MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

CREATING A CIRCULAR FUTURE

OPTIMIZING PHOSPHORUS REMOVAL FOR MUNICIPAL WASTEWATER POST-TREATMENT WITH *Chlorella vulgaris*.

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WATER RESEARCH BIOTECHNOLOGY

Toulouse, 10.11.2022

The background

#eutrophication #phosphorus #wastewater

PO_4 >0.1 mg L^{-1} → Algal blooms

The background

SMALL WWTPs (<2000 PE)

***Appropriate* phosphorus reduction**

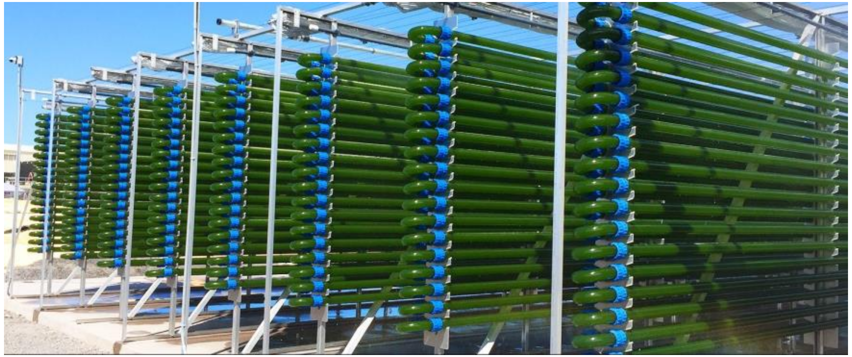
Directive 91/271/EEC

P-PO_4 in effluent >10 mg L^{-1}

POST-TREATMENT

Chemical precipitation

High costs, excess chemical sludge



MICROALGAE

Nature friendly alternative

Photosynthetic O_2 – no aeration

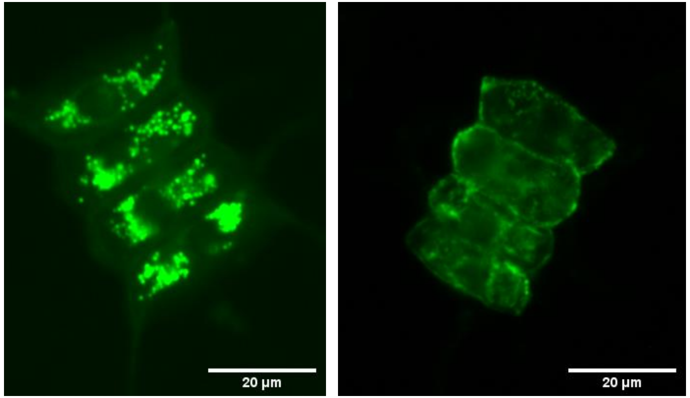
Atmospheric CO_2 capture

Nutrient (incl. PO_4) uptake

Micropollutant removal

Valuable biomass

The background

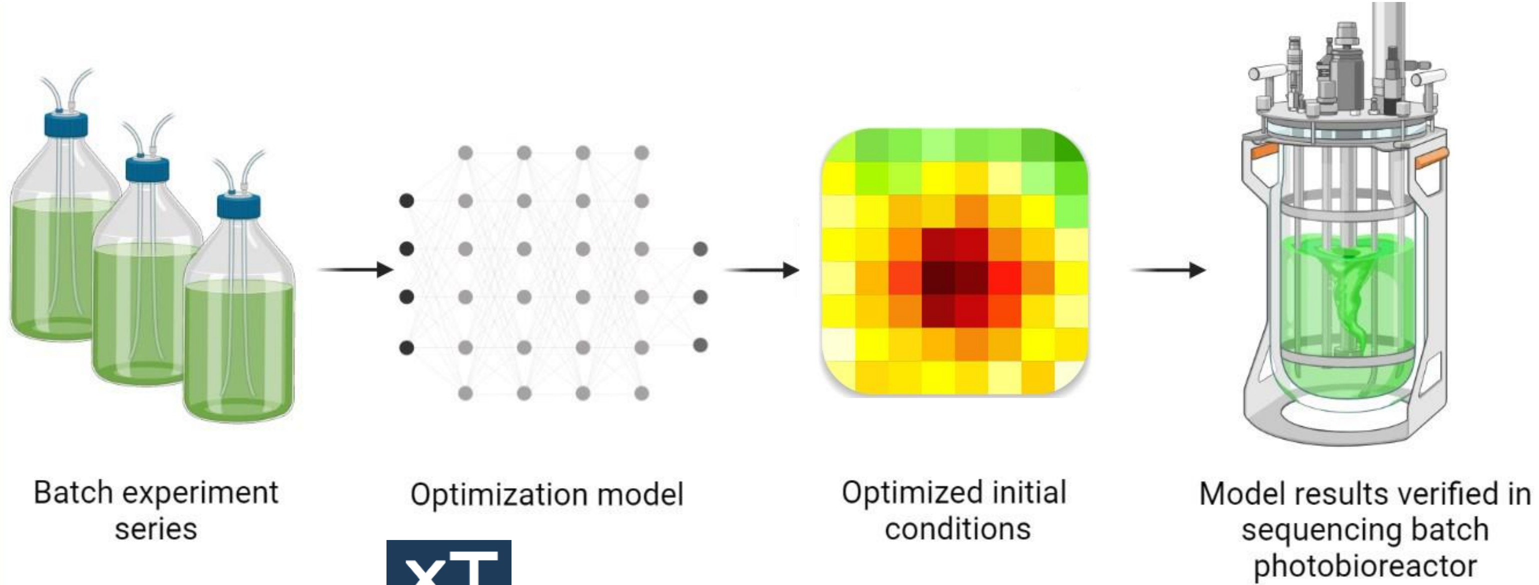


MANIPULATION WITH P-STRESS

Enhanced P uptake
Valuable molecule synthesis

POSSIBLE COST RECOVERY AND PROFIT

The experiment

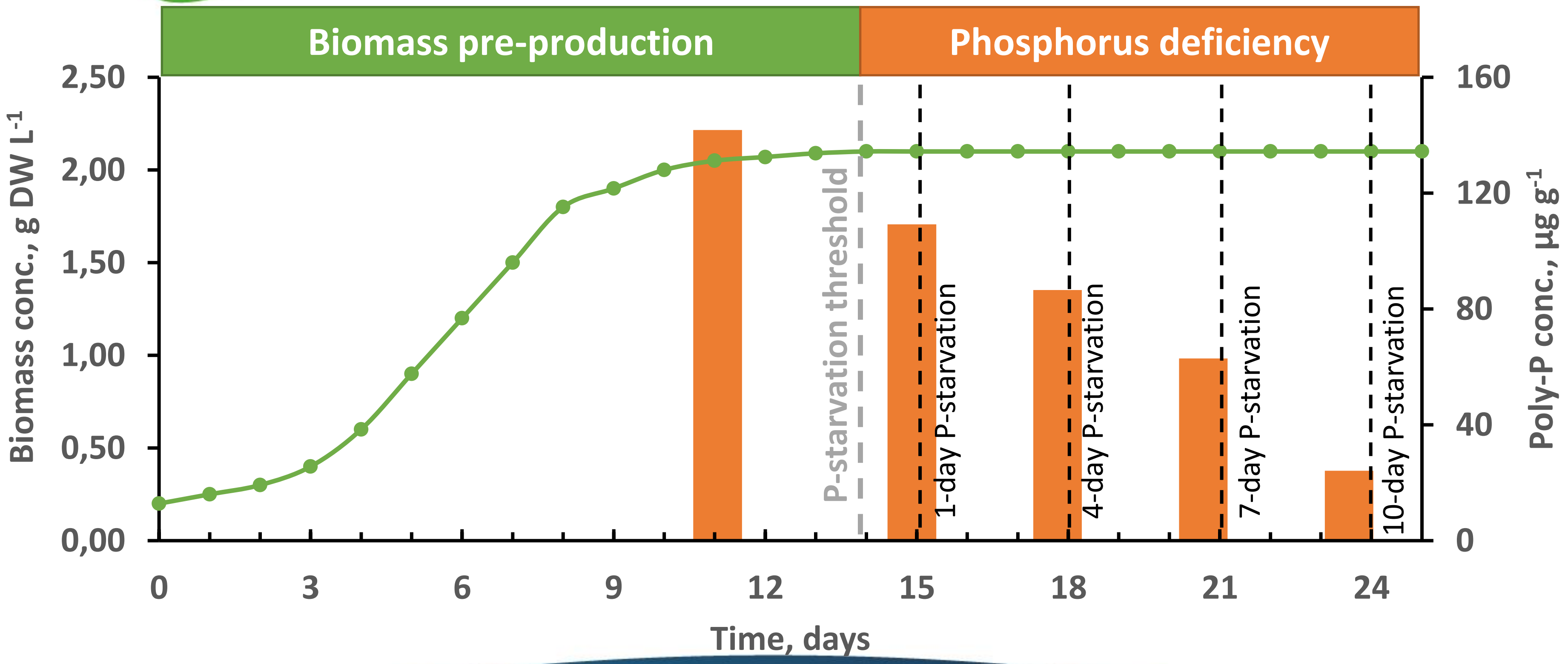


XT SAAM https://www.x-t.ai/xt-saam/

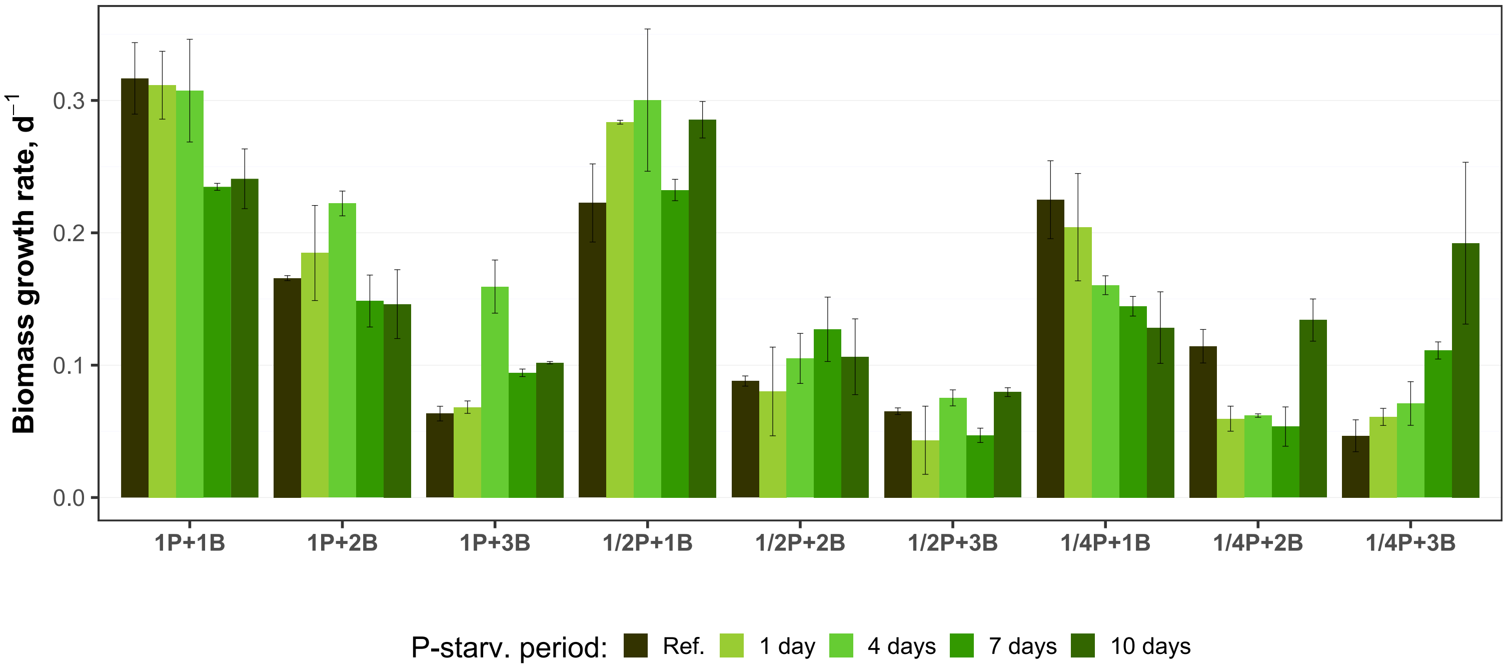
Batch setups

		Initial phosphate concentration (P), mg P-PO_4 L^{-1}		
		22	**12**	**5.5**
Initial biomass concentration (B), g DW L^{-1}	**0.2**	1P+1B	1/2P+1B	1/4P+1B
	0.6	1P+2B	1/2P+2B	1/4P+2B
	1.5	1P+3B	1/2P+3B	1/4P+3B

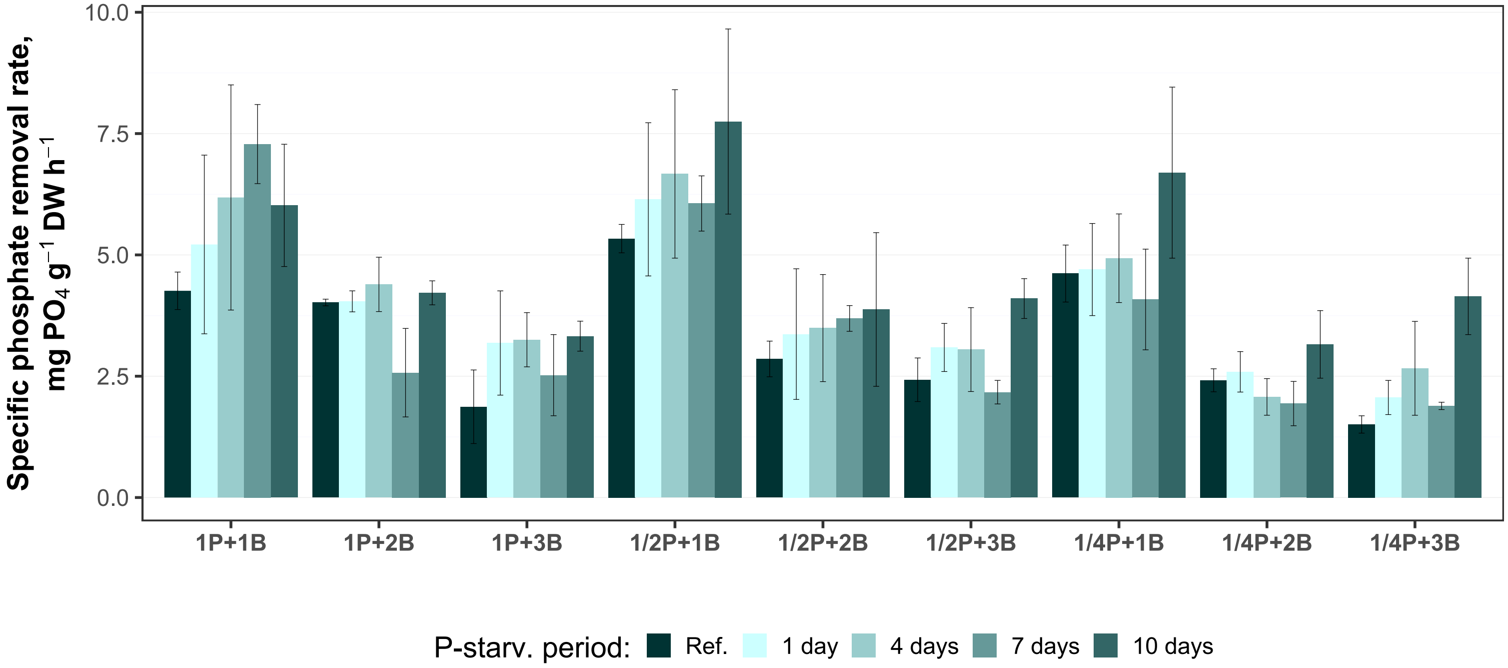
Biomass phosphorus starvation



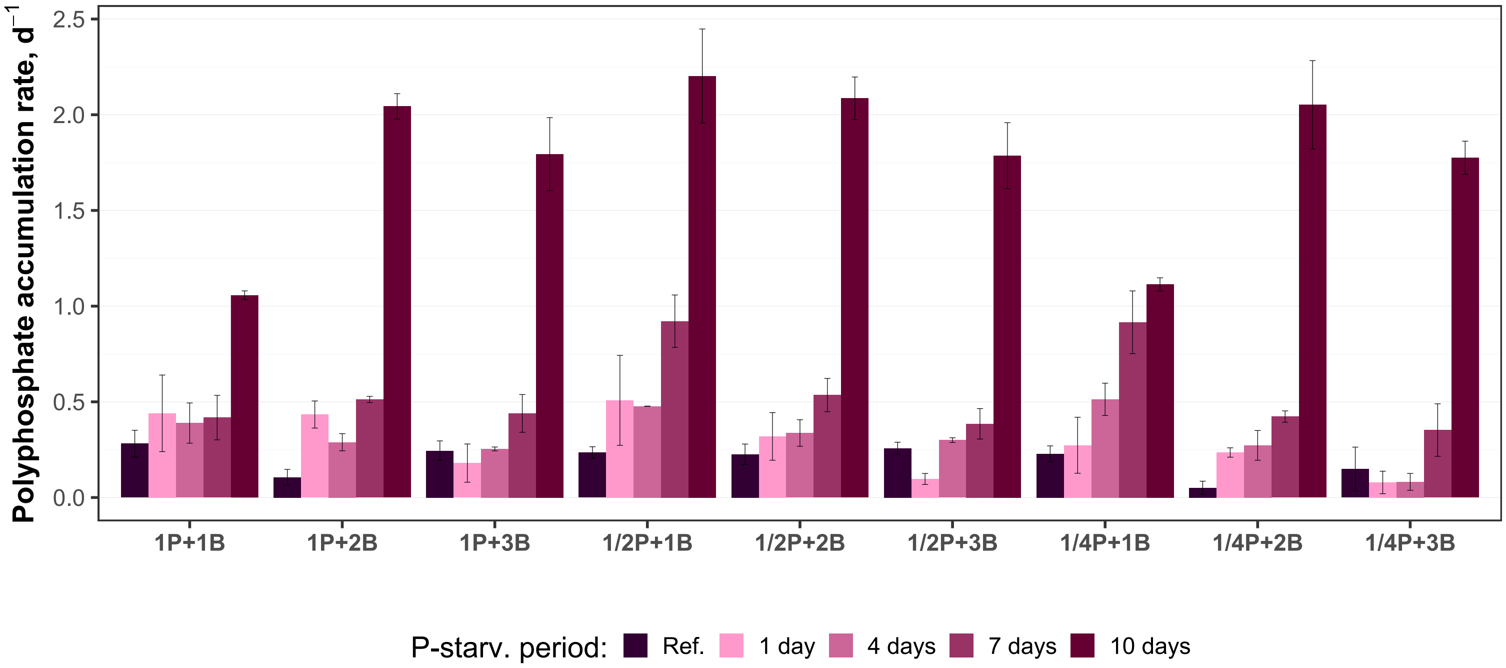
Batch experiment series



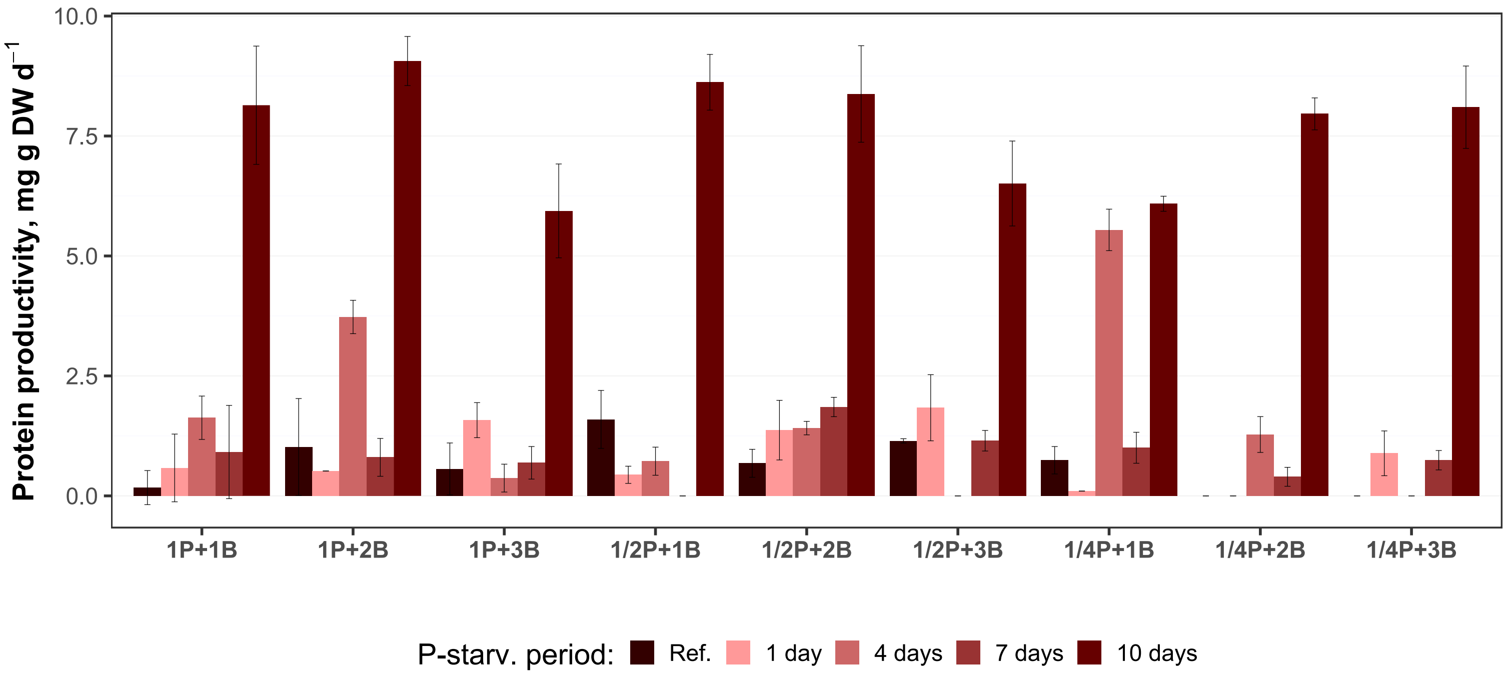
Batch experiment series



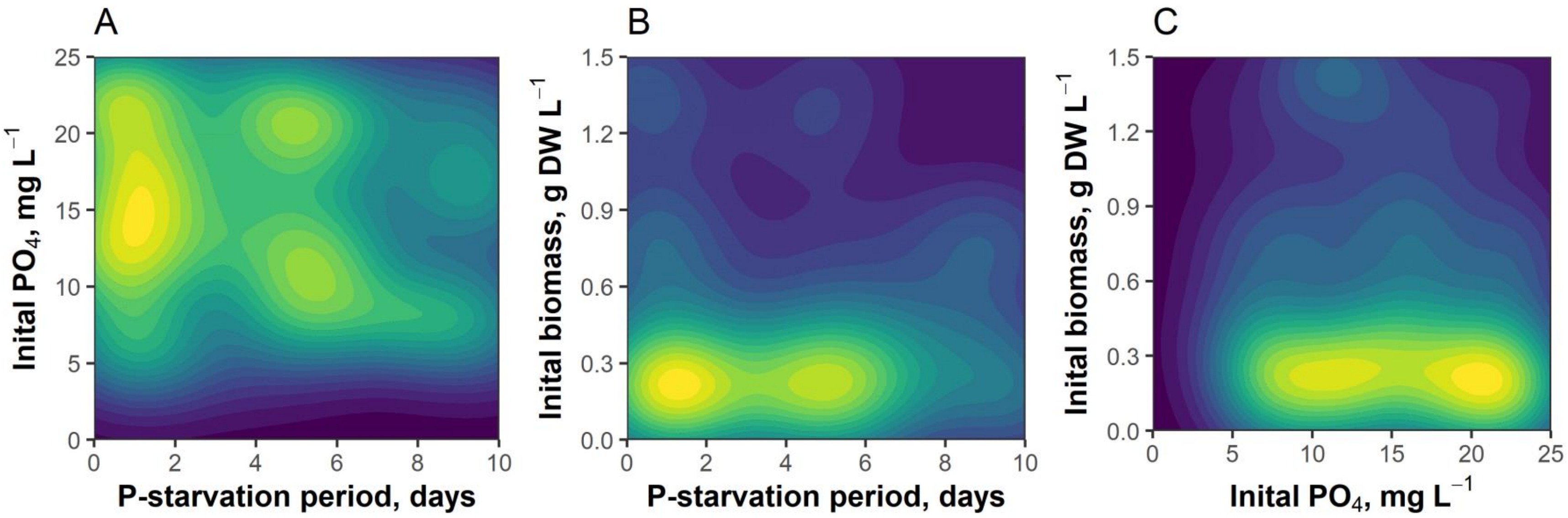
Batch experiment series



Batch experiment series



Optimization



WW treatment in a sequenced batch PBR

	Biomass growth rate, d^{-1}	Specific PO_4 removal rate, mg g DW h^{-1}	Polyphosphate accumulation rate, d^{-1}	Protein productivity, mg g DW d^{-1}
Reference (n = 4)	0.072 ± 0.016	0.279 ± 0.134	0.280 ± 0.066	1.682 ± 0.210
P-starved (n = 5)	**0.110 ± 0.024**	**0.563 ± 0.082**	**0.666 ± 0.063**	1.031 ± 0.365

Conclusions

- *C. vulgaris* is capable of **enhanced phosphate removal** from wastewater after its biomass **exposure** to **phosphorus deficiency** conditions.
- Main drivers - **depletion** of **cellular P** reserves and **activation** of **P transporters**.
- The effect biomass P-starvation is further supported by **lower initial biomass concentration** which allows higher **light availability** and increases cellular activity.
- The initial **phosphate concentration** had a **lesser impact** on the overall *C. vulgaris* biochemical performance.
- Majority of **polyphosphate** is utilized for cell **metabolite synthesis.**
- **Model** suggestions for **optimum initial conditions** show that biomass exposure to **P deficiency** for **one day is enough** to sustain a **rapid phosphate removal** and **polyphosphate accumulation**.
- Biomass P-starvation - a strategy for improved algae-based municipal wastewater post-treatment?

Next step

- Experimental pilot system for municipal WW post-treatment
  - 60 L
  - Microalgae P-starvation
  - Automated
- Municipal WWTP (PE <10000)

Further reading

Lavrinovičs, A.; Mežule, L.; Cacivkins, P.; Juhna, T. **Optimizing Phosphorus Removal for Municipal Wastewater Post-Treatment with *Chlorella vulgaris*.** *Journal of Environmental Management*, 2022, 324, 116313.

Acknowledgment

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THANK YOU.

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