Technical University of Denmark DTU

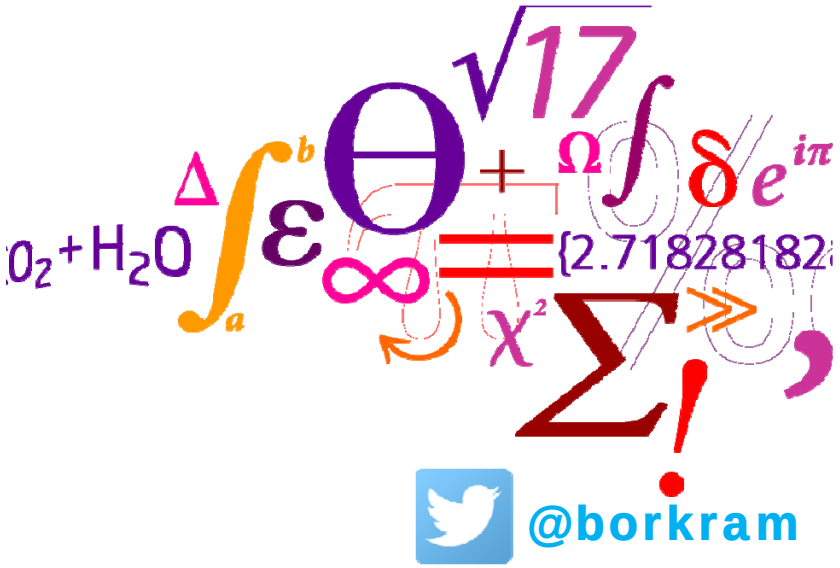
Valorisation of Effluents from Anaerobic Digestion as Single Cell Protein – Focus on Safe Gas Supply

Borja Valverde Pérez

Bioenergy and Microbial Ecology and Technology Laboratory (Metlab) research groups

August Z. Zachariae, Astrid F. Kjeldgaard, Zahra Rasouli, Wei Xing, Alejandro Palomo, Martina D'Este, Davide De Francisci, Mathias L. Pape, Barth F. Smets, Irini Angelidaki

DTU Environment
Department of Environmental Engineering



Agenda

- Microbial protein and its impact on nitrogen cycle
- Co-cultivation of green microalgae and methanotrophic bacteria
- Bubble-free membrane bioreactor

Microbial protein and Methane Oxidizing Bacteria (MOB)

What is microbial protein?:protein produced by microbes, which can be used as feed ingredient (EU approved!)

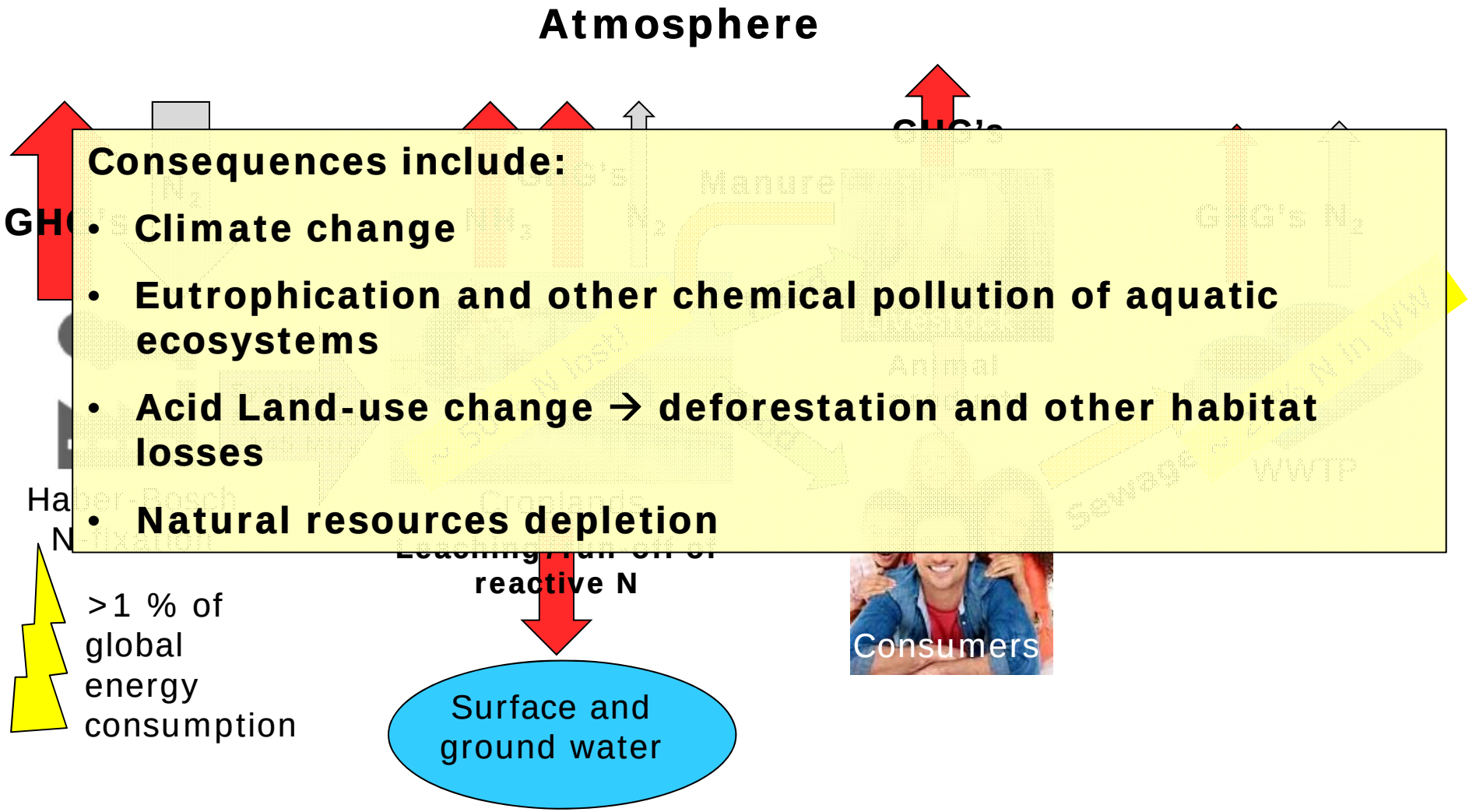
Why MOB?:

- Bacteria have high growth rates and crude protein content compared to algae and fungi.
- Compared to algae, the cultivation of MOB's is less space demanding.
- 1st generation process already exists: natural gas and synthetic nitrogen resources

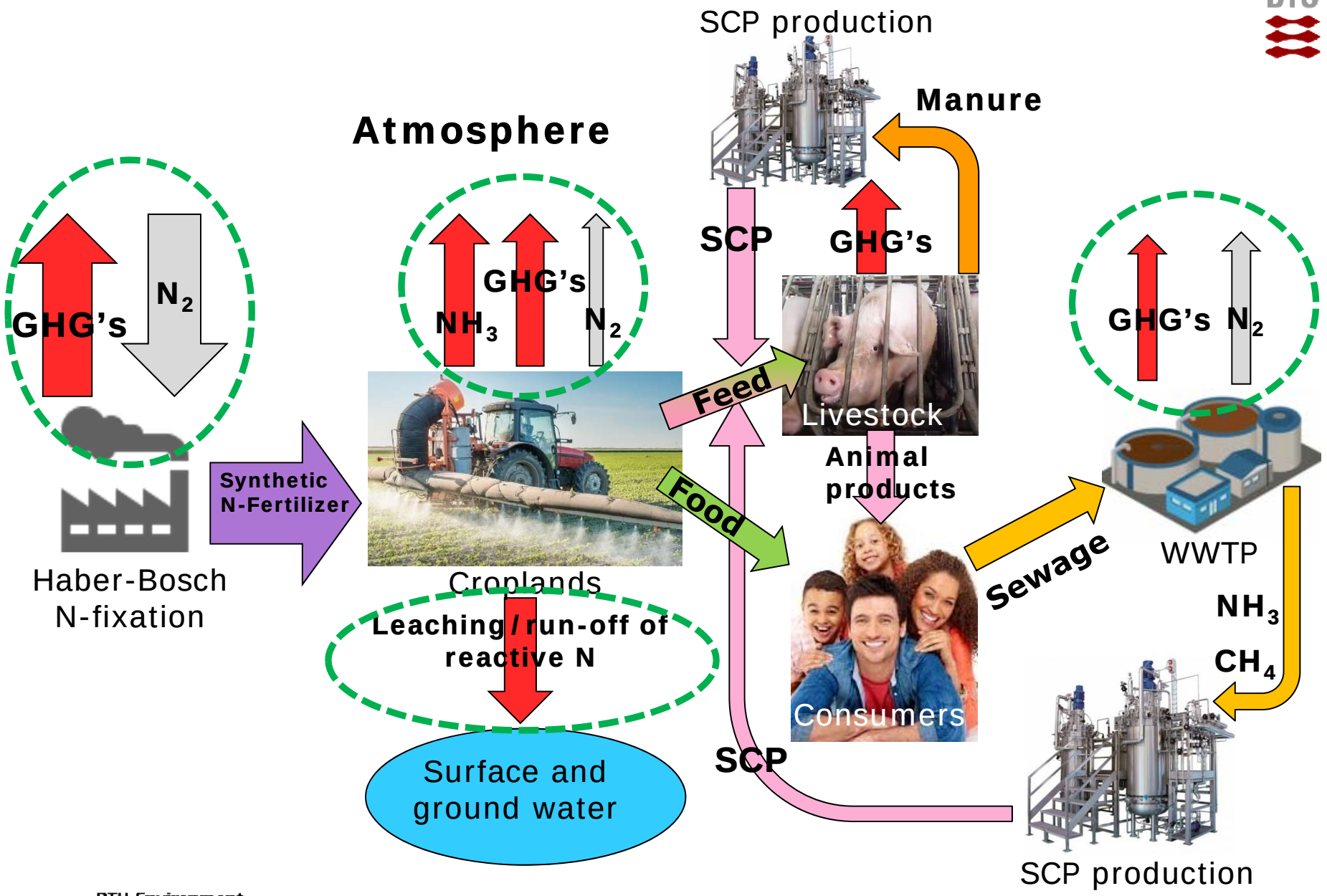
[http://www.unibio.dk]

- Methane can be produced from most organic waste at a relatively low cost.

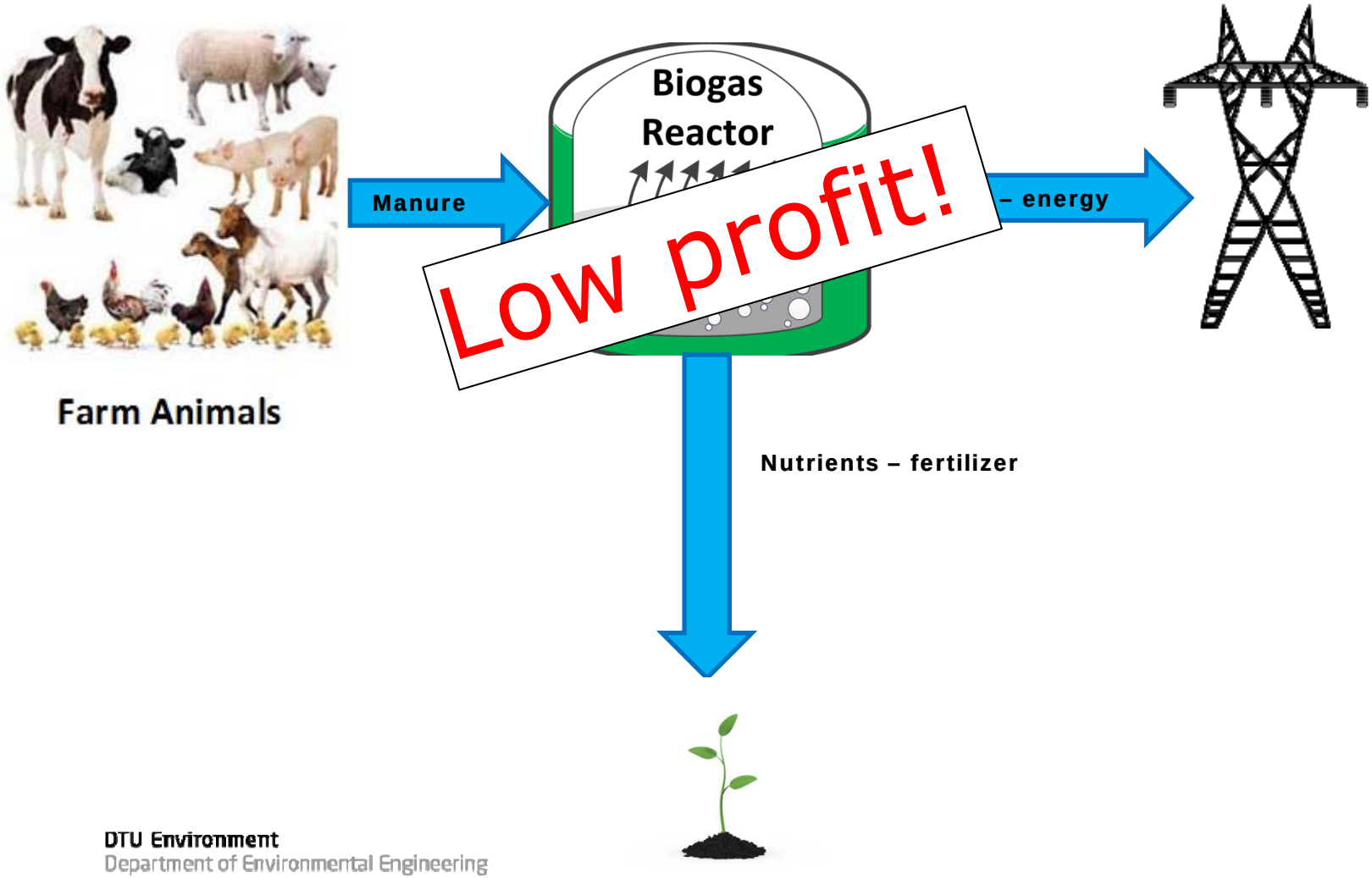
Anthropogenic nitrogen cycle



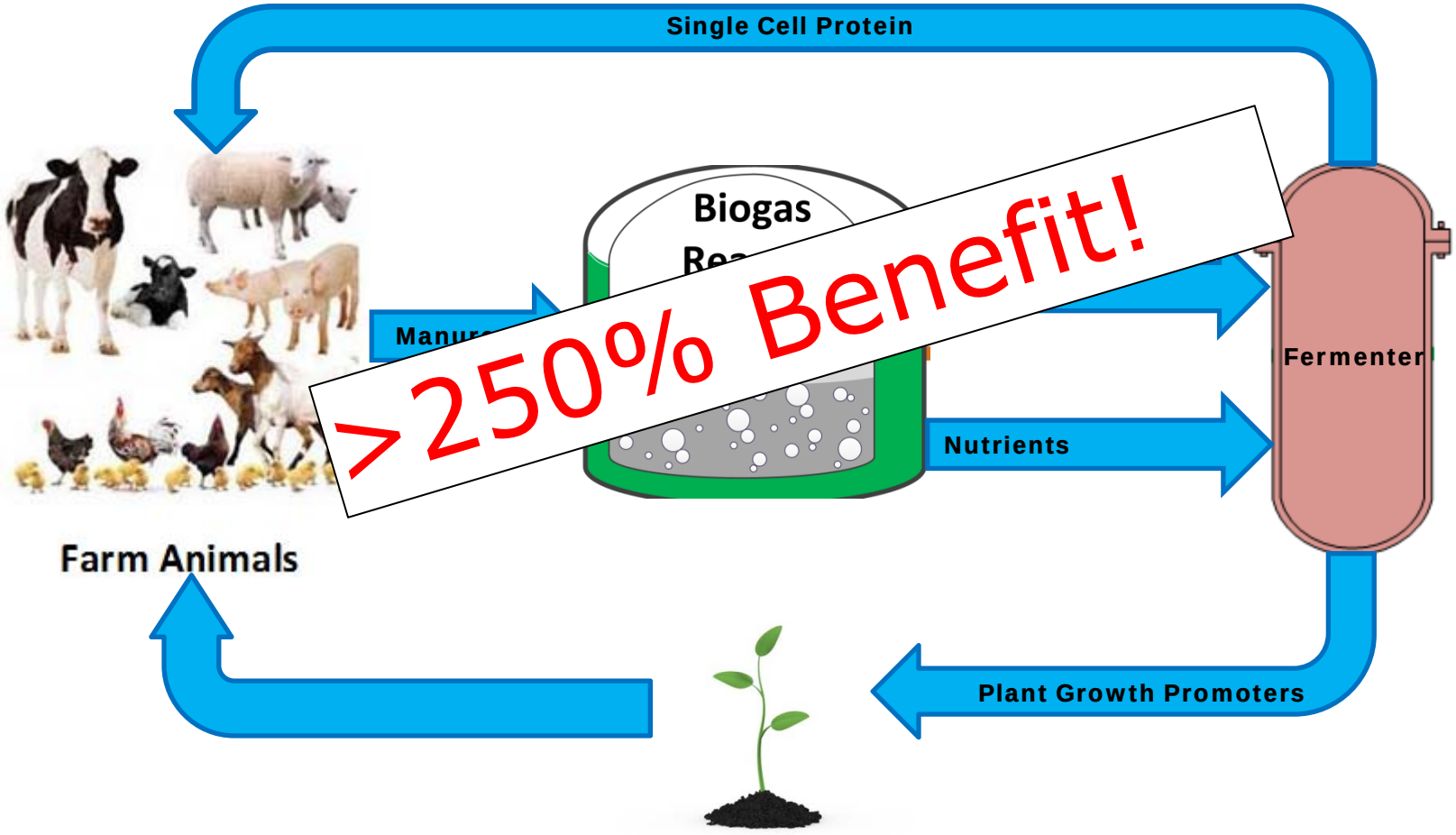
Closing the nitrogen drain



Nutrient Management – Traditional approach



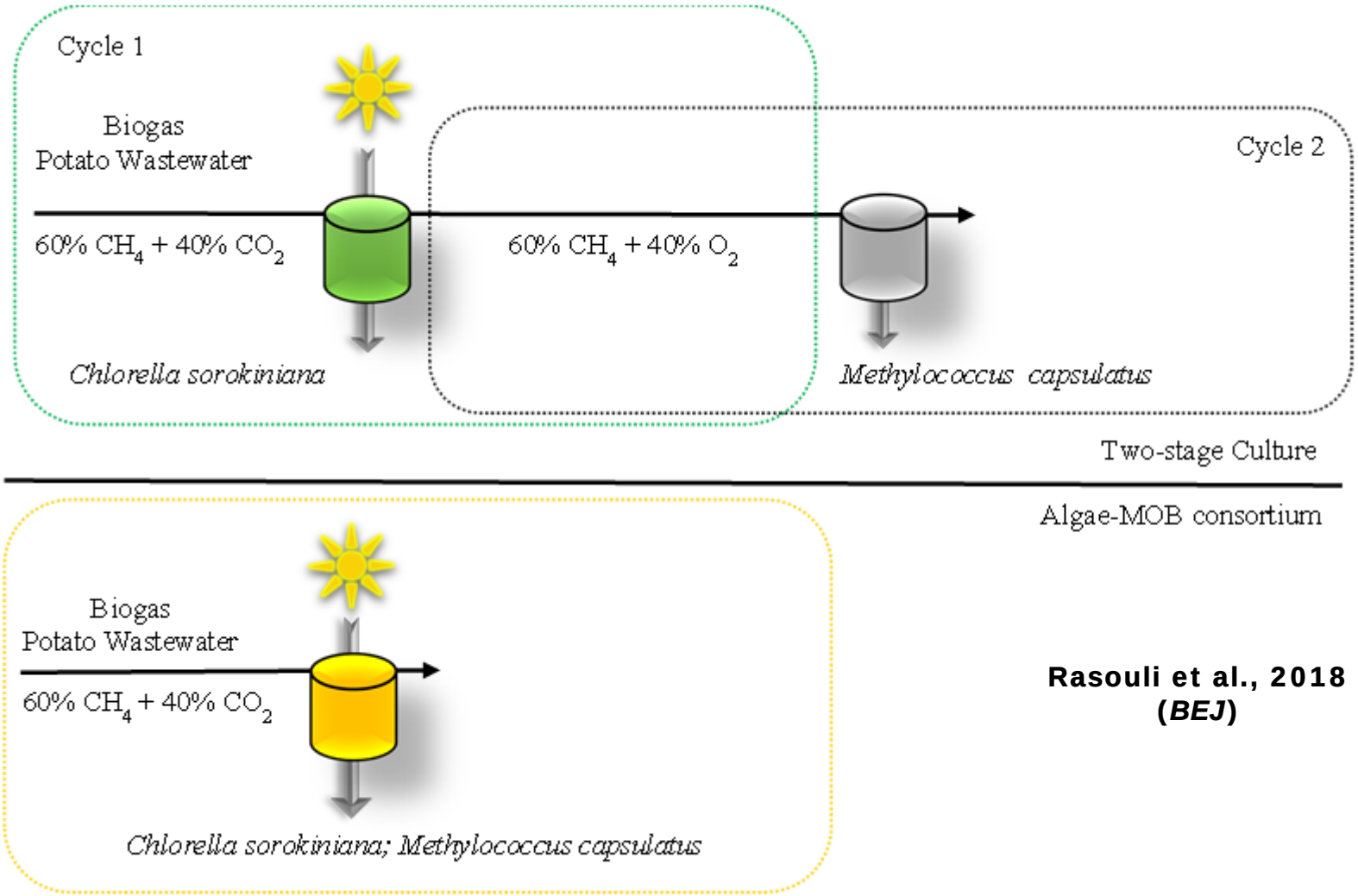
Nutrient Management – Nutrient Upcycling and Reuse in Agriculture



Focus on Safe Gas Supply

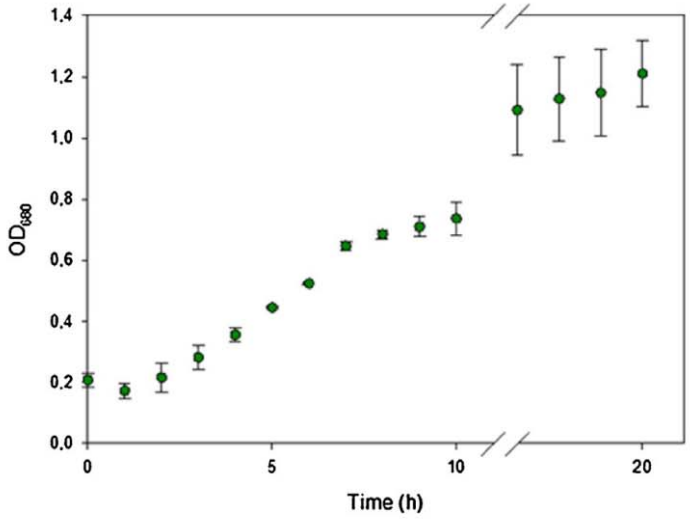
DTU Environment
Department of Environmental Engineering

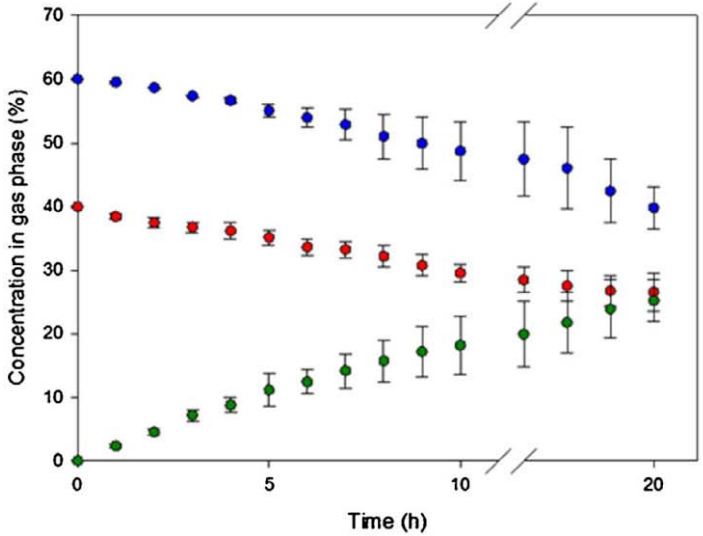
Co-cultivation of algae and methanotrophs



Rasouli et al., 2018 (*BEJ*)

Co-cultivation of algae and methanotrophs

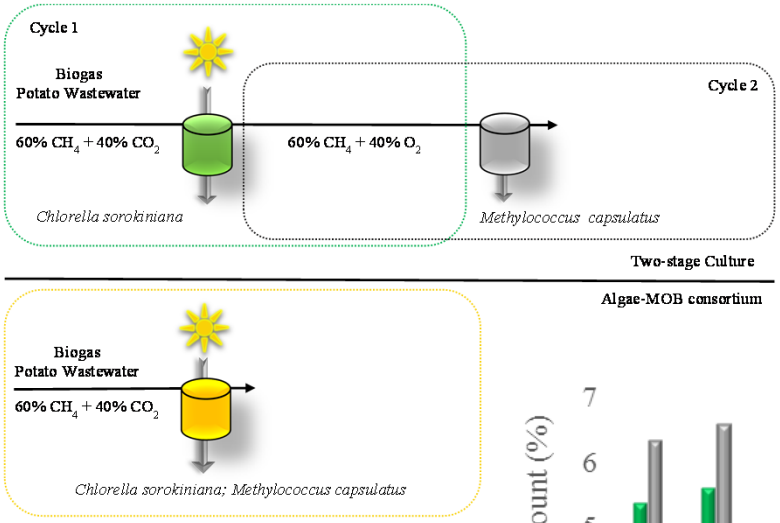




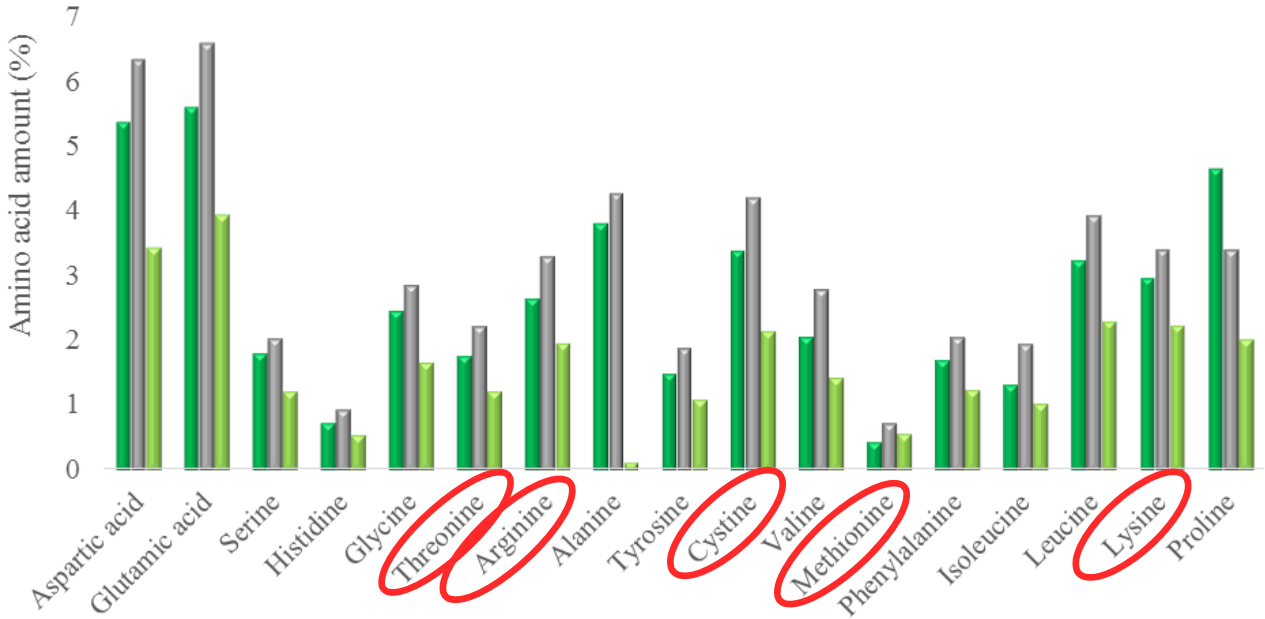
Blue: CH_4
Red: CO_2
Green: O_2

- The consortium effectively removed organic carbon and nutrients
- Imbalance between photosynthesis and methane oxidation
  - Level of explosion is achieved!
- Further optimization is needed

Co-cultivation of algae and methanotrophs



Contains the essential amino acids for chicken

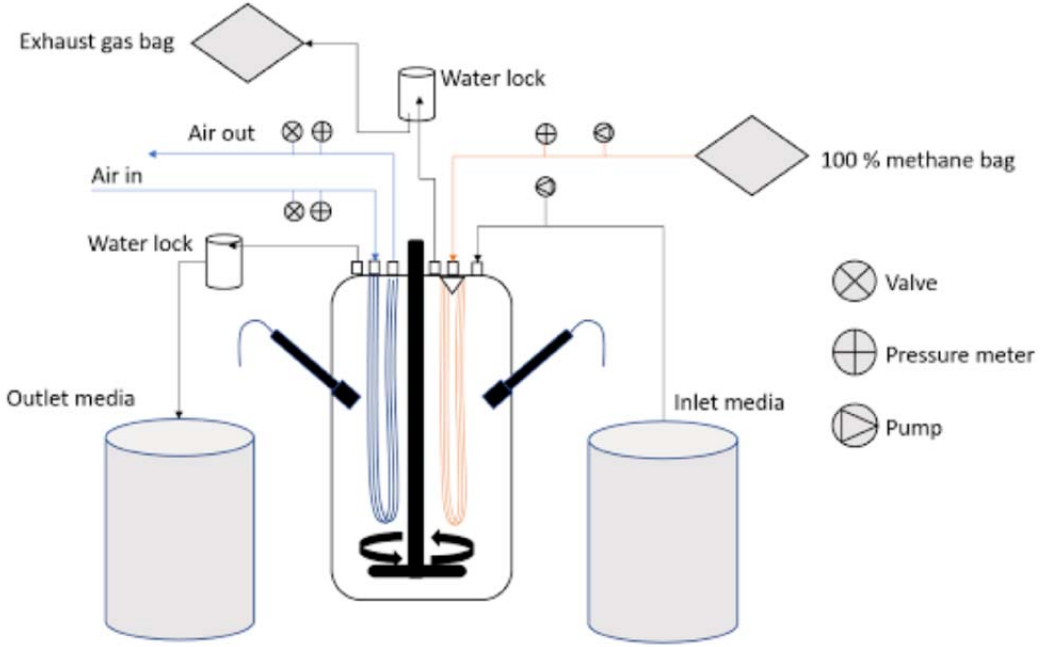


Bubble-free membrane bioreactor

Cultivation of a mixed culture of methane oxidizing bacteria

First experiences:

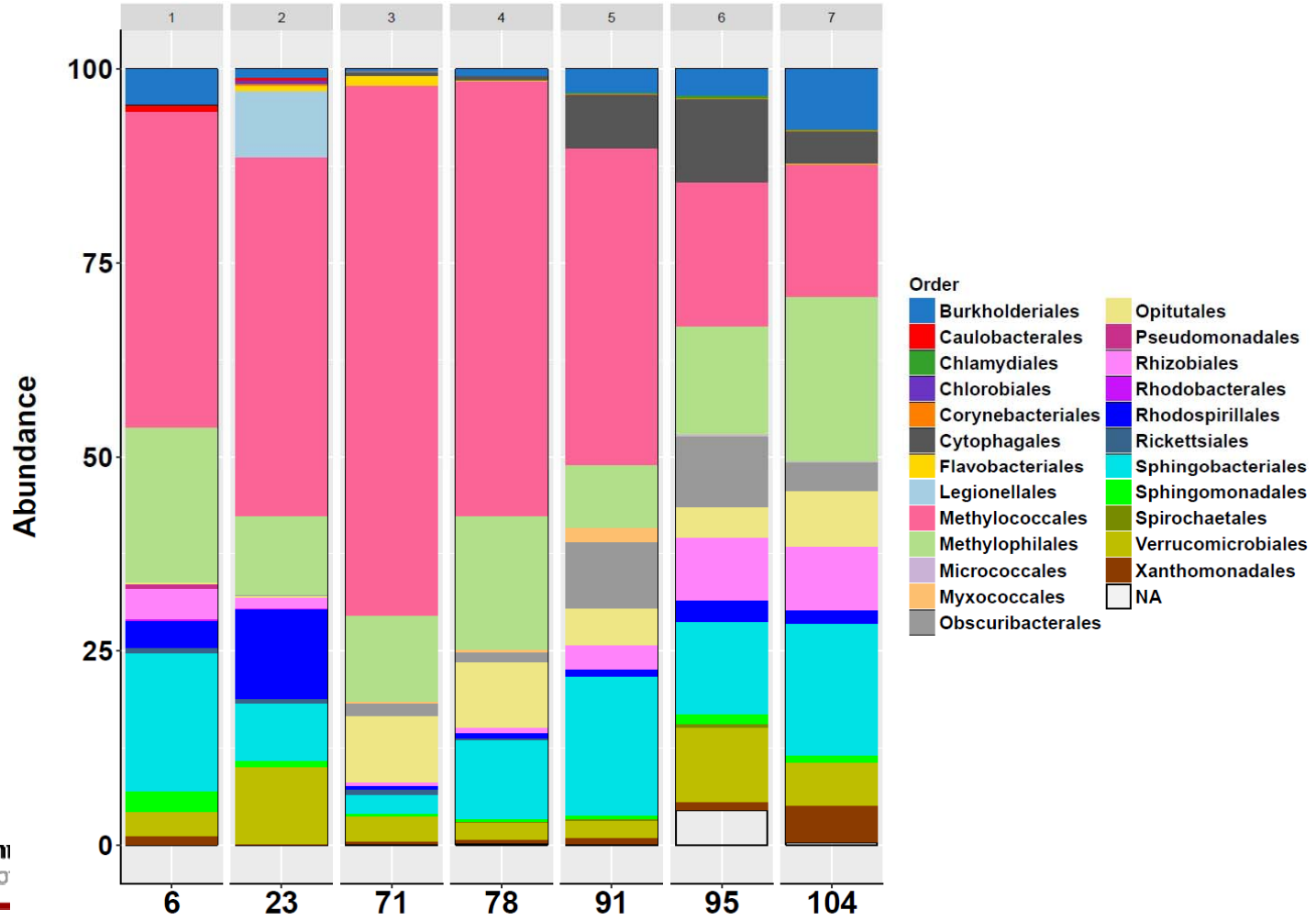
- Suboptimal supply of gasses leads to biofilm formation
- Leakage of gases and building of headspace
- Progressive lose of methanotrophs



Bubble-free membrane bioreactor

Progressive lose of methanotrophs

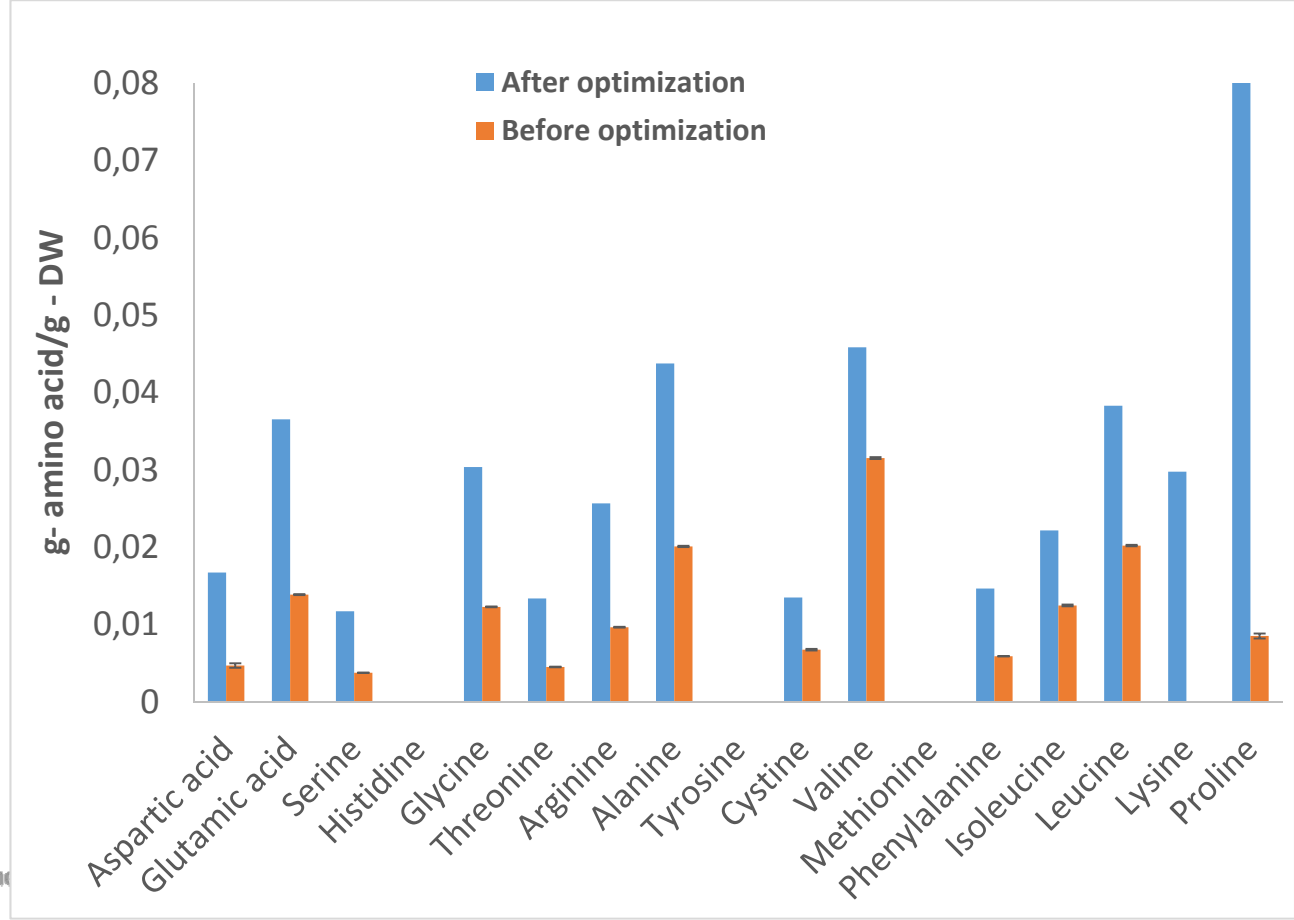
- Methylococcales (pink)
- Methylophilales (light green)



Bubble-free membrane bioreactor

After gas supply optimization → good oxygen to methane ratio

- Biomass grows in suspension
- Microbial protein content increased → potential recovery of methanotrophic biomass
- Minimization of gas leakage and avoidance of head space



Take home message

- Both proposed options can produce biomass suitable as feed ingredient
- Co-cultivation of green microalgae and methanotrophs
  - Challenges
    - Photosytensis and methane oxidation need to be balanced
    - Complex process control is needed
  - Opportunities
    - Valorization of the carbon dioxide from biogas
- Bubble-free membrane bioreactor
  - Challenges
    - Risk of carbon dioxide accumulation from biogas and methane oxidation
  - Opportunities
    - Operation below the low explosive limit

Acknowledgement

@IriniAngelidaki

@Metlab_DTU

DTU Environment
Department of Environmental Engineering

What happens with the real pollutants?

Who are the bad guys?

- Heavy metals
- Impurities
- Pathogens
- Pharmaceuticals
- Antibiotic resistance genes

How do we get read of them?

- Membrane filtration
- Bio-electrochemical systems