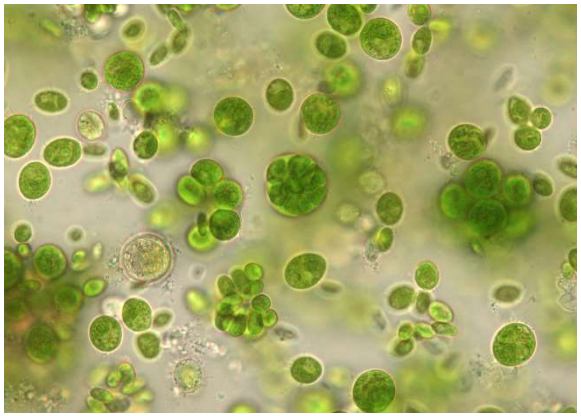
Closing cycles from wastewater by microalgae: opportunities and challenges

Tânia V. Fernandes



Guillaume Tixier

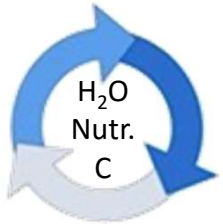
NEDERLANDS INSTITUUT VOOR ECOLOGIE (NIOO-KNAW)
NETHERLANDS INSTITUTE OF ECOLOGY (NIOO-KNAW)

KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN

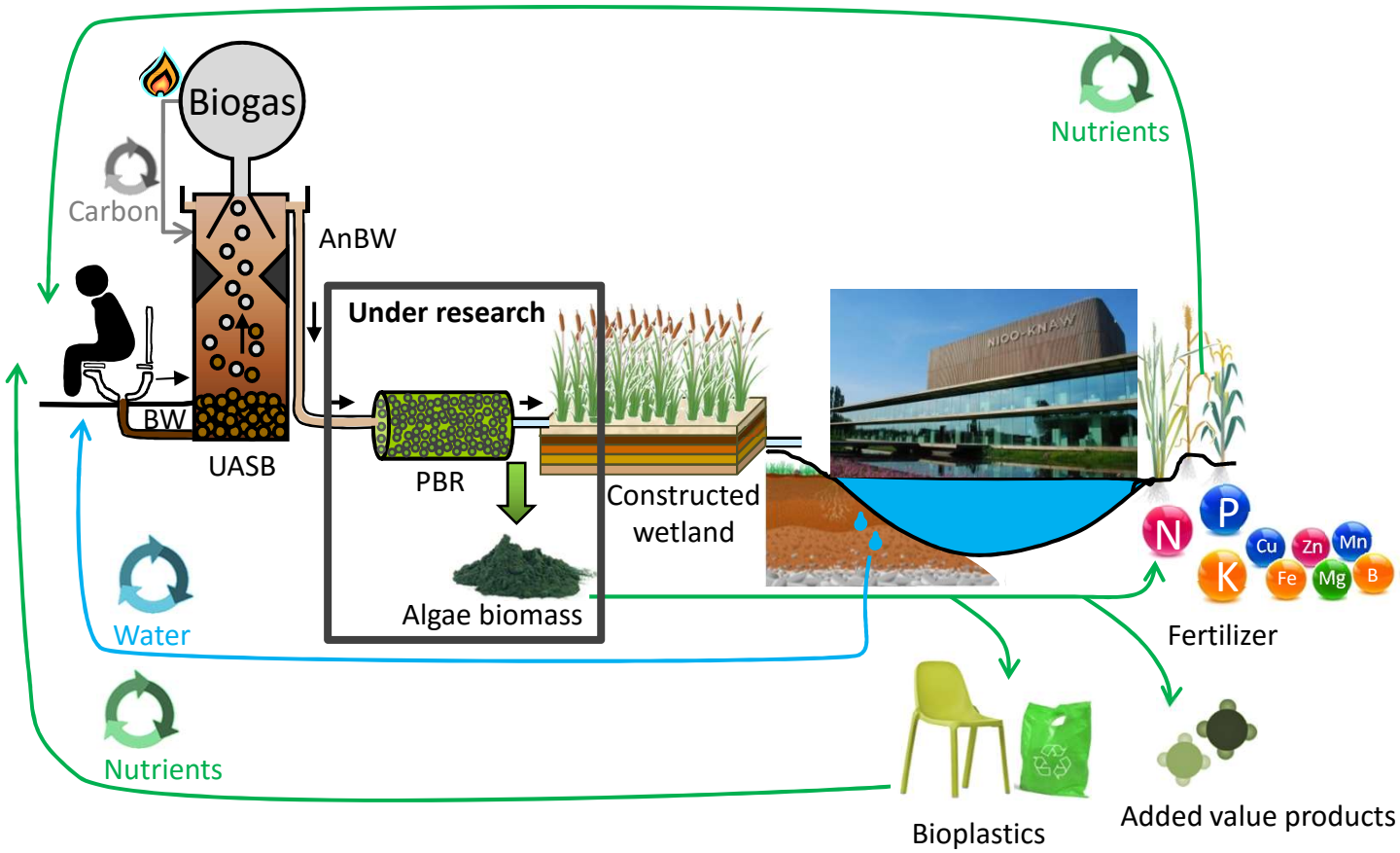
Opportunity

NIOO circular sanitation system

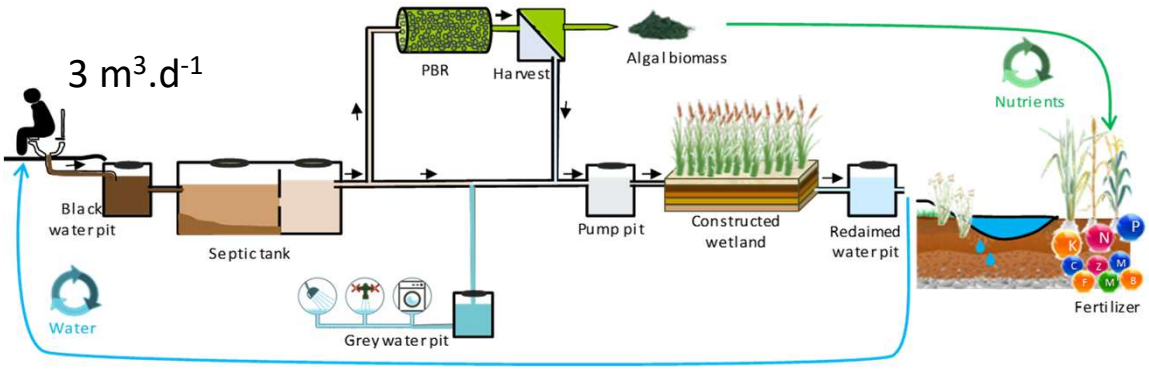
- C2C building
- Separates GW from BW
- ≈ 300 p (5 d/week)
- > 50% part-timers
- BW flow = 0.35 $m^3.d^{-1}$



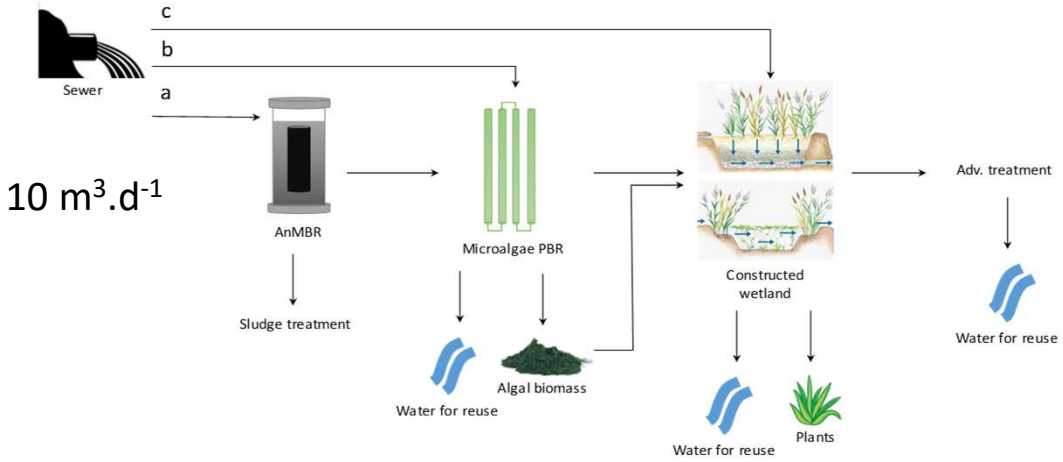
NIOO circular sanitation system



Other circular sanitation systems



Other circular sanitation systems



New Delhi, India

Challenges

Pollutants removal

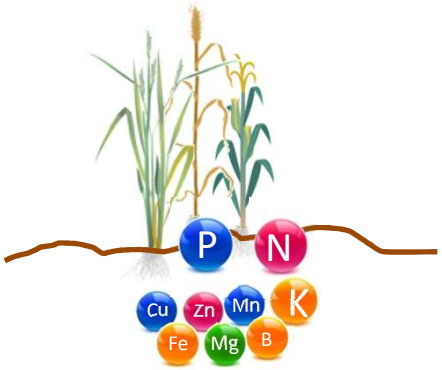
N & P

Micropollutants

Human pathogens

Heavy metals

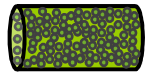
Biomass valorisation



C & nutrients recovery as fertilizer (biostimulant)

Contamination

Up-scaling & implementation

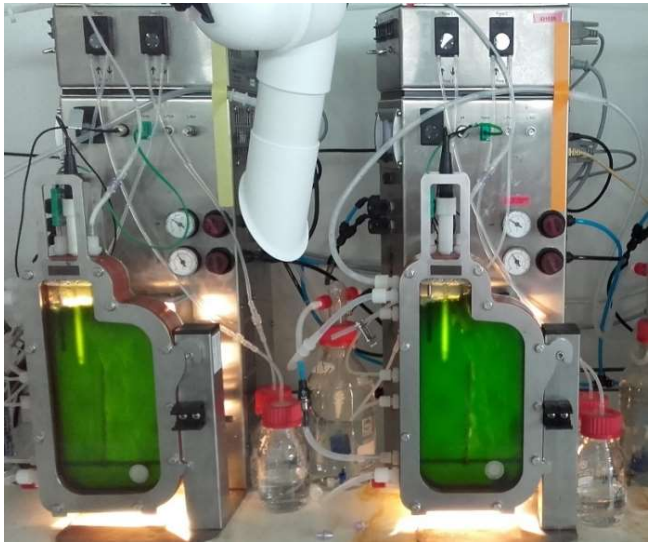


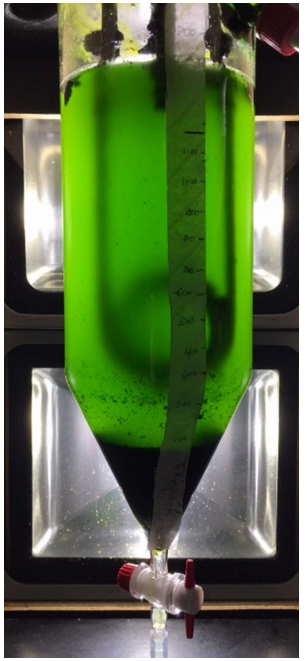
Reactor design

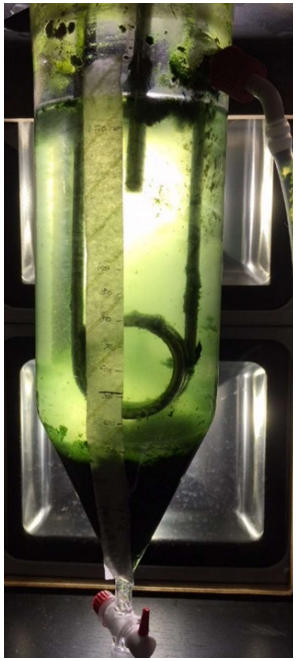
Footprint

Harvest

N and P removal







N and P removal rates:

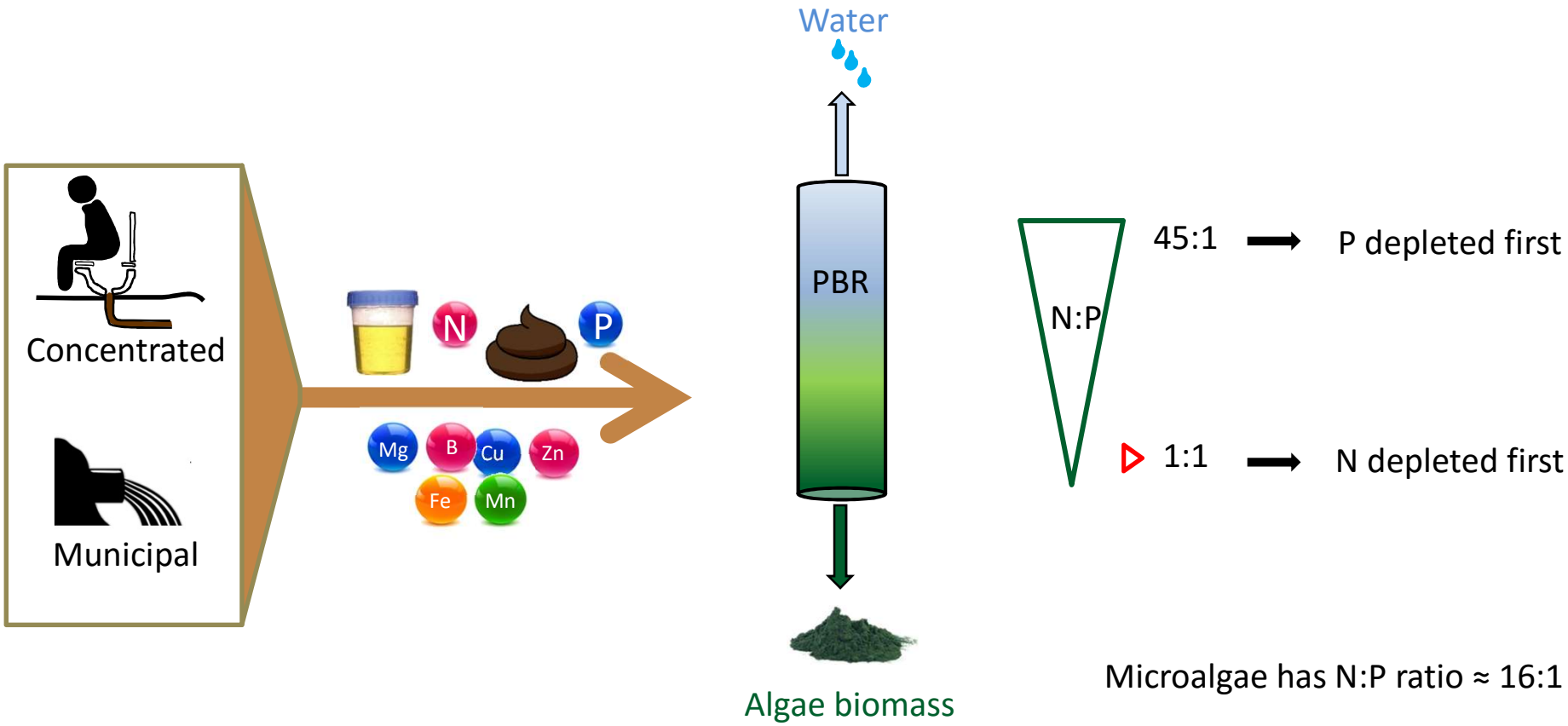
20 - 160 mg $N.L^{-1}.d^{-1}$

3 - 30 mg $P.L^{-1}.d^{-1}$

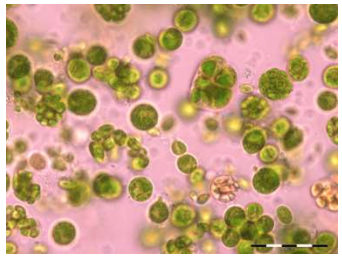
N and P removal % depends on N:P ratio of WW

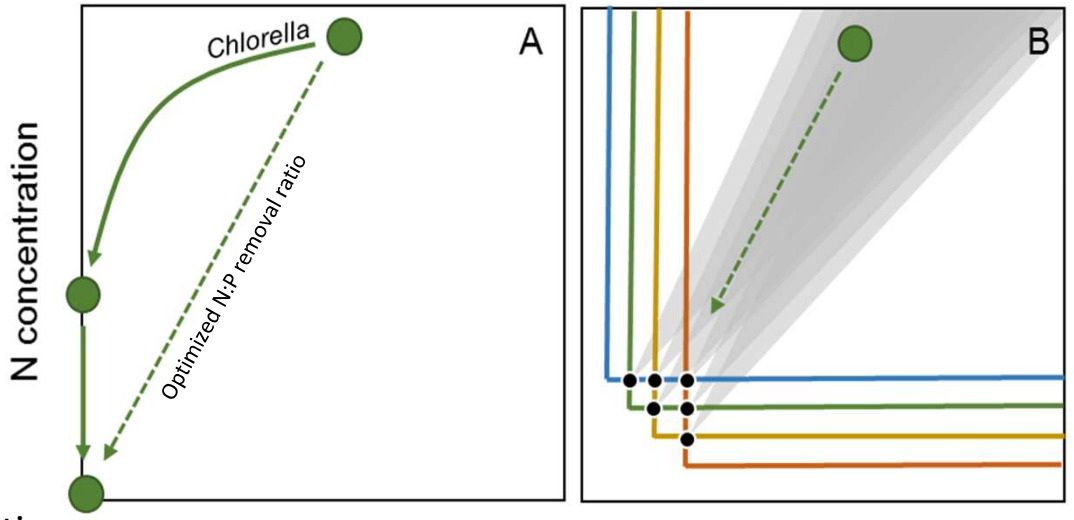
Fernandes et al., Environ. Sci. Technol., 2015; Fernandes et al., Front. in Micro., 2017

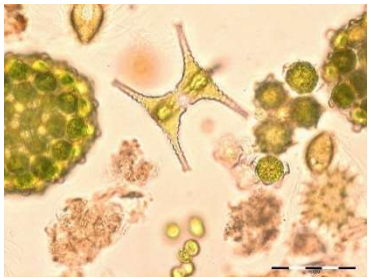
Variation in WW N:P ratio



Explore traits and functions







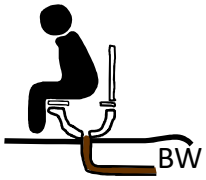
Species with ↑ N:P ratios
↓
↑ N recovery rate
↓
↑N&P recovery

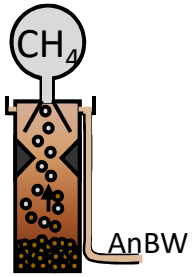
↑ biodiversity
↓
↑ functional trait diversity
↓
↑N&P recovery

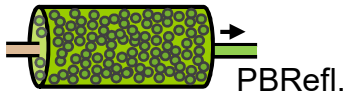
Fernandes et al., Front. in Micro., 2017

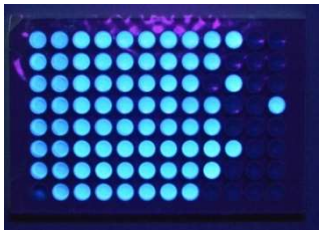
Pollutants removal

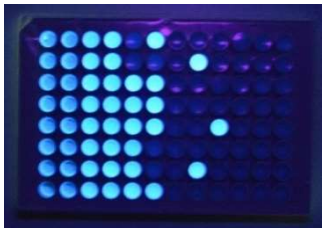
Human pathogens

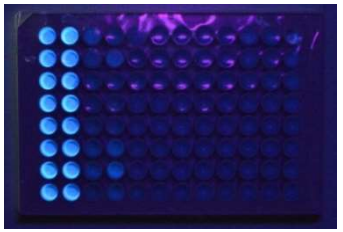












<u>4-log removal for E. coli</u>

log removal = to conventional WWTP;

water reuse quality = outdoor crop irrigation

Suetti et al. in prep.

Pollutants removal

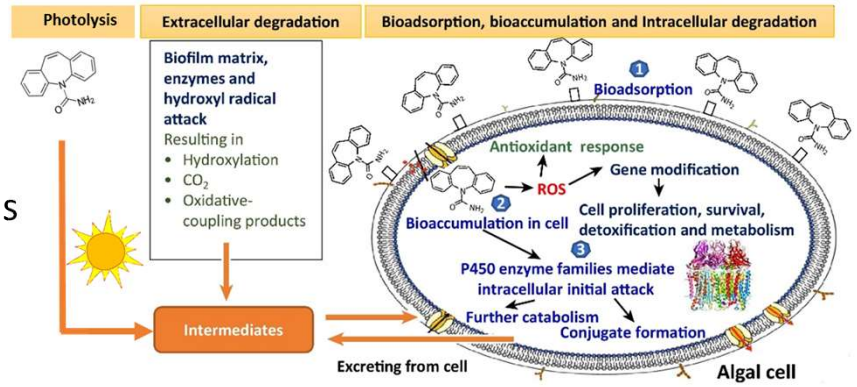
Micropollutants

	Removal (%)
Ibuprofen	100
Diclofenac	60
Paracetamol	100
Trimethoprim	60
Metoprolol	70
Carbamazepine	30

de Wilt et al., Jor. Haz. Mat., 2015

18 CEC Chemicals of emerging concern	Removal in algae reactors (%)
Sulfamethoxazole (antibiotic)	?
Mecoprop (herbicide)	?
Methylbenzotriazole (corrosion inhibitor)	?

Removal mechanisms



Biomass valorisation

Contamination

	Removal (%)
Ibuprofen	100
Diclofenac	60
Paracetamol	100
Trimethoprim	60
Metoprolol	70
Carbamazepine	30

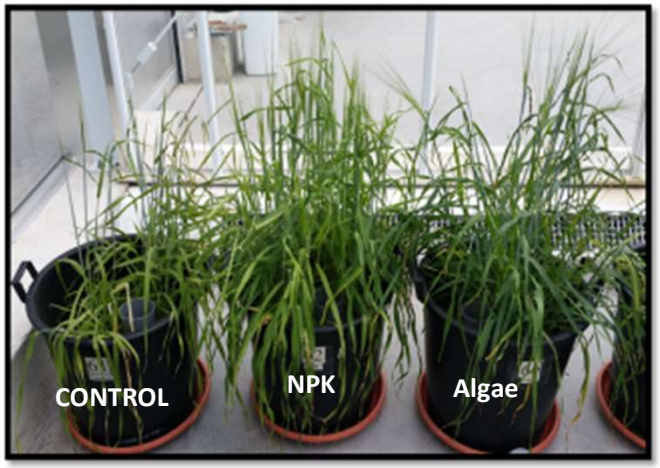
de Wilt et al., Jor. Haz. Mat., 2015

Adsorption to suspended matter (inc. microalgae):

Yes, but a majority no

Fertilizer? positive results, but more research needed

Biomass valorisation



Suleiman., A. et al., in preparation

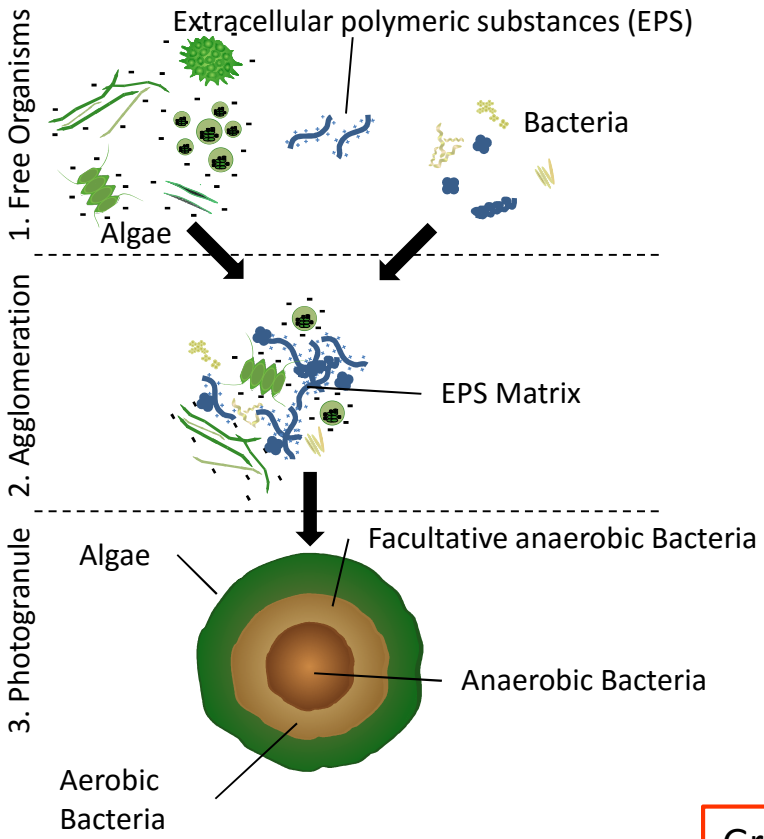
Biomass valorisation

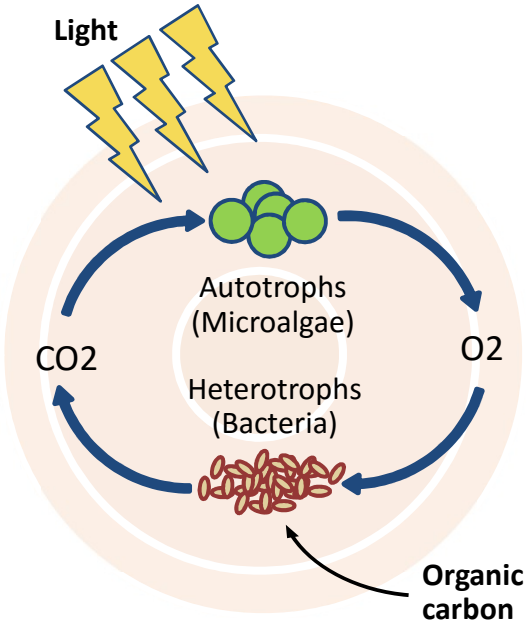
Table S1: Nutrient composition of some elements in organic fertilizers (Möller & Schultheiss, 2014). Ca, K, Mg, Na, P, S, N, C in g/kg, Co, Cu, Fe, Mn, Mo, Ni, Zn in mg/kg. *Concentrations were too low to be measured.

	Ca	Co	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	S	Zn	N	C
Microalgal biomass from this study	8.1	0.0	70.9	122.8	26.2	2.7	11.1	0.3	97.0	5.0	10.1[5]	5.7	111.9	59.8[5]	323[5]
Bioilsa[8]	61	*	6	526	2	1	18	*	8	*	10	43	62	105	431
Biosol[8]	4	*	11	319	5	1	9	*	9	*	6	20	13	73	475
Bone meal	187	*	*	175	2	4	5	*	6	1	88	3	121	75	293
Clover grass pellets	10	8600	8	1630	24	3	164	3	*	4	3	1	29	19	386
Cocoa shells	4	14600	41	1119	26	5	79	1	*	10	4	2	64	26	507
DGGS-based fertilizers	2	6400	8	227	19	5	54	1	6	2	12	5	85	56	506
Faba bean seed meal	3	*	19	83	14	2	30	2	*	4	7	2	62	48	470
Feather mealbased fertilizers	9	*	23	362	16	2	38	1	2	2	4	14	120	110	517

Silva., G.R et al., Algal Research, 2019

Photogranules

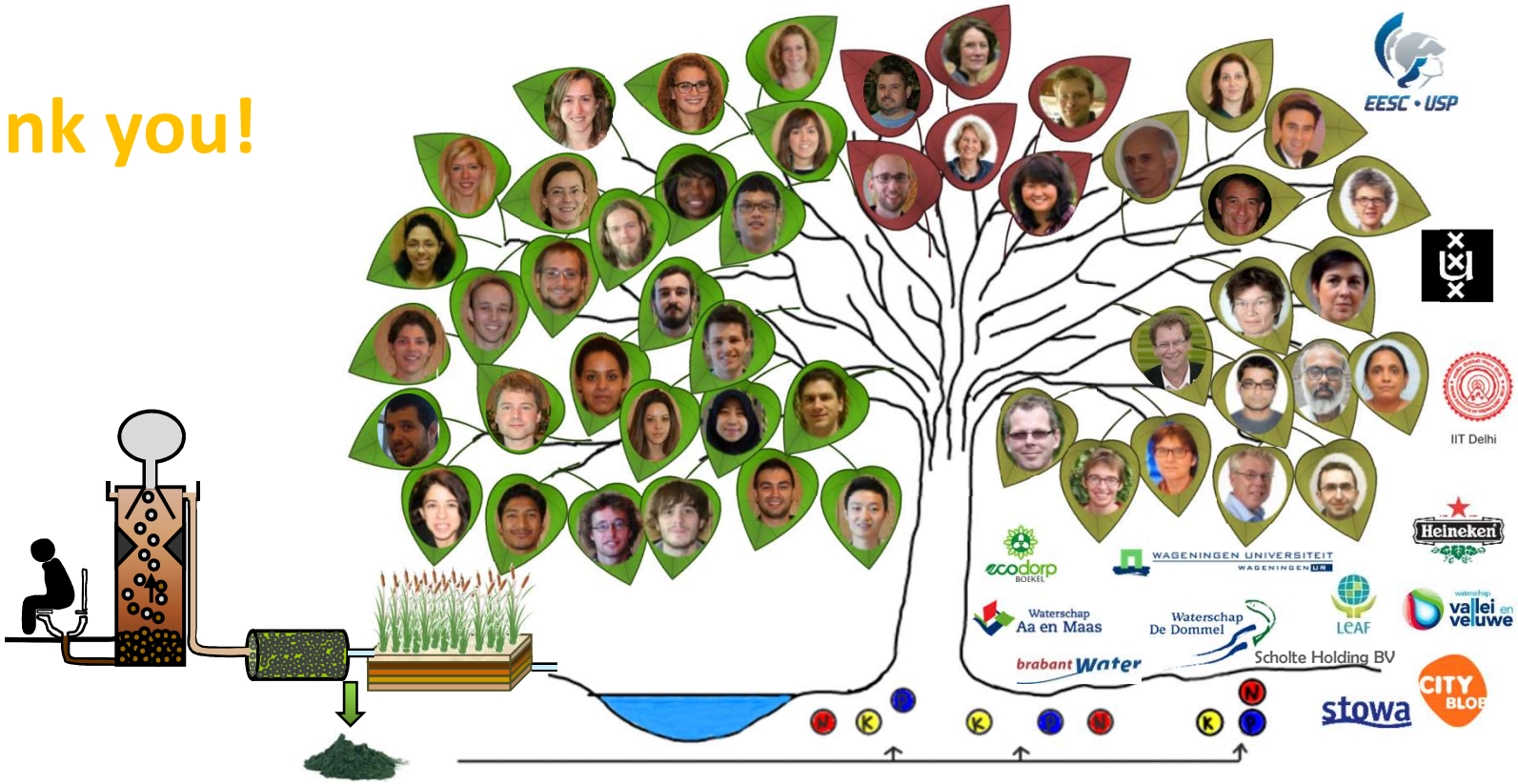




Growth and harvest in 1 reactor… and no aeration needed

The future is bright… the future is GREEN

Thank you!



www.nioo.knaw.nl @niooknaw