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Dried Duckweed Biomass as a Boron-Binding Soil Amendment Produced through Nutrient Recovery from Agricultural Drainage Water

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Agricultural drainage waters contain recoverable plant nutrients but may contribute to eutrophication when discharged untreated. This study evaluated *Lemna minor* for nutrient recovery from agricultural drainage water and, more importantly, investigated the unexplored potential of its dried biomass to bind boron (B) in soil and mitigate B toxicity in a crop plant. Duckweed was cultivated in drainage water from a soilless tomato greenhouse and a vertical farm, with nutrient solution as a reference. Nutrient removal and mineral accumulation were determined. The resulting dried biomass was assessed (i) in water, (ii) during a 90-day soil incubation, and (iii) in a cucumber seedling experiment under increasing B supply.

Lemna minor grew successfully in both drainage waters and substantially depleted nitrate and phosphorus while accumulating macro- and micronutrients, including B. Incorporation of dried duckweed into soil at 0.5% (w/w) markedly reduced hot-water-extractable B, and this effect persisted throughout incubation. At soil-relevant pH, the biomass released B into B-free water but bound more than half of the B in B-enriched water, indicating bidirectional buffering capacity. Duckweed amendment increased cucumber shoot biomass across all B levels and prevented visible B-toxicity symptoms at the highest B treatment.

Although the high B-accumulation capacity of living *Lemna* and the involvement of cell-wall apiogalacturonan are known, this is, to our knowledge, the first demonstration that mineral-rich, dried *Lemna* biomass retains B-binding functionality in soil and can mitigate B toxicity during crop growth. Thus, agricultural wastewater treatment and nutrient recovery generate a multifunctional soil amendment within a circular agricultural system.

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References

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