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Group therapy: Macrophyte polyculture of *Lemna* species and *Azolla filiculoides* for the optimized remediation of meat processing wastewater

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Small, fast-accumulating, floating, aquatic macrophytes such as Lemnaceae (duckweeds) and *Azolla* have gained attention as an eco-friendly and cost-effective solution to be used for wastewater remediation due to their ability to remove nutrients and their potential for valorisation. Polycultures in agricultural systems have the potential to outperform monocultures through complementary resource use, niche partitioning, and enhanced stability, although their performance can be dependent on species identity, relative abundance, and environmental conditions. This study investigated the phytoremediation potential and growth performance of polyculture combinations of *Lemna minor*, *Lemna minuta*, and *Azolla filiculoides* (*Azolla*), grown on local meat processing wastewater, assessing how species composition and surface covers influenced biomass yield and nutrient removal efficiency. Results indicated that species interactions significantly impacted growth, with *L. minuta* generally facilitating higher *Azolla* growth rates than *L. minor* at laboratory scales. Owing to its greater tolerance of nutrient-rich wastewater, 20% surface cover of *L. minuta* combined with 40% surface cover of *A. filiculoides* emerged as an optimal configuration (community RGR: 0.065 ± 0.065 day⁻¹), achieving high growth performance with $38.13 \pm 0.93\%$ removal of total phosphorus. The transition to upscaled conditions showed less pronounced growth effects, highlighting the challenges of translating controlled laboratory findings to larger-scale applications and the need for further optimisation of system design and operational parameters. These findings demonstrate the potential of macrophyte polycultures for agri-food wastewater treatment, offering a sustainable approach to protecting aquatic ecosystems and creating additional value streams through biomass valorisation.

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Keywords

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References

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