MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

CREATING A CIRCULAR FUTURE

The effect of phosphate starvation on nutrient uptake and cellular content of the microalgae *Desmodesmus communis* and *Chlorella protothecoides*

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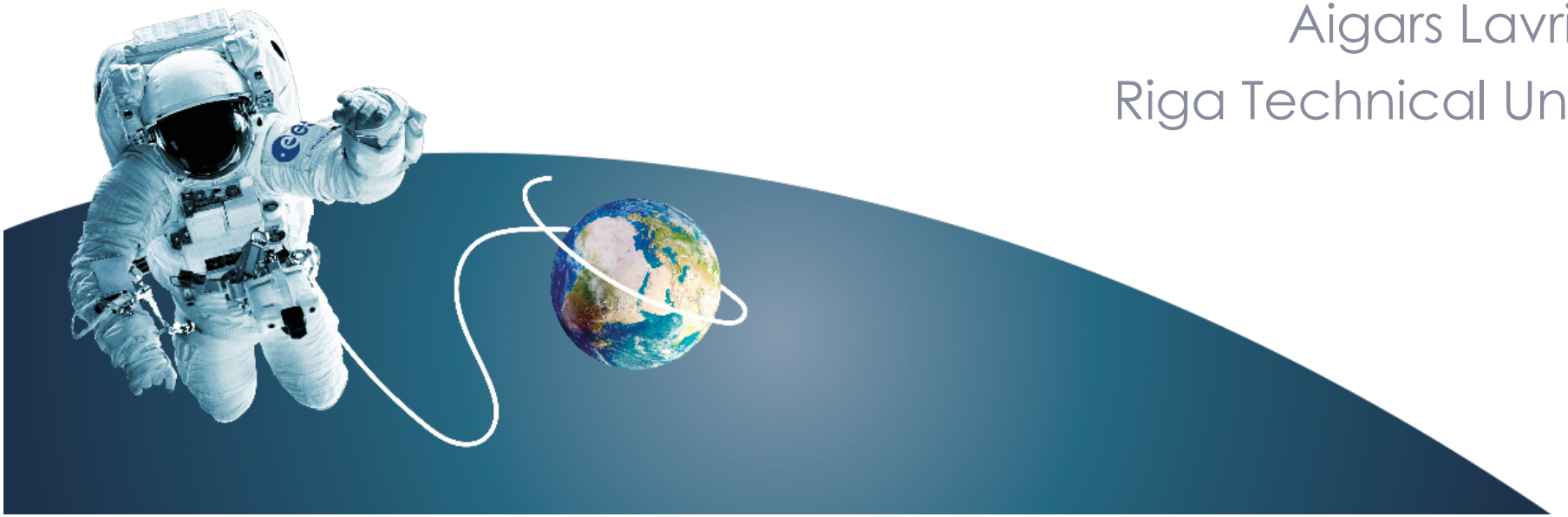
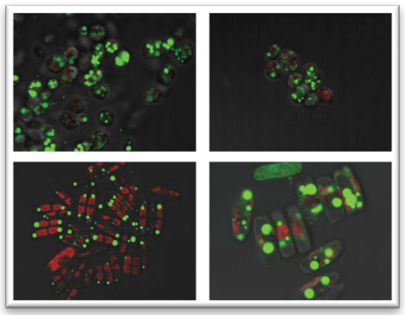


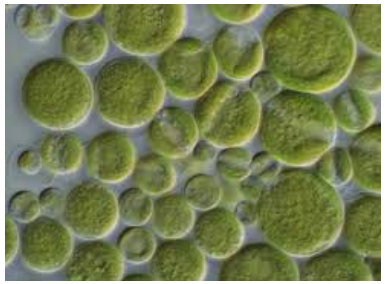
Background

- No phosphorus reduction limits for small (PE<2000) MWWTP;
- Algae biomass as nature-friendly alternative for post-treatment;
- Luxury P uptake – cellular phosphorus storage;
- Phosphorus starvation – enhanced cellular P uptake;
- Nutrient stress (e.g. P deficiency) – higher lipid, protein & carbohydrate production.





Experimental setup

WWTP in Roja, LATVIA (<3000 PE)		
Receiving sewage (Primary WW)		**Treated effluent (Secondary WW)**
		
D. communis		*C. protothecoides*
Phosphate starvation period		
0 days	*7 days*	*14 days*
pH, Temp., algal biomass (g DW L^{-1}), DIN & DIP (mg N & P L^{-1}), Poly-P (µg mg-1)		
10 days, room temp. (~24 °C), ~100 µmol m^{-2} s^{-1}, n = 3		

Wastewater characteristics

Parameter		Primary WW	Secondary WW
Total nitrogen	mg N L^{-1}	110	40
NH_4	mg N L^{-1}	68	0.5
NO_{2+3}	mg N L^{-1}	21	32
Total phosphorus	mg P L^{-1}	36	36
PO_4	mg P L^{-1}	30	30
pH		8.3	8.2
EC	µS/cm	1700	1600
BOD	mg O2 L^{-1}	530	5.3
COD	mg L^{-1}	970	42
N:P ratio		3:1	1:1

Sewage from fish processing factory

Biomass starvation

BG-11:

K_2HPO_4

$MgSO_4 \cdot 7H_2O$

$CaCl_2 \cdot 2H_2O$

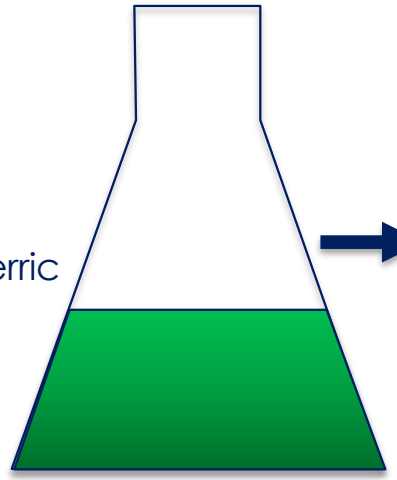
Citric acid

Ammonium ferric citrate green

$EDTANa_2$

Na_2CO_3

Trace metal solution



Biomass pre-production

BG-0:

~~K_2HPO_4~~

$MgSO_4 \cdot 7H_2O$

$CaCl_2 \cdot 2H_2O$

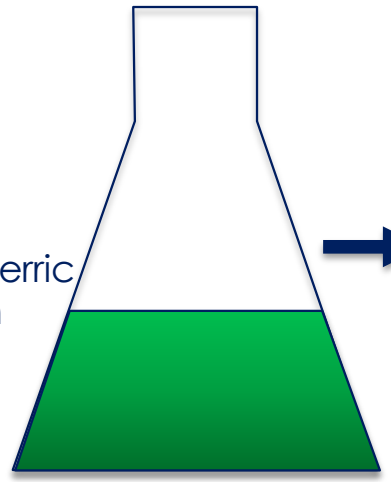
Citric acid

Ammonium ferric citrate green

$EDTANa_2$

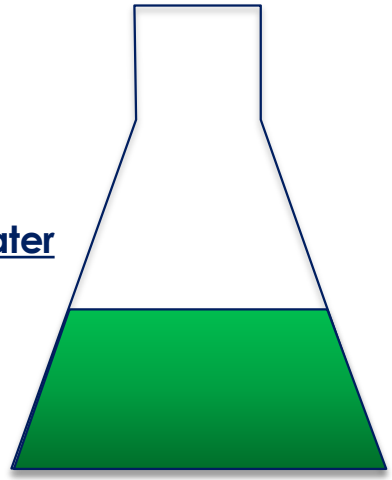
Na_2CO_3

Trace metal solution



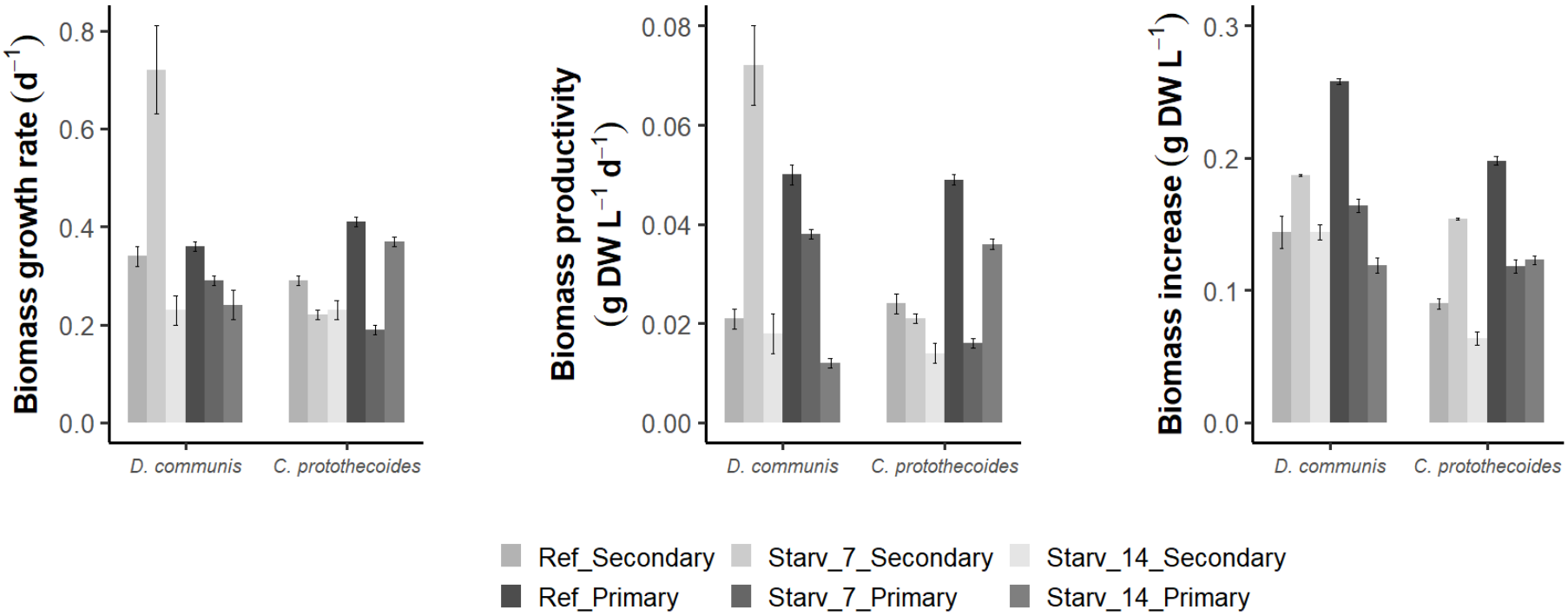
Biomass P-starvation

Wastewater

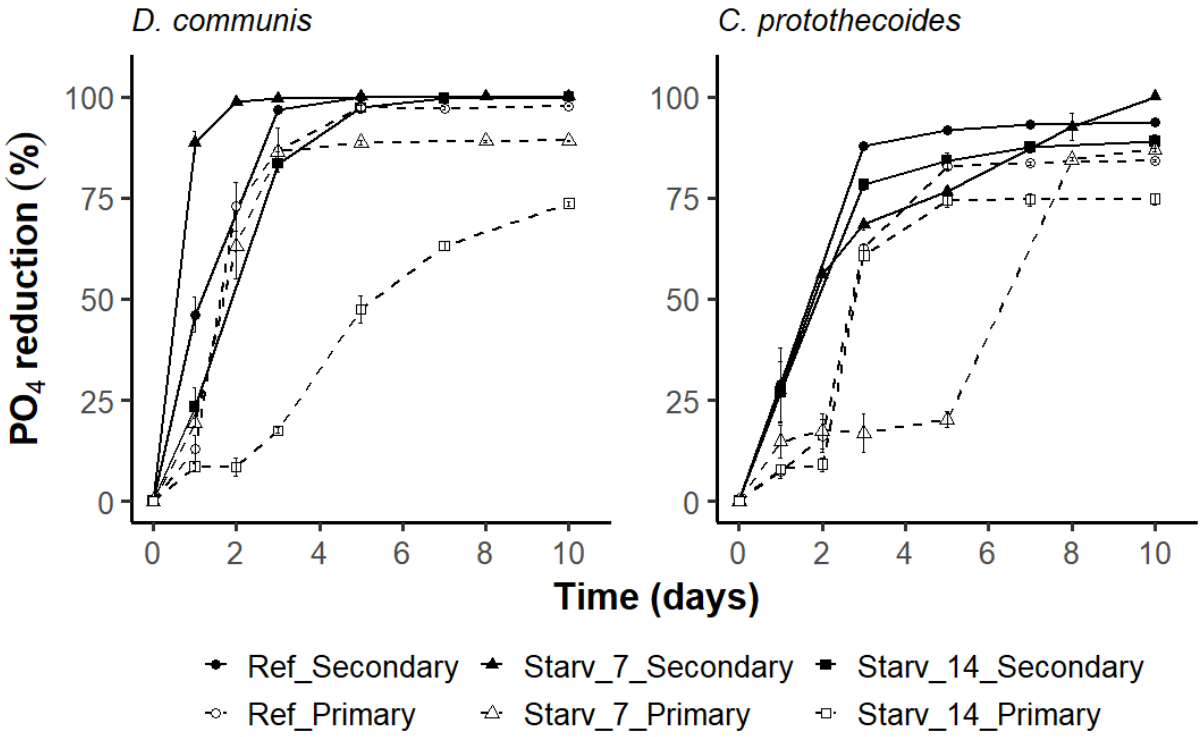


Experiment

Results - BIOMASS



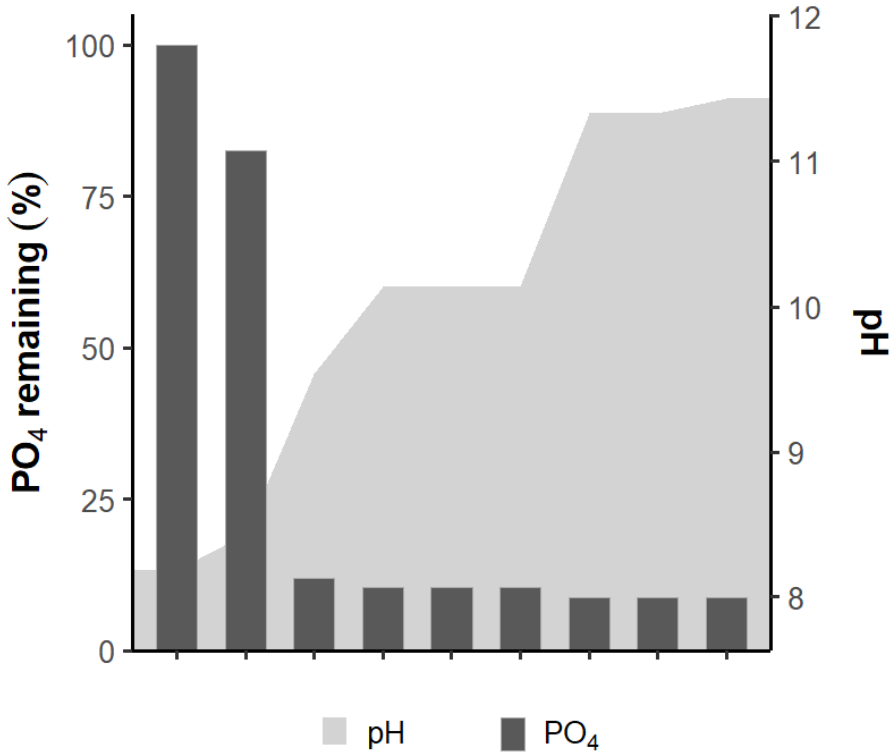
Results - NUTRIENTS



Phosphate reduction rate (%) under different treatments.

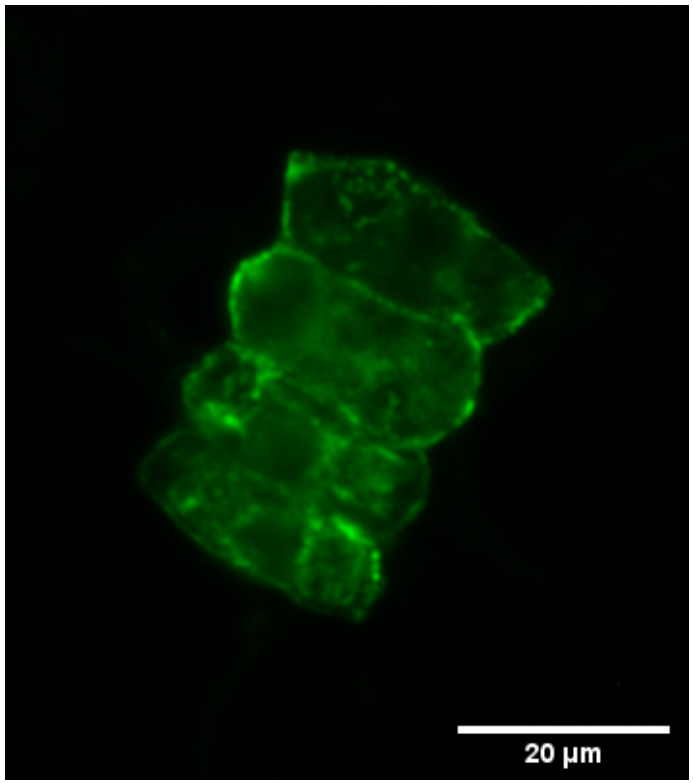
Ref_Secondary – reference conditions with secondary wastewater;
Starv_7_ Secondary – algal biomass starvation for 7 day period with secondary wastewater;
Starv_14_ Secondary – algal biomass starvation for 14 day period with secondary wastewater;
Ref_Primary – reference conditions with primary wastewater;
Starv_7_ Primary – algal biomass starvation for 7 day period with primary wastewater;
Starv_14_ Primary – algal biomass starvation for 14 day period with primary wastewater.

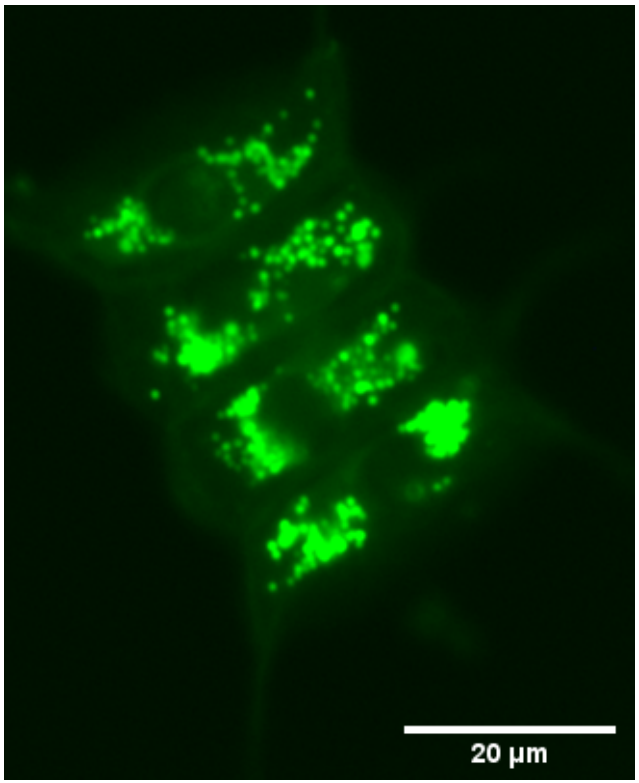
NUTRIENTS (PO_4) - Role of pH



Relation of the phosphate content to pH changes in the control batch.

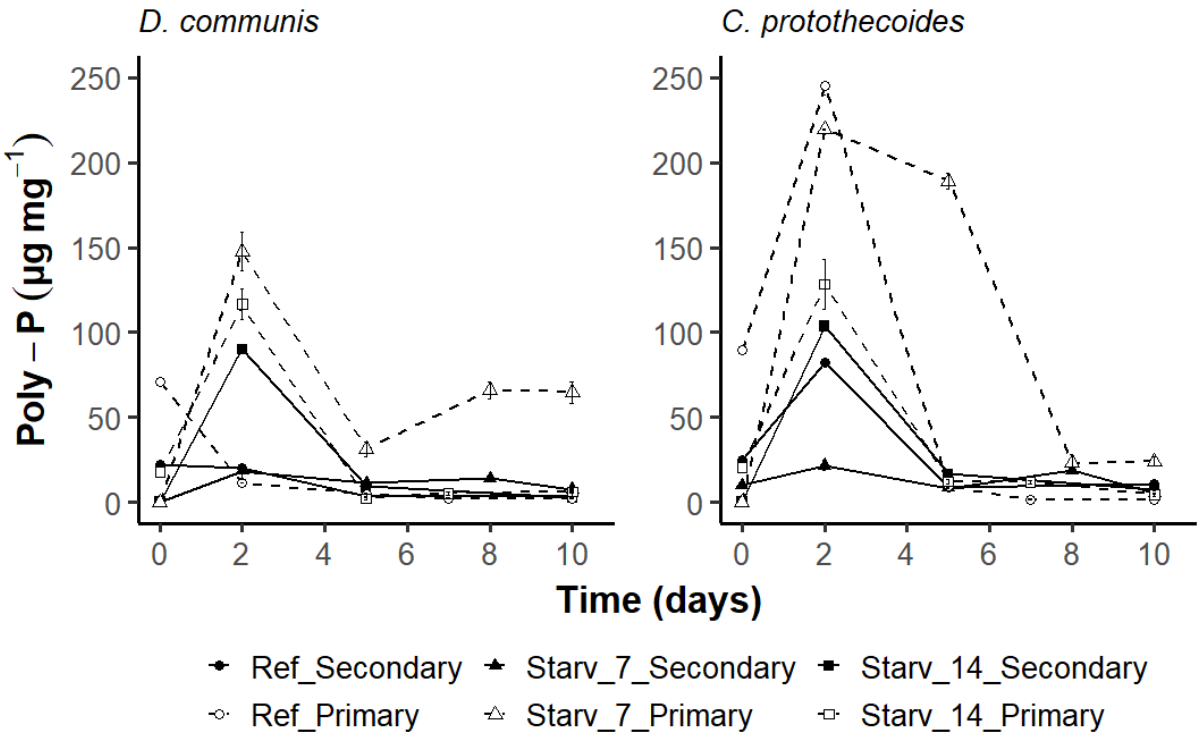
Results - POLYPHOSPHATES





Desmodesmus communis **cell without polyphosphate granules (left) and with Poly-P granules stored in the cell (right).**

Results - POLYPHOSPHATES



Polyphosphate (Poly-P) accumulation in algal biomass under different treatments.

Ref_Secondary – reference conditions with secondary wastewater;
Starv_7_ Secondary – algal biomass starvation for 7 day period with secondary wastewater;
Starv_14_ Secondary – algal biomass starvation for 14 day period with secondary wastewater;
Ref_Primary – reference conditions with primary wastewater;
Starv_7_ Primary – algal biomass starvation for 7 day period with primary wastewater;
Starv_14_ Primary – algal biomass starvation for 14 day period with primary wastewater.

Conclusions

- Control of pH – addition of CO2;
- Control of N/P ratio;
- Realistic & economically feasible starvation period;
- Sequenced – batch mode.

Further reading

Lavrinovics, A., Mezule, L., Juhna, T., 2020. Microalgae starvation for enhanced phosphorus uptake from municipal wastewater. *Algal research,* 52, Dec. 2020.

Acknowledgment

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LZP-2019/1-0271

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THANK YOU.

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