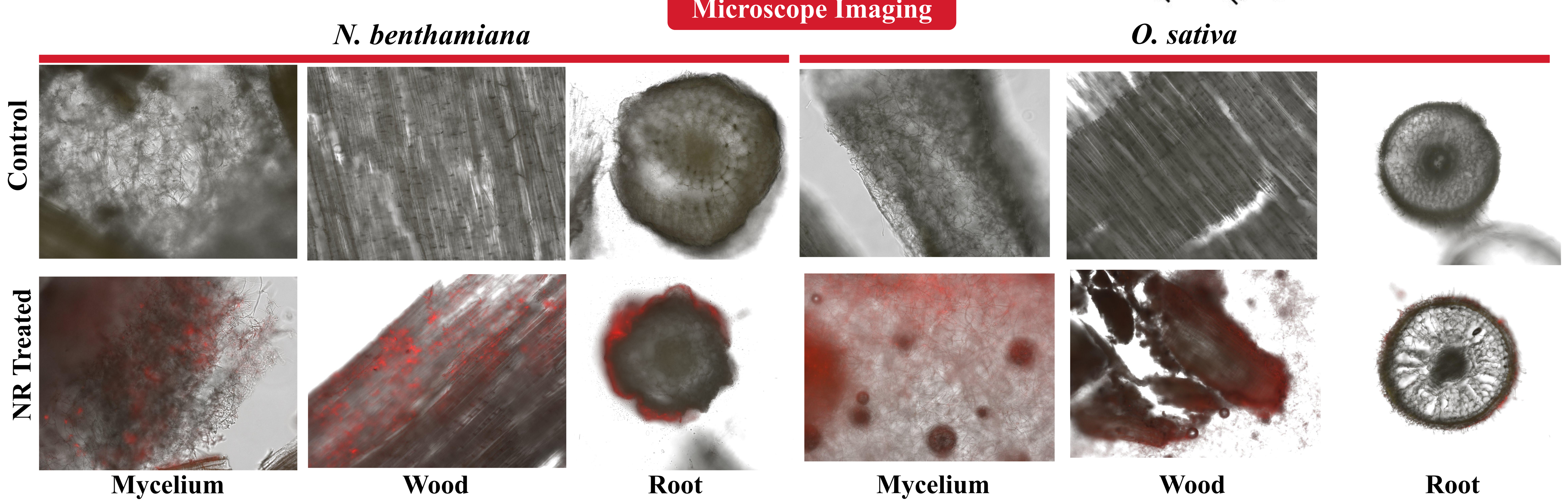
Results

Dynamic Light Scattering Data

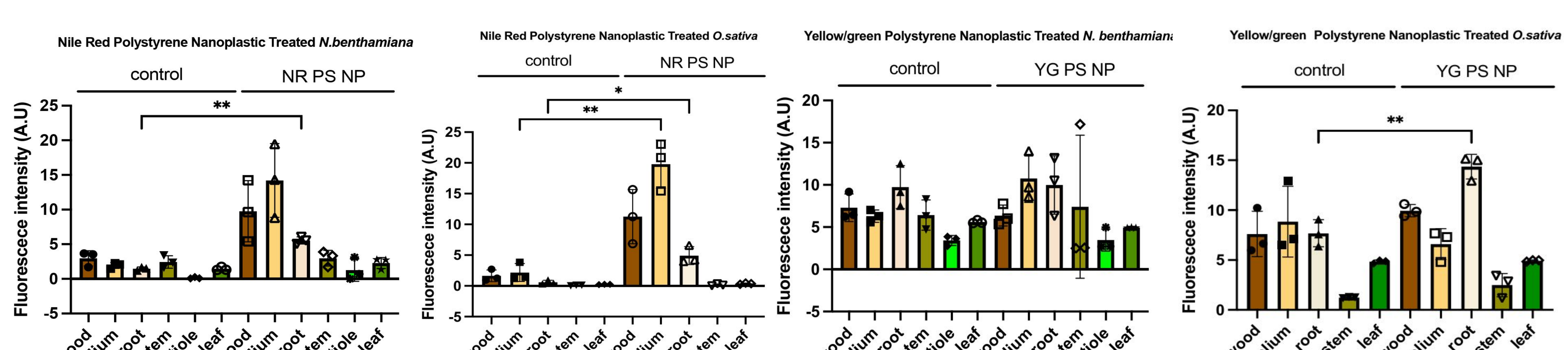




Microscope Imaging



Fluorescence Intensity



Conclusion and Future Steps

Our results reaffirmed the mycelium capability for bioremediation. While the mycelium paddies were unable to completely extract the nanoplastics from the system, it was able to absorb a significant amount, whereas both plants only showed significant absorption on the root tissue. Furthermore, constant modification to the design of the system highlighted the constraints of mycelium use in plant growth due to its dynamic interaction with its imbedded plants, though our collected results conveyed their effectiveness. Connecting back to our initial hypothesis, a difference in nanoplastic absorption between the monocot and eudicot was identified. *O. sativa* experienced significantly greater changes in fluorescence intensity within its root tissue between the experimental and control imaging, whereas *N. benthamiana* experienced changes in fluorescence intensity only with the nile red nanoplastic.

Overall, our objective was accomplished during this experiment. It was observed that the mycelium paddies were effective, highlighting their potential application in larger scale bioremediation.

Future Steps:

- Long-term experiment to observe the extended effect of nanoplastics
- Experimentation with dose-dependent nanoplastic concentrations
- Streamline design of hydroponic system and mycelium-plant integration
- Consider other variables (submersion of Biopods + roots, non-aerated vs. aerated, autoclaving of Biopods)

References

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2. Zhu, R., Wang, Y., Yuan, Y., Zhou, F., Yan, N., Song, Q., Zhong, H., & Dang, F. (2026). Route-Specific Phytotoxicity: Foliar Polystyrene Nanoplastics Inhibit Rice Photosynthesis. *Environmental science & technology*, *60*(5), 3899–3910.
3. Kochanek, A.; et al., Micro- and Nanoplastics in the Environment: Current State of Research, Sources of Origin, Health Risks, and Regulations—A Comprehensive Review. Toxics 2025, 13, 564. https://doi.org/10.3390/toxics13070564

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