Application of *Lemna minor* in site remediation strategies

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Introduction

Living organisms can be exposed to heavy metals and radionuclides. Surface waters can be contaminated, this can become an environmental problem and therefore remediation approaches are needed. Phytoremediation is already recognized as an efficient site remediation technology for various types of pollutants. *L. minor* is a small vascular plant that grows easily on surface waters. It is a model plant in laboratories, used in ecotoxicity tests and has a high removal capacity for pollutants. Therefore *L. minor* can be used in phytoremediation applications.

Objectives

Radionuclides and heavy metals

Effects on and uptake by *Lemna minor*

+

Lemna minor growth

Transfer of pollutants

Validation

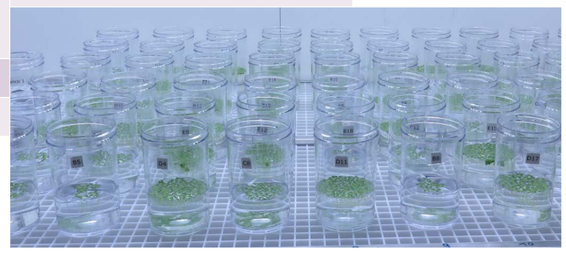
→

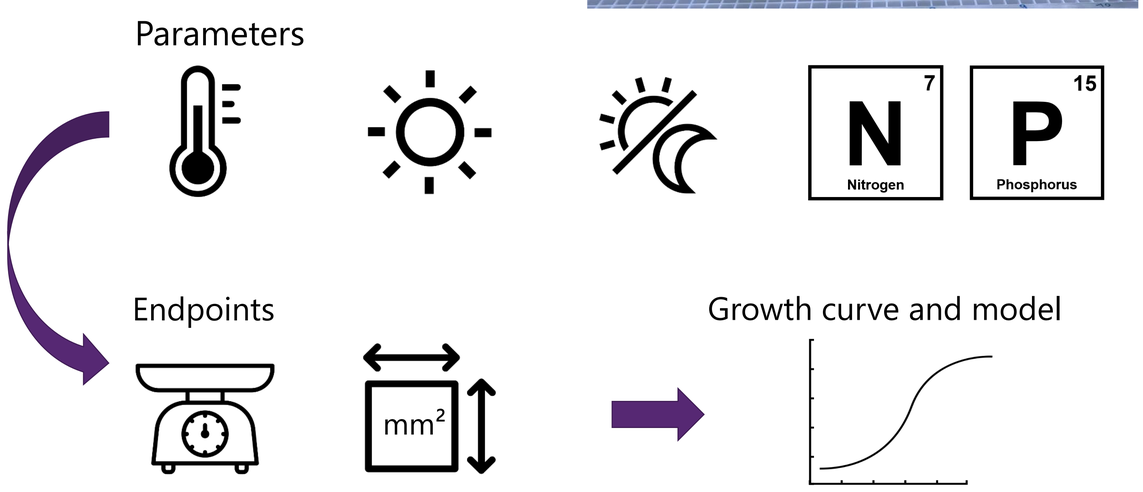
Lemna minor remediation system

Comparison towards other techniques

Experimental setup

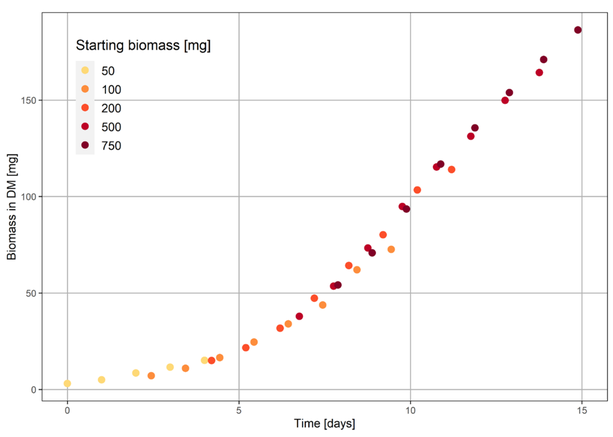
Parameter	Standard conditions	Changing parameters
Temperature	25°C	6° – 10° – 15° – 20° – 25° – 30° – 35°C
Light intensity	220 µmol m^{-2} s^{-1}	63 – 118 – 170 – 220 – 262 µmol m^{-2} s^{-1}
Photoperiod	14h/10h	12h/12h
Growth medium	Modified Hoagland solution N:P ratio: 7.73 • 22.54 mg N/L • 3.10 mg P/L	N:P ratio: 29.57 – 1.18 – 3.36
Starting biomasses	Varying from 50 to 750 mg	
Time	1 week	

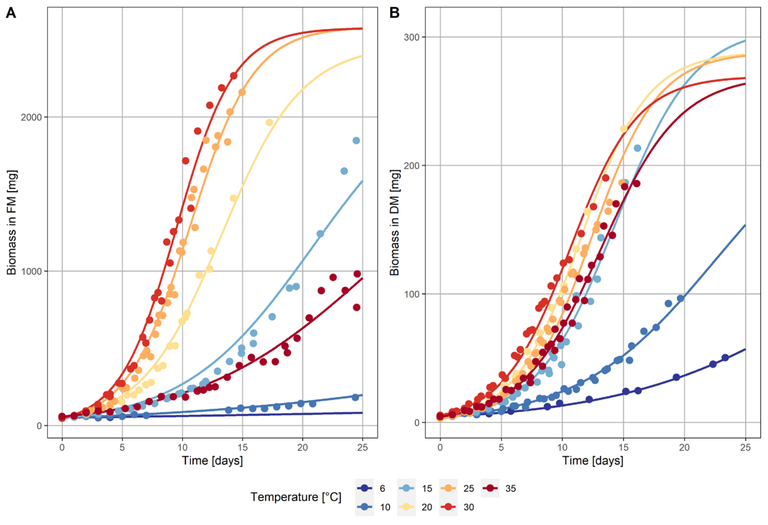


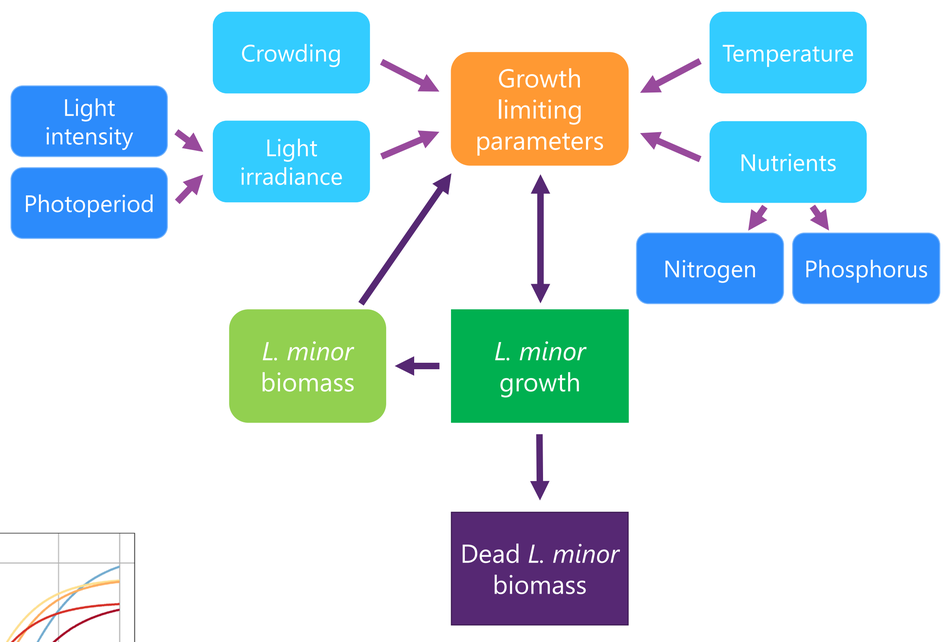


Results

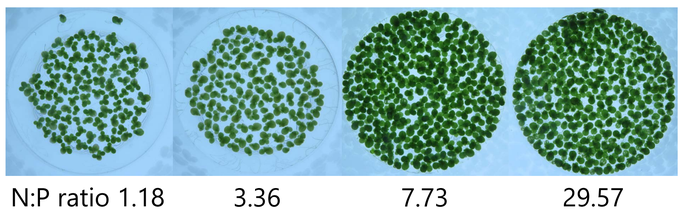
Growth curves







Appearance



Equations

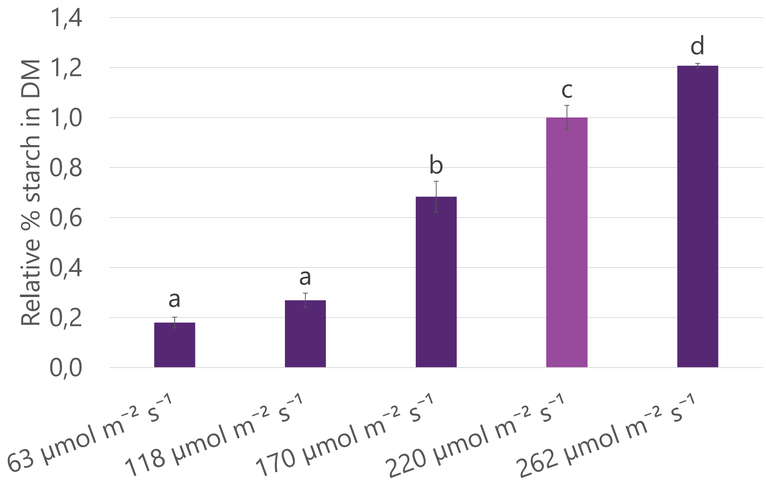
$$\frac{dB}{dt} = B \times r \times f(T,B,N,P) - r_d \times B$$

$$r = \begin{cases} r_{opt} \times \left(\left(\frac{T_{max}-T_{exp}}{T_{max}-T_{opt}}\right) \times \left(\frac{T_{exp}-T_{min}}{T_{opt}-T_{min}}\right)^{\left(\frac{T_{opt}-T_{min}}{T_{max}-T_{opt}}\right)}\right)^{\delta}, & if\ T \in (T_{min}, T_{max}) \\ 0, & if\ T \notin (T_{min}, T_{max}) \end{cases}$$

$$r = \tau \times r_{max,L} \times \begin{cases} \frac{L_{exp}}{K_L + L_{exp}}, & if\ L < L_{max} \\ \frac{L_{max}}{K_L + L_{max}}, & if\ L \geq L_{max} \end{cases}$$

$$r = r_{max,N} \times \frac{N}{N + h_N} \qquad r = r_{max,P} \times \frac{P}{P + h_P}$$

Starch content



Conclusion

Development, optimisation and validation of a more transferable and experimental *L. minor* growth model as function of biomass, temperature, light irradiance and variable nutrient concentrations.

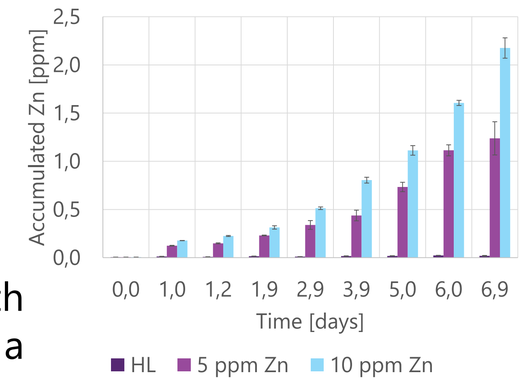
The model can predict *L. minor* growth under different environmental conditions, which can also be used for many other applications such as optimisation of *L. minor* growth for usage as food additive, the evaluation of remediation options and decision making.

Future work

Experiments with radionuclides (Cs-137 and Co-60) and heavy metals (Zn, Ni and Mn):

- Dose response curves
- Uptake and release curves
- Effects on photosynthesis, pigments, starch, soluble sugars

Integrating pollutants into growth model for the development of a remediation model.



Reference

Van Dyck, I., Vanhoudt, N., Vives i Batlle, J., Horemans, N., Nauts, R., Van Gompel, A., Claesen, J., Vangronsveld, J., (2021). Effects of environmental parameters on *Lemna minor* growth: An integrated experimental and modelling approach. *Journal of Environmental Management*, 300, 1-14.

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