MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

CREATING A CIRCULAR FUTURE

Improving ammonification for nitrate production in bioconversion of organic fertilizers to liquid products

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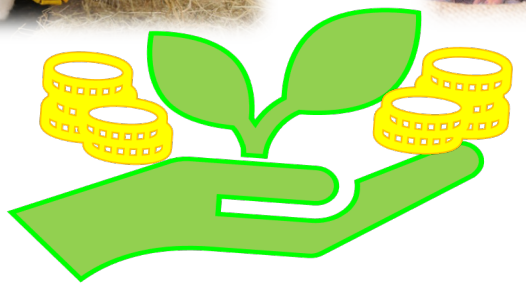
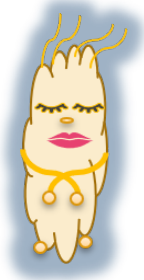
Organic fertilisers

Animal-based fertilisers: e.g. Blood meal, animal manures

Plant based fertilisers: e.g. Cocoa shells, soybean meal



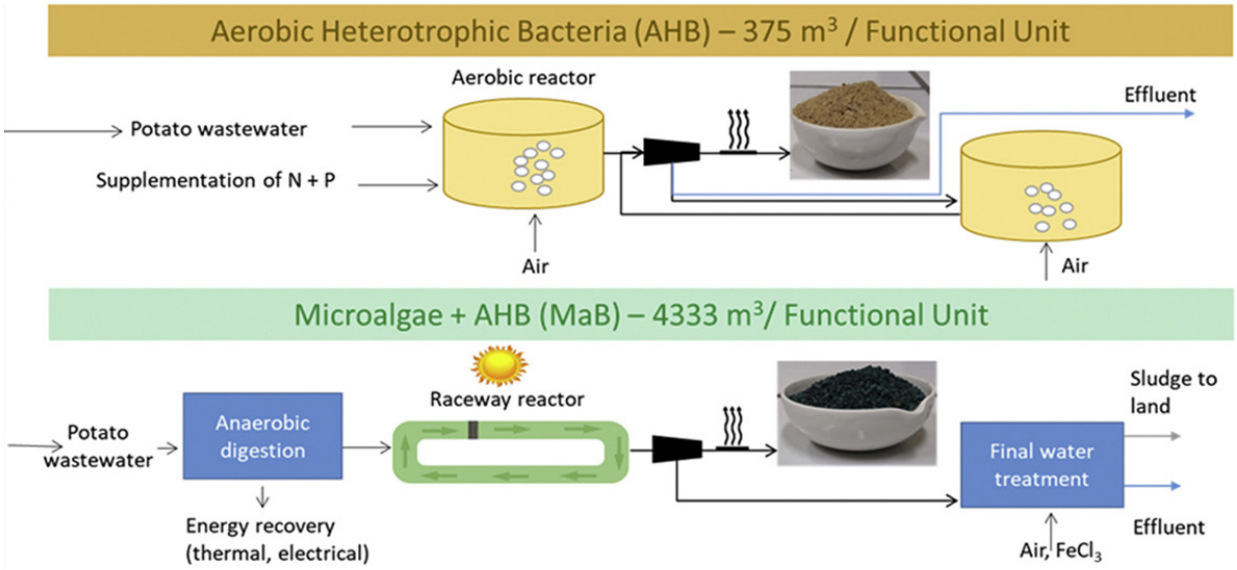


Microbial fertilizer: Aerobic heterotrophic bacteria, microalgae

(Pictures from https://www.google.com) (Spanoghe et al. 2020)

microbial fertilisers

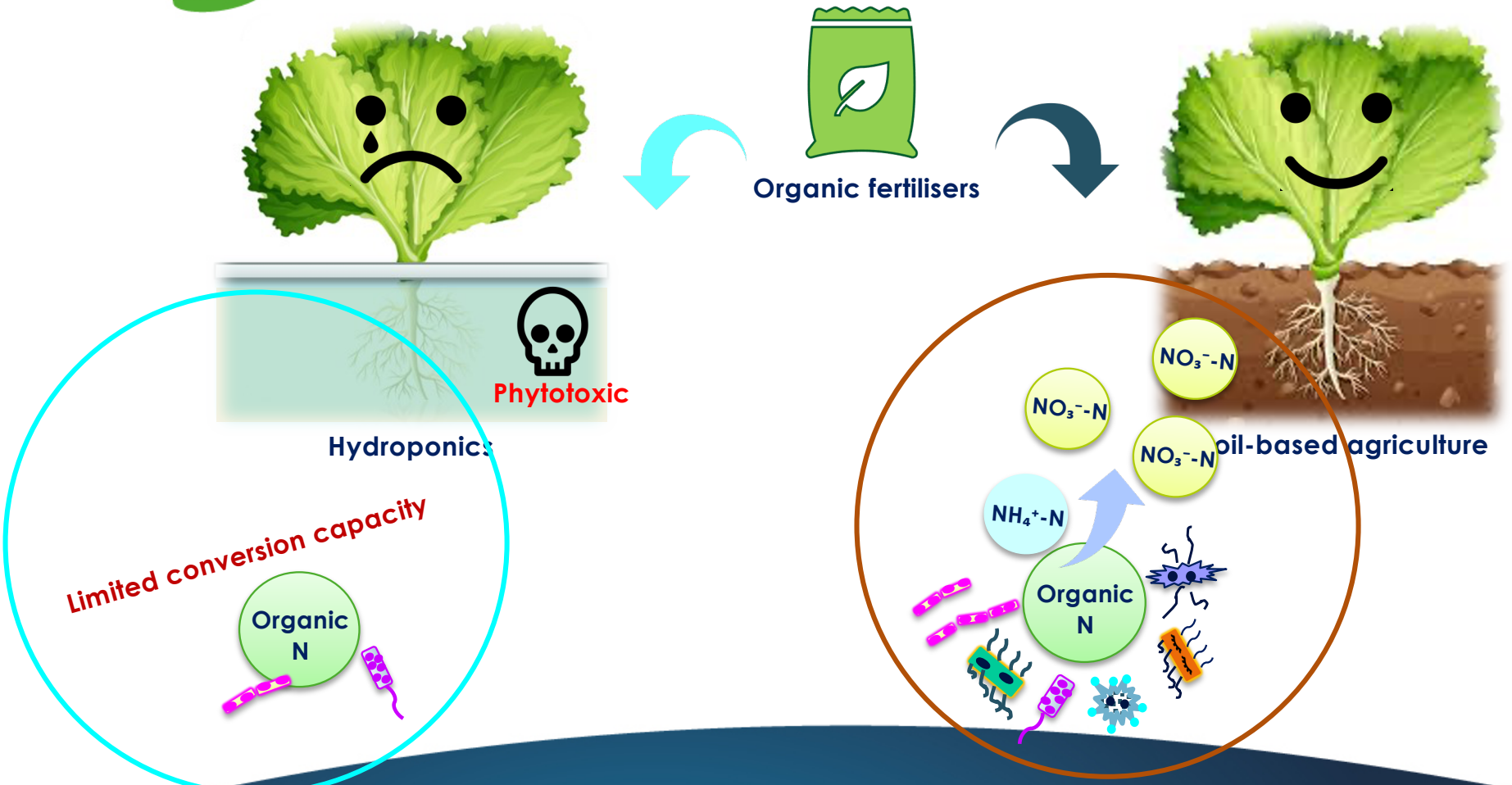
consequential Life Cycle Assessment (cLCA); *functional unit: 1 ton crude protein*



❖ **Microbial fertilizers better than soybean meal: lower impacts in the human health and the ecosystem** (data not shown).

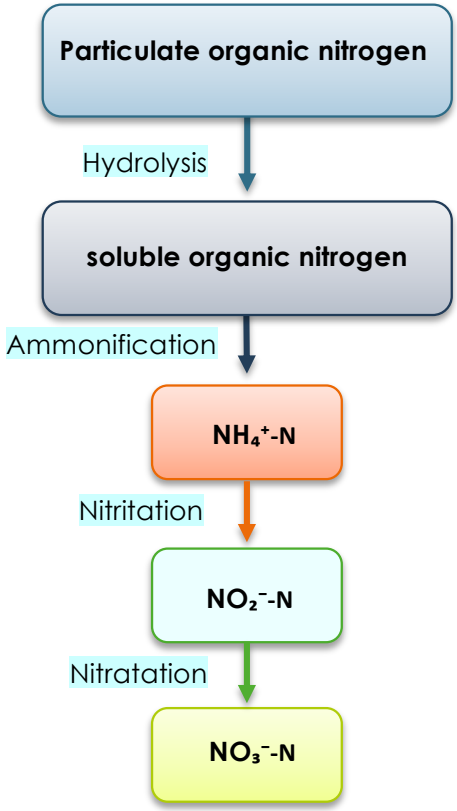
(Spiller et al., 2020; Spanoghe et al. 2020))

Plant production



(J.G. Lee et al, 2006; J. L. Garland et al. 1997)

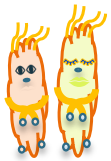
Nitrogen conversion from organic fertilisers to nitrate



Concept of nitrogen conversion process

(H Simsek et al.,2012; T. Katipoglu-Yazan et al. 2012)

Objective1- batch tests



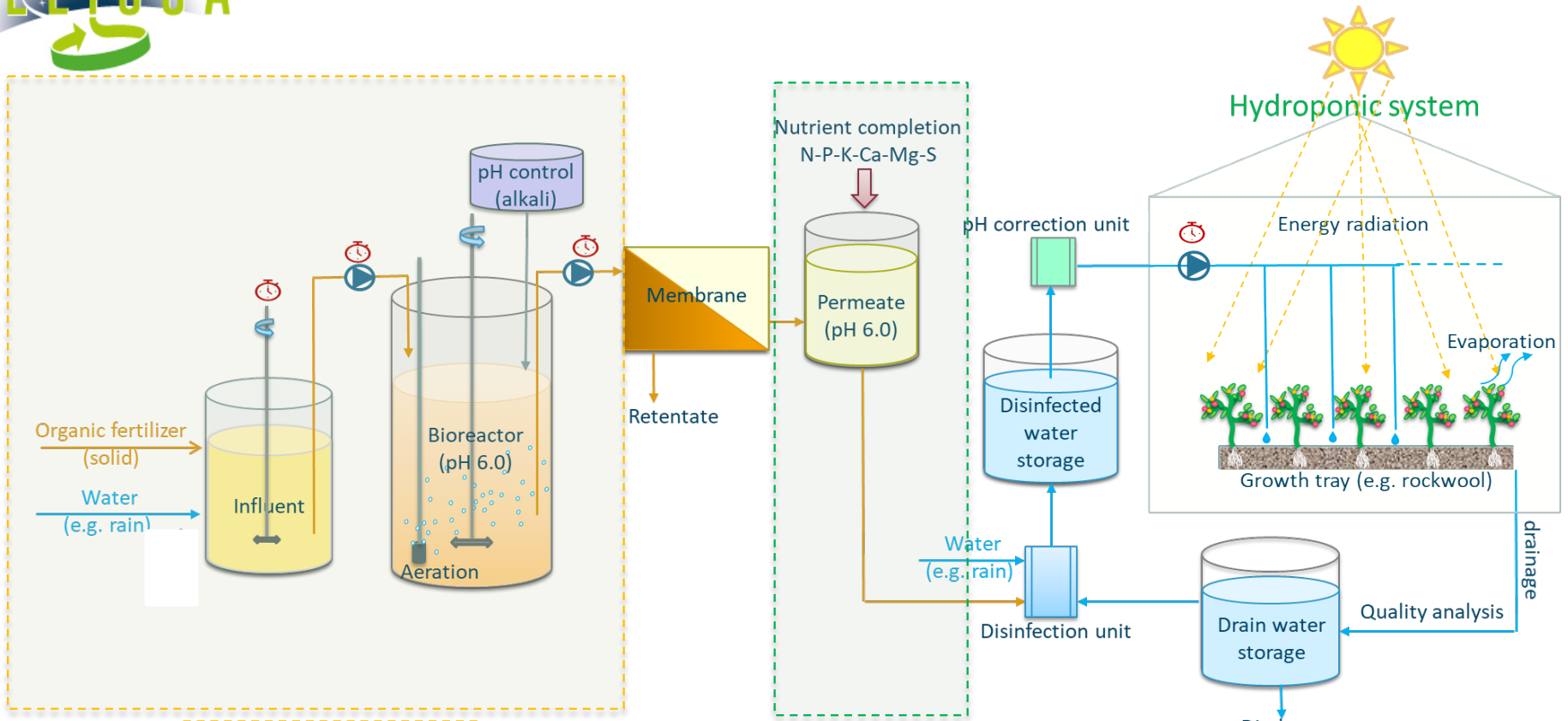
Inoculum type

Reaction temperature

Ammonification rate

Dissolved oxygen

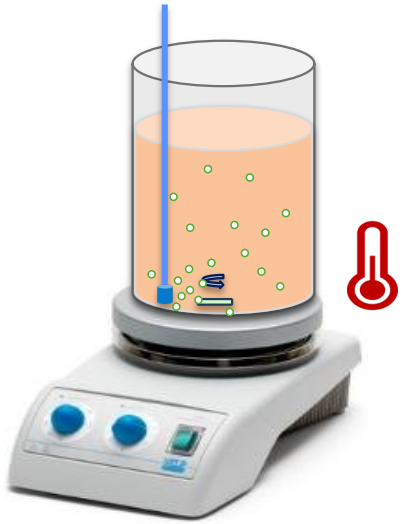
Objective 2 & 3- reactor tests



A concept from organic fertiliser to hydroponic system

Batch tests

Batch	Inoculum source	Inoculum level (g VSS/L)	pH	T (°C)	DO	Fertiliser type (370mg TKN/L)
1	ADS	0.4	7.0±0.2	20±1& 35±1°C	X	PF & MF
2	AS	0.4		20±1& 35±1°C	√	MF

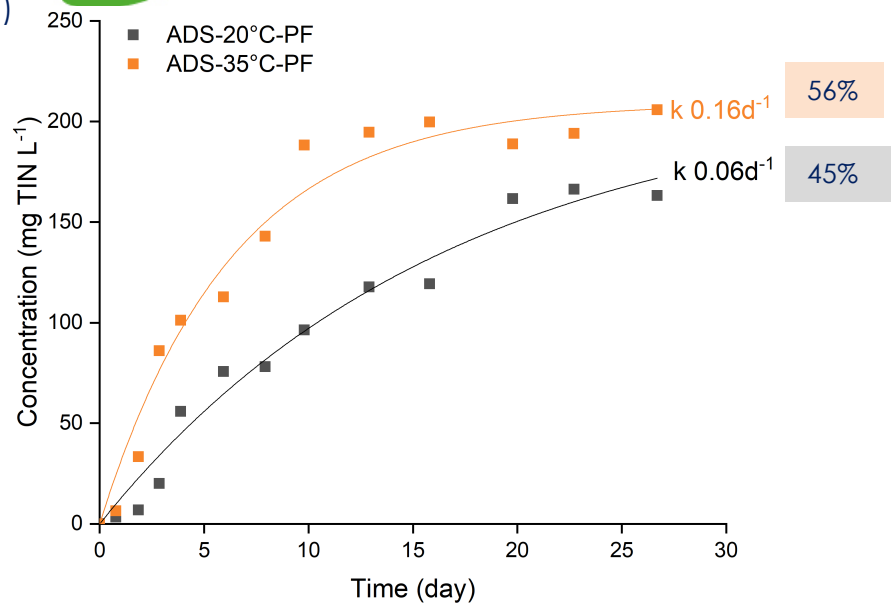


Note:

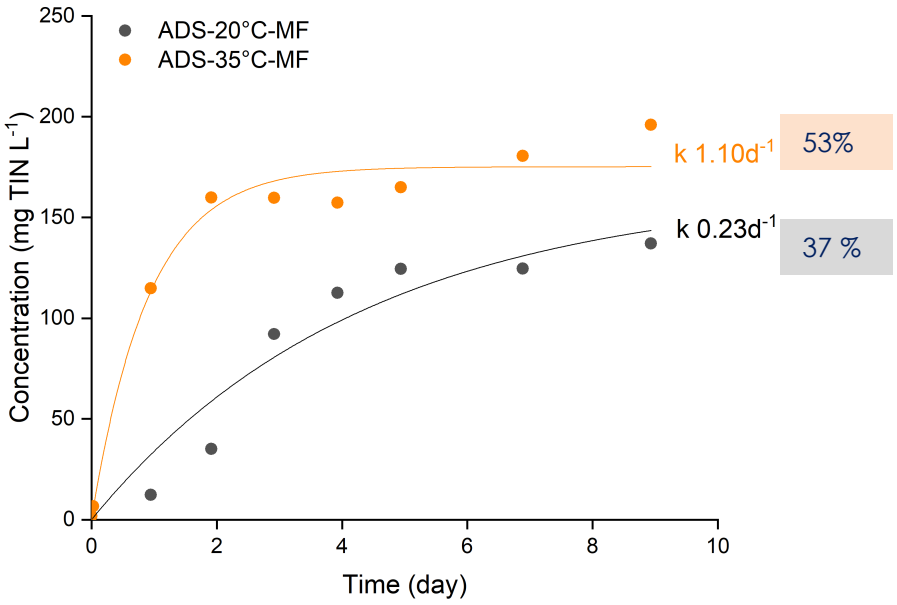
- ADS- anaerobic digestion sludge; AS- activated sludge; (from a local wastewater treatment plant);
- Plant-based fertilizer (PF) : a commercial product (BioAgenasol® profigreen);
- Microbial fertilizer (MF) : a consortium of aerobic bacteria (CAB) (the company Avecom, Belgium);

Batch 1

(a)



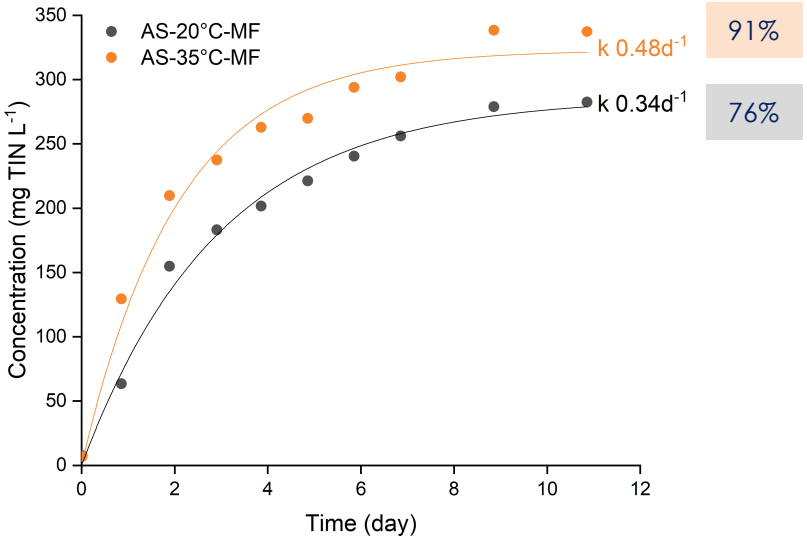
(b)



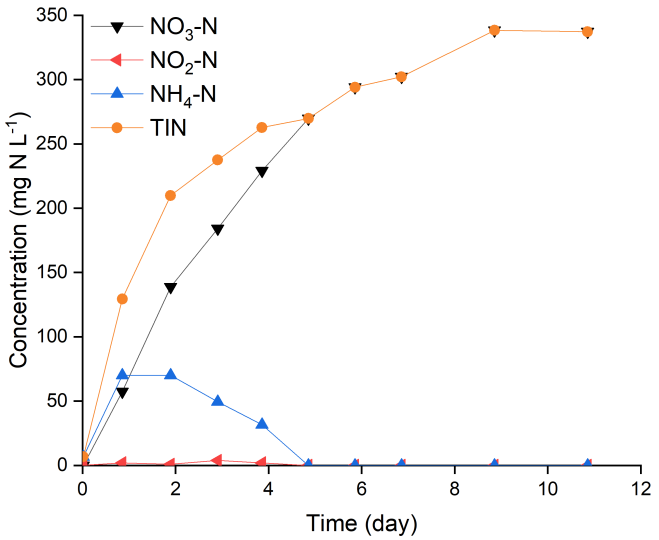
- Total inorganic nitrogen (TIN) release : first-order kinetics;
- Anaerobic incubation at 35°C: **3 and 5-fold** rate constant improvement in bioconversion of PF and MF, respectively;
- MF: faster in TIN (i.e. NH_4^+-N) release→ as a more sustainable fertilizer;

Batch 2

(a)

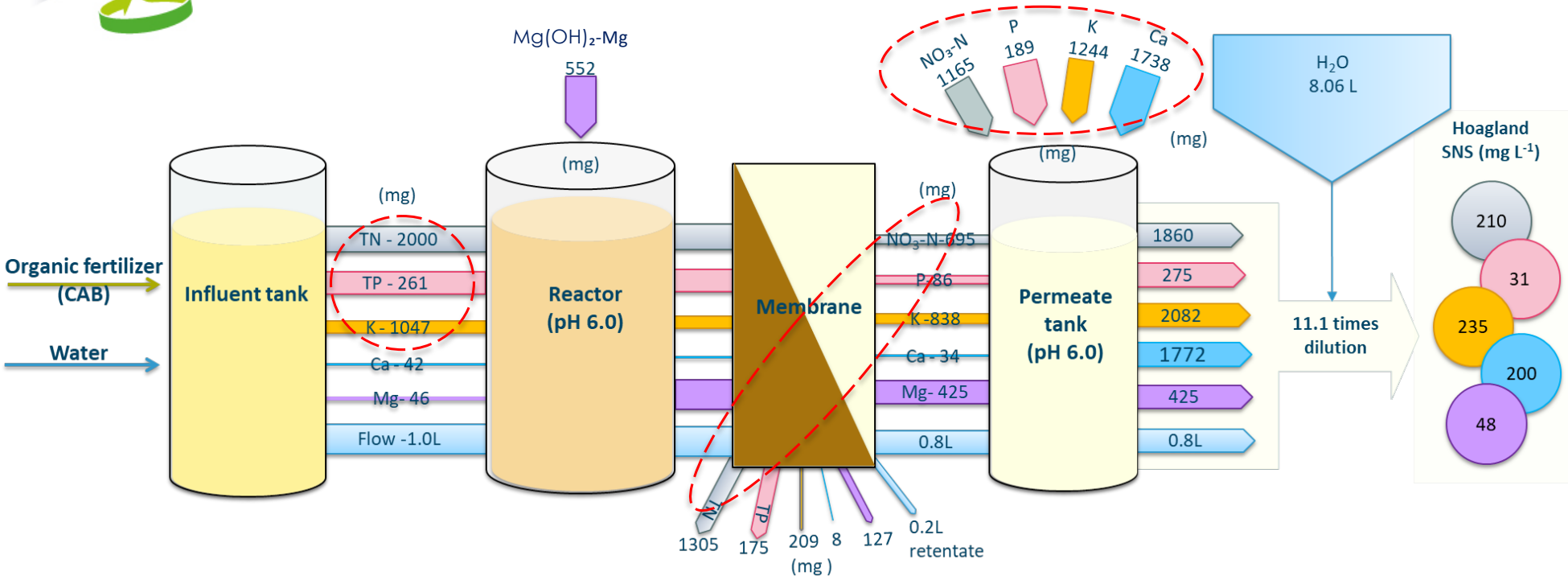


(b)



- Aerobic incubation :
  - significantly improve the TIN releasing efficiency, especially at 35°C;
  - further convert the produced NH_4^+-N to NO_3^--N in a one-stage process.

Sankey diagram based on mass



- Sequencing batch reactor (SBR) condition: 400 mg TN L^{-1} d^{-1}, 5-day-HRT ($Mg(OH)_2$ as pH control regent);
- Around 43% of organic nitrogen converted to NO_3-N (include the part in retentate);
- Hoagland standard nutrient solution: extra commonly used compounds were dosed;

Extrapolated operational expenditure (OPEX)

commercial

OPEX cost categories		Baseline scenario[1]	YaraTera Kristalon Scarlet[2]	YaraTera Kristalon Brown[3]	FloraFlex B1+B2[4]	SBR scenario
Organic fertiliser (CAB)	g NO_3^--N_{OG} L^{-1} Hoagland			N.A.		0.1
	g NO_3^--N_{OG} g^{-1} CAB					0.03
	Euro L^{-1} Hoagland					**2.8×10^{-3}**
Chemical compounds	**Euro L^{-1} Hoagland**	2.3×10^{-8}	1.0×10^{-3}	1.0×10^{-3}	3.4×10^{-2}	**1.6×10^{-8}**
Aeration	g O_2 L^{-1} Hoagland (nitrification)			N.A.		0.4
	g O_2 L^{-1} Hoagland (COD consumption)					1.6
	Euro L^{-1} Hoagland					**1.2×10^{-4}**
Total cost	**Euro L^{-1} Hoagland**	**2.3×10^{-8}**	**1.02×10^{-3}**	**1.01×10^{-3}**	**3.4×10^{-2}**	**2.9×10^{-3}**

- The cost of organic fertilizer (CAB) dominates the OPEX in this study.
- **Prices of SBR scenario has the potential to be cost competitive.**

- [1] composted of se… utrients);
- Assumptions:
  - CAB cost: 0.001 euro g^{-1}
  - The O_2 consumption for complete nitrification is 4.57 g g $^-$ NO_3^--N.
  - The O_2 consumption via COD removal should be around 18.3 g L^{-1} SBR permeate;
  - Average oxygen transfer efficiency: 2 kg O_2 kWh^{-1}; electricity cost: 0.117 EUR kWh^{-1};

Take home

- Optimal conditions to improve the ammonification performance: **35°C+ DO + microbial fertiliser.**
- SBR at 400 mg TN L^{-1} d^{-1} with a 5-day-HRT: **around 43% NO3-N production.**
- Compared to commercial solutions, organic nutrient solution: **cost competitive.**

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THANK YOU.

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国家留学基金管理委员会 • CHINA SCHOLARSHIP COUNCIL •

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