Biotechniques for Air Pollution Control & Bioenergy 2019

Optimisation of CH_4 bioconversion into high added value biopolymers: Polyhydroxyalkanoates (PHA)

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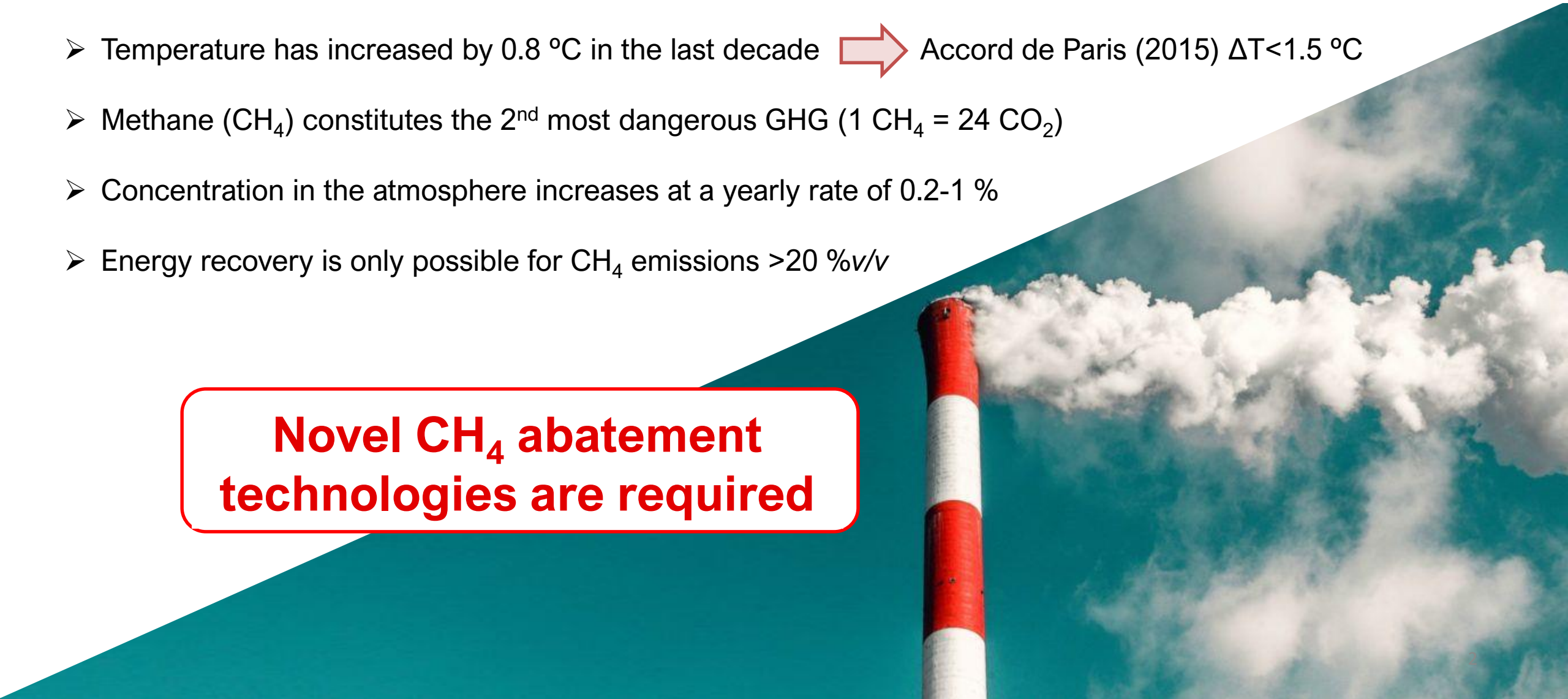
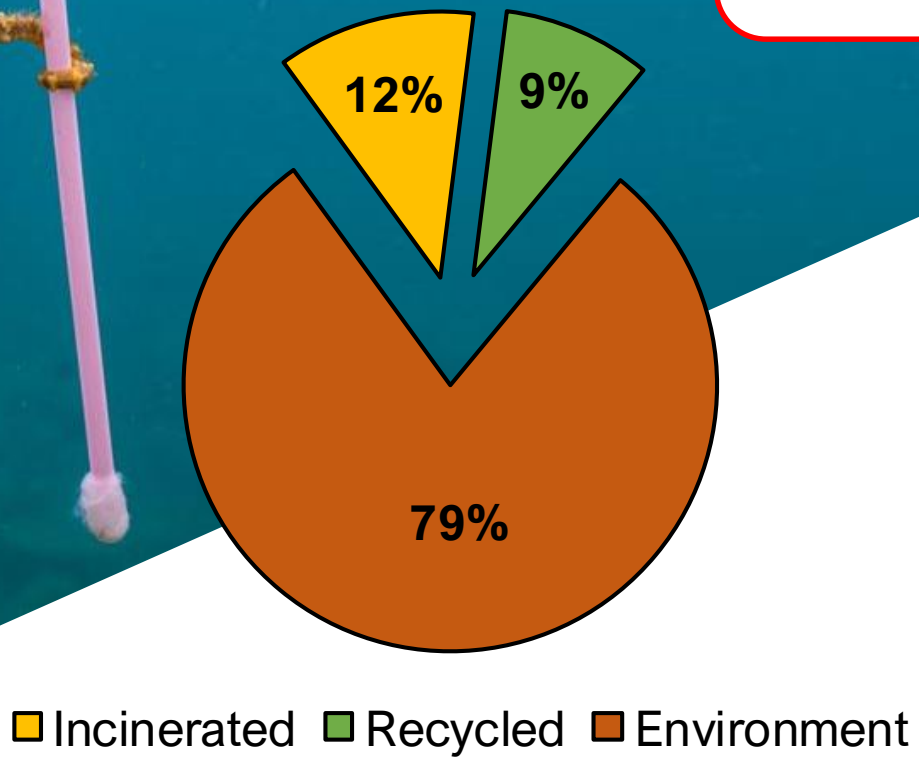
Introduction: Climate change & plastic pollution

- Temperature has increased by 0.8 ºC in the last decade ⇨ Accord de Paris (2015) $\Delta T<1.5$ ºC
- Methane (CH_4) constitutes the 2nd most dangerous GHG (1 CH_4 = 24 CO_2)
- Concentration in the atmosphere increases at a yearly rate of 0.2-1 %
- Energy recovery is only possible for CH_4 emissions >20 %*v/v*

Novel CH_4 abatement technologies are required



Introduction: Climate change & plastic pollution

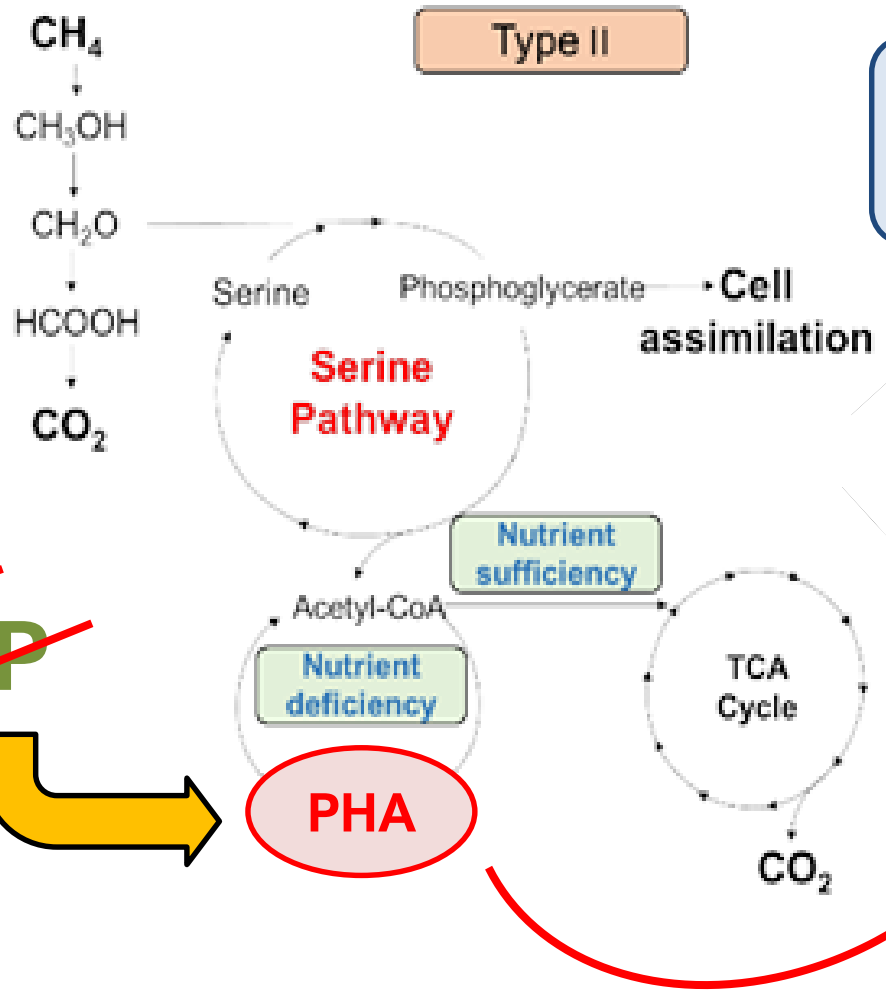


Low-cost, biodegradable and renewable polymers are needed

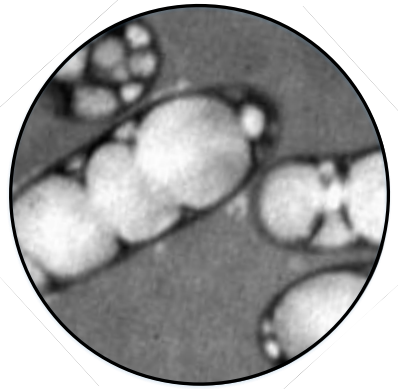
- Yearly plastic production: 335,000,000 ton:
  - < 1% of bioplastics
  - < 50% of bioplastics are biodegradable
  - 50 % of single use plastics

Introduction: Methanotrophs

Type II methanotrophs can use CH_4 as the only carbon and energy source



Some species accumulate 20-60 %*w/w*

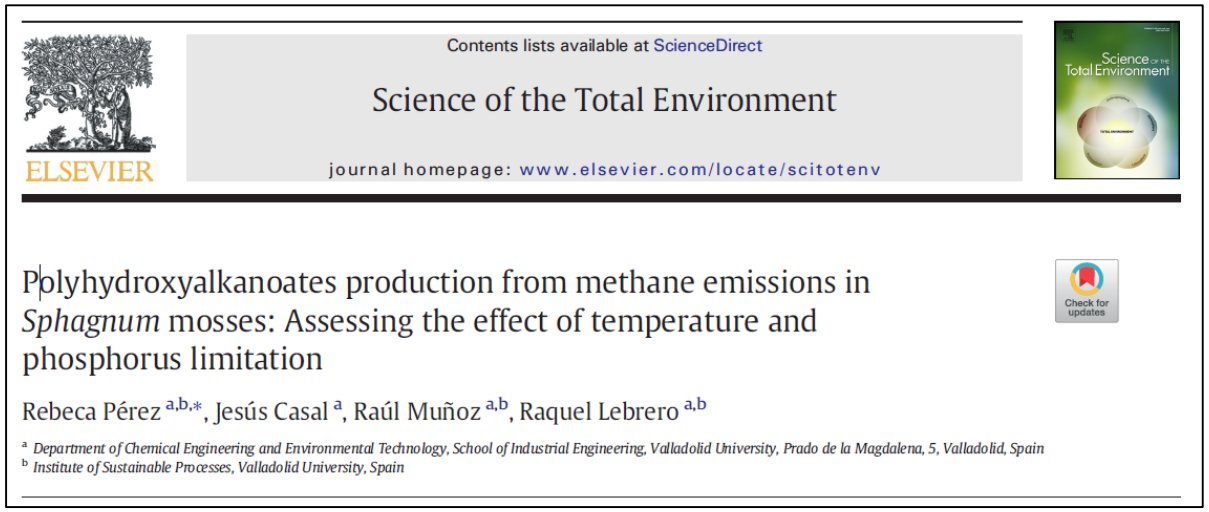


Nutrient limitation induces intracellular PHA accumulation

Introduction: Polyhydroxyalkanoates (PHA)

- Comparable characteristics to PP and PE
- Reduced environmental impact and **positive carbon footprint**
- Produced from renewable resources and waste streams **(4 - 20 €/kg)**:
  - Carbon source constitutes 40 - 50 % of total production costs
  - CH_4 emissions are **free!!**
- Poly-3-hydroxybutyrate (PHB) is predominant in PHA accumulating methanotrophic bacteria
- Applications in packaging, medicine and agriculture

Introduction: Previous work



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Polyhydroxyalkanoates production from methane emissions in *Sphagnum* mosses: Assessing the effect of temperature and phosphorus limitation

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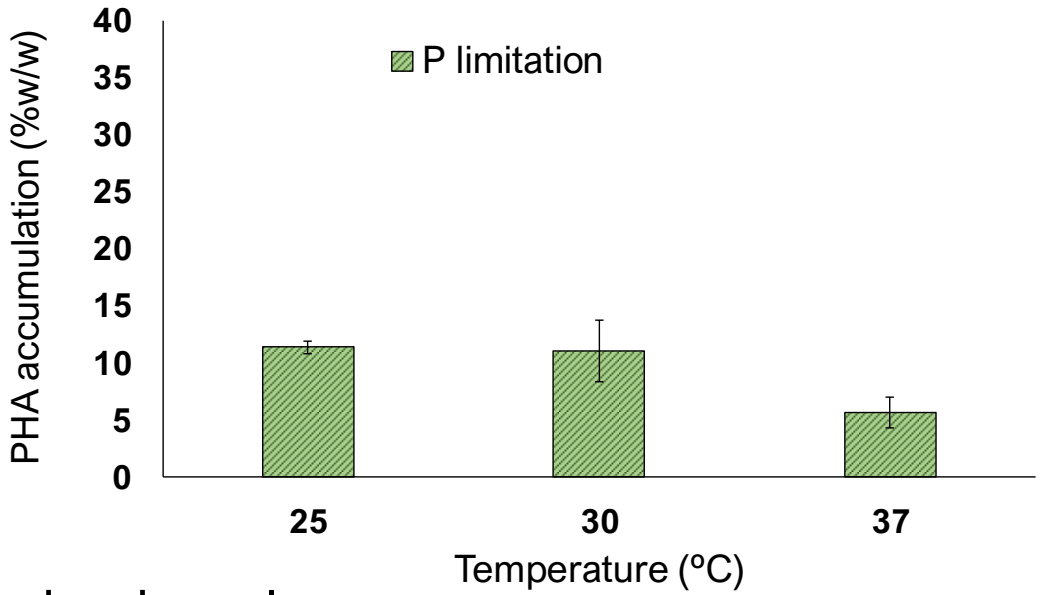
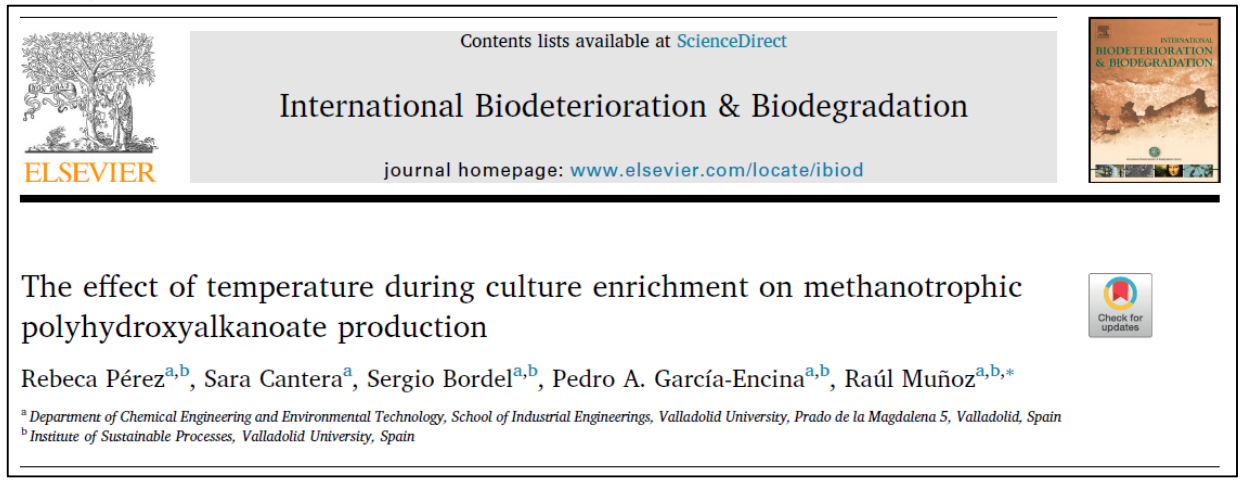


- *Sphagnum Mosses* and activated sludge were used as inoculum
- PHA accumulation under P limitation remained <15 %
- T is a selective pressure for enrichment of PHA accumulating bacteria under P limitation :
  - 0.08 % *Methylocystis* ⇨ 17-34 % *Methylocystis*

Introduction: Previous work



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International Biodeterioration & Biodegradation

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The effect of temperature during culture enrichment on methanotrophic polyhydroxyalkanoate production

Rebeca Pérez[a,b], Sara Cantera[a], Sergio Bordel[a,b], Pedro A. García-Encina[a,b], Raúl Muñoz[a,b,*]

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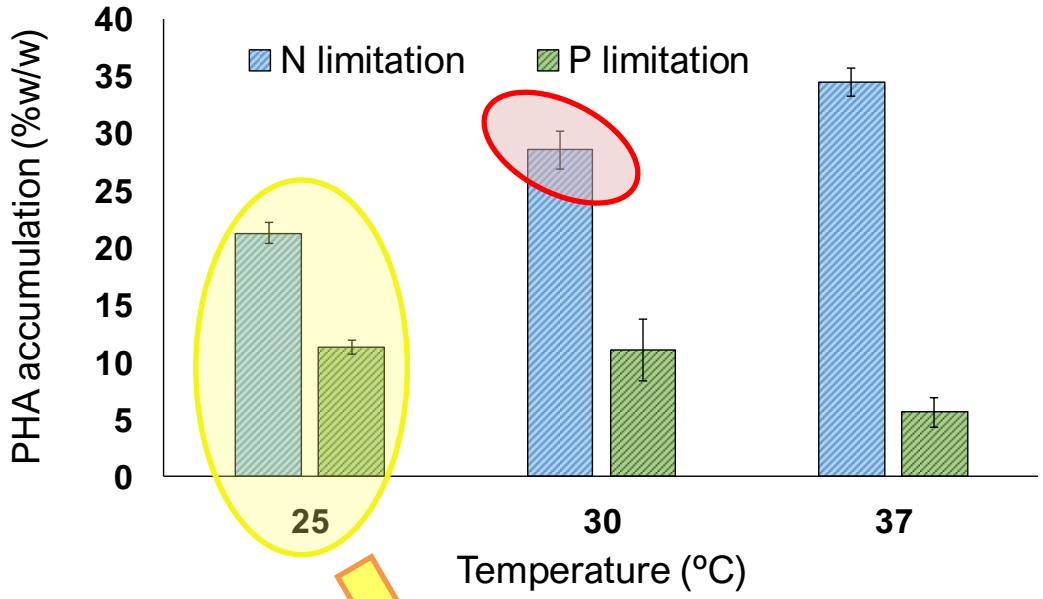
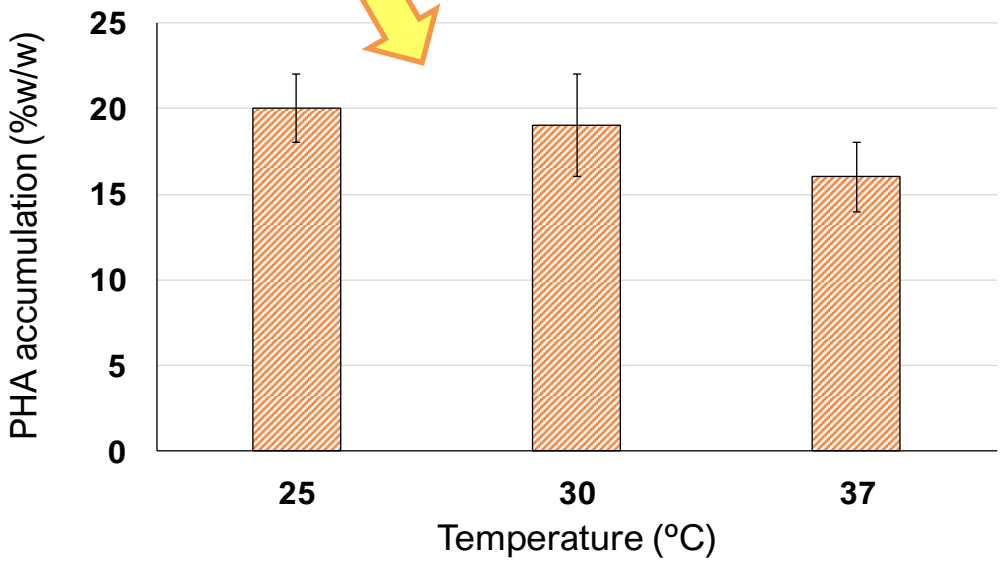
[b] Institute of Sustainable Processes, Valladolid University, Spain

- PHA increase with T during N limitation
- **N limitation** >> **P limitation**
- Effective enrichment: ~30% *Methylocystis*
- No effect of temperature during PHA accumulation
- **Biomass enriched at 30 ºC showed lower CH_4 and N requirements**



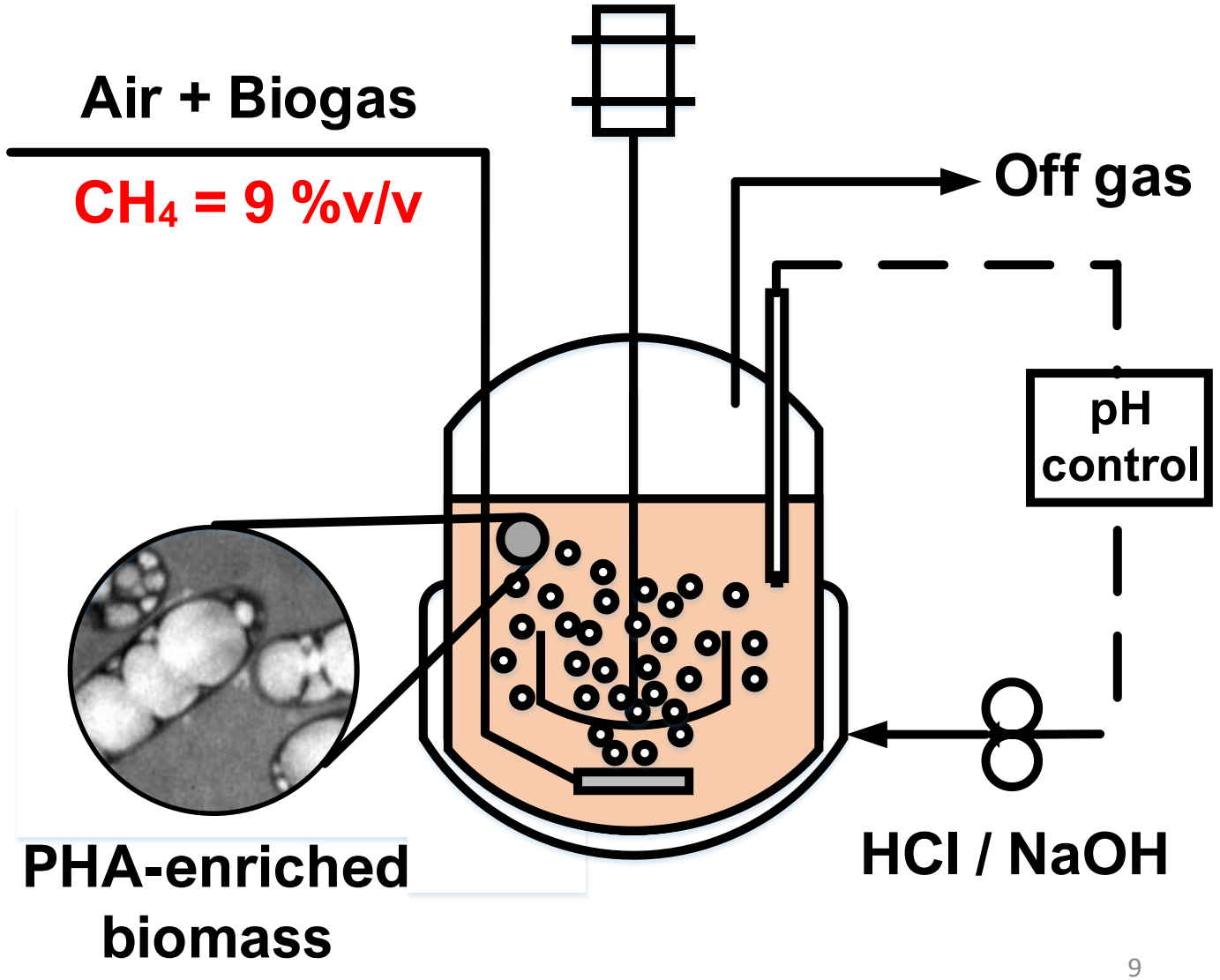


Objectives

- Selecting optimum conditions for CH_4 bioconversion into PHA in a bioreactor under nitrogen limitation
- Assessing the effect of pH on CH_4 abatement and PHA accumulation (pH = **5.5**, **7**, **8.5** and **10**)
- Evolution of microbial diversity under nitrogen limitation at different pH

Materials & Methods: Experimental set-up

- Biostat Sartorius
- Volume = 2.5 L
- Mixing = 600 rpm
- EBRT = 60 min
- O_2:CH_4 = 2
- pH = 5.5, 7, 8.5 and 10
- T = 25 ºC
- N limitation
  - Whittenbury modified
- Pyrosequencing analysis



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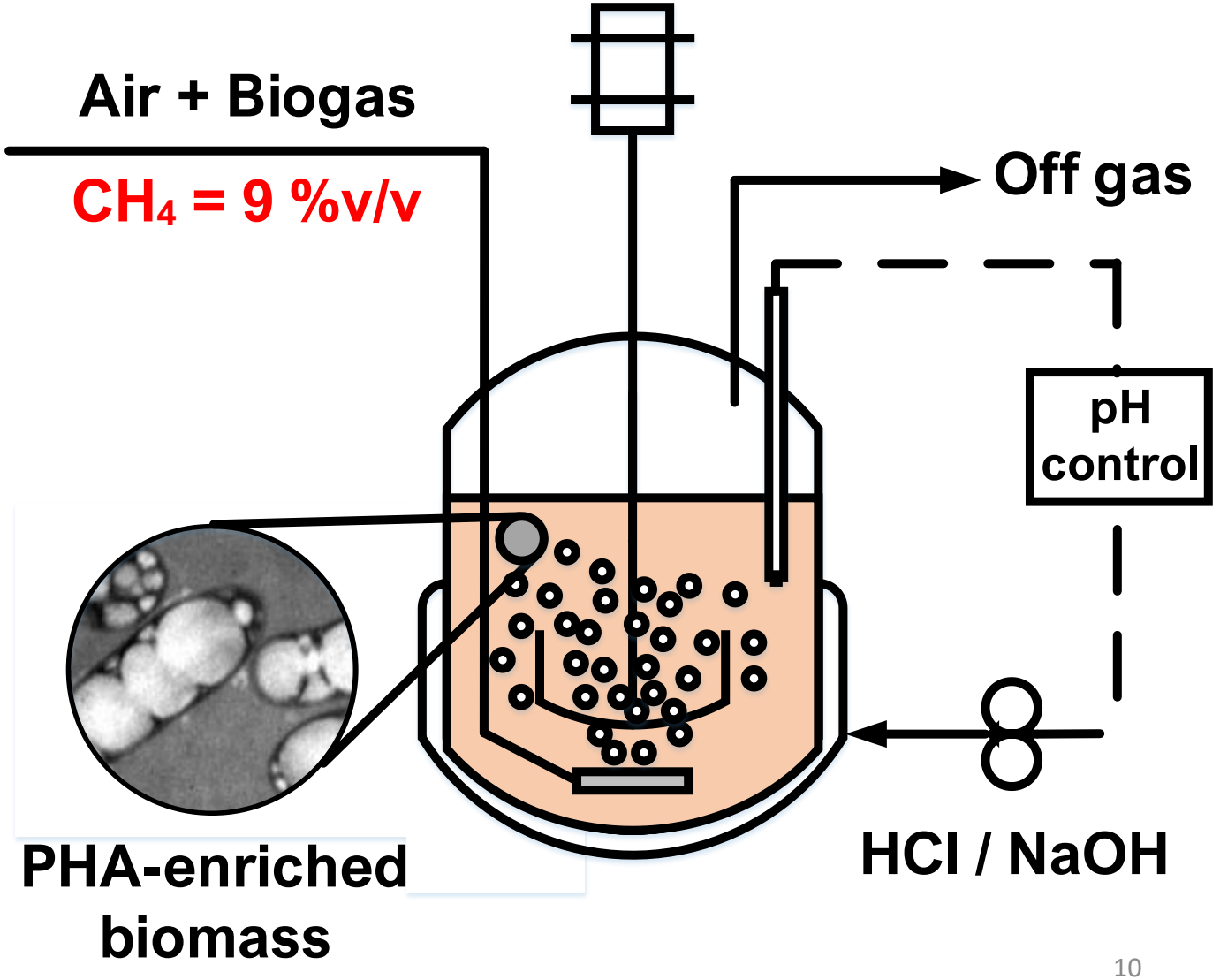
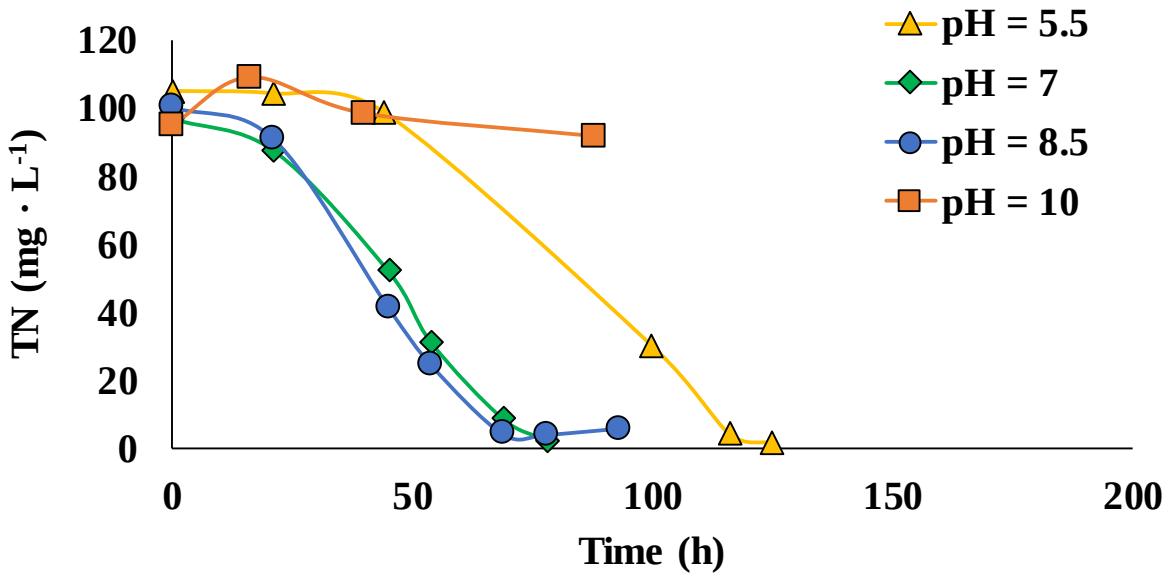
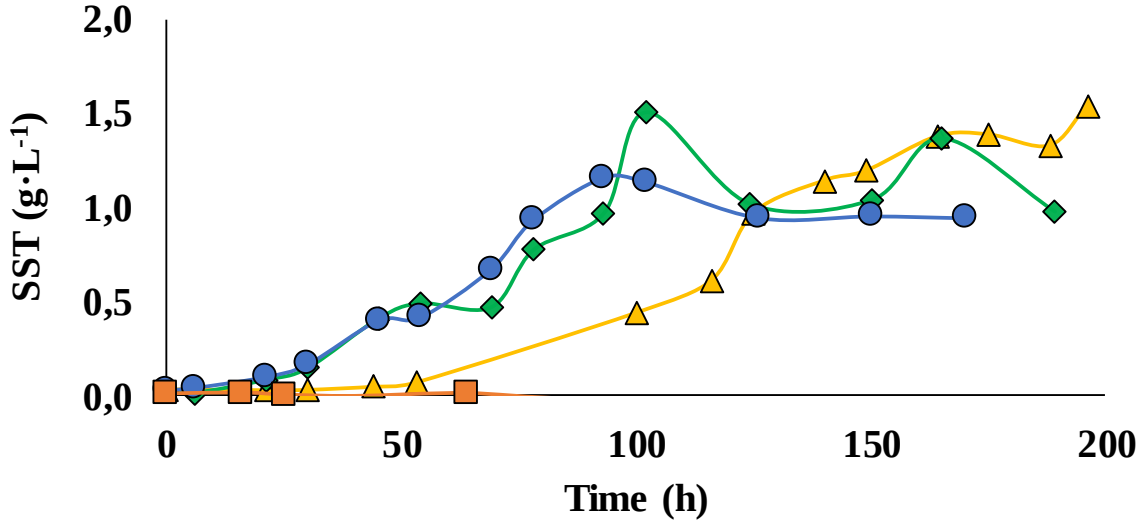


Results: Nitrogen depletion

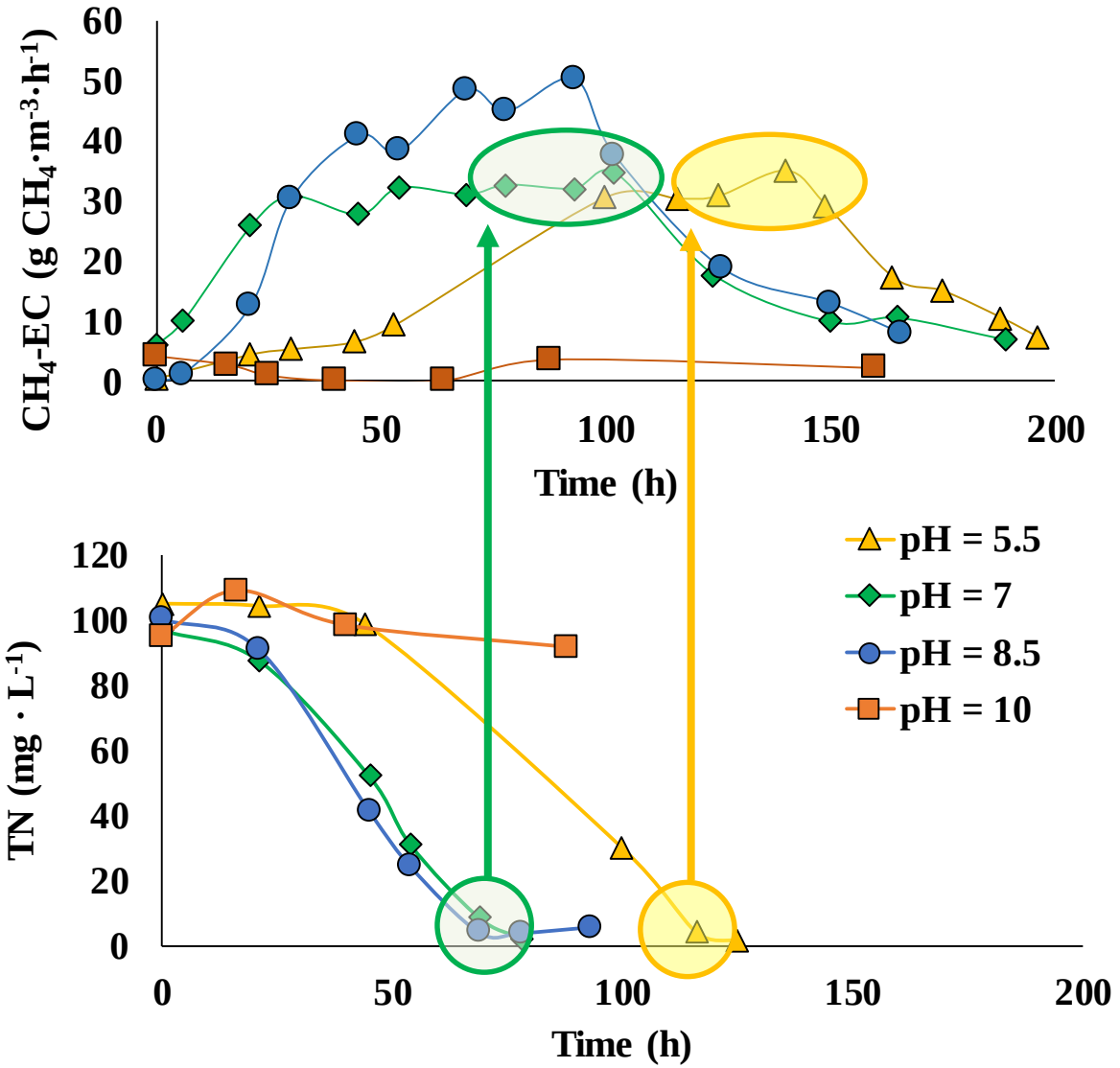
- Slower growth at pH = **5.5**
- Similar growth at pH = **7** and **8.5**
- No growth observed at pH = **10**





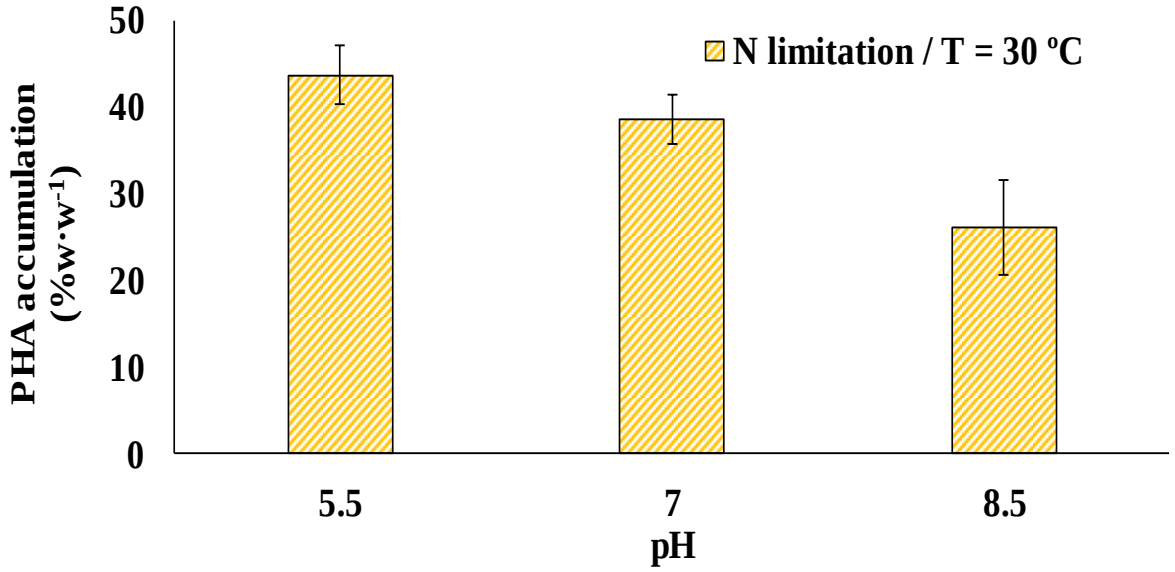
Results: CH_4 abatement

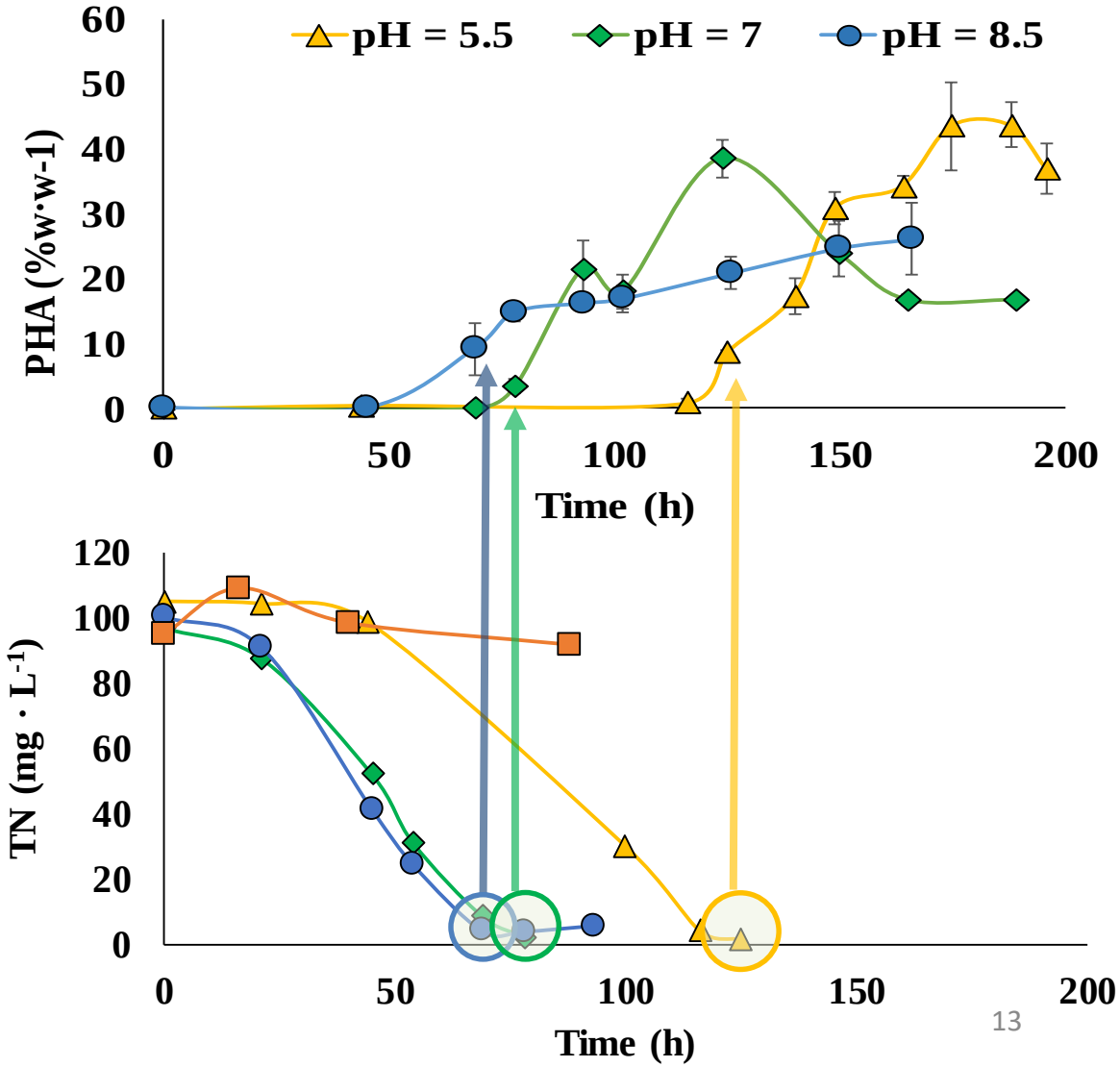
- pH = **8.5** supported the highest CH_4 abatement and no elimination was observed at pH = **10**
- Similar CH_4 abatement at pH = **5.5** and **7**
- System is mass transfer limited:
  - Na^+ ⇧ Bubble coalescence ⇩
- CH_4 abatement is maintained ~48 h after N depletion (PHA accumulation)



Results: PHA accumulation

- PHA accumulation started immediately after N deprivation
- PHA accumulation decreased with pH

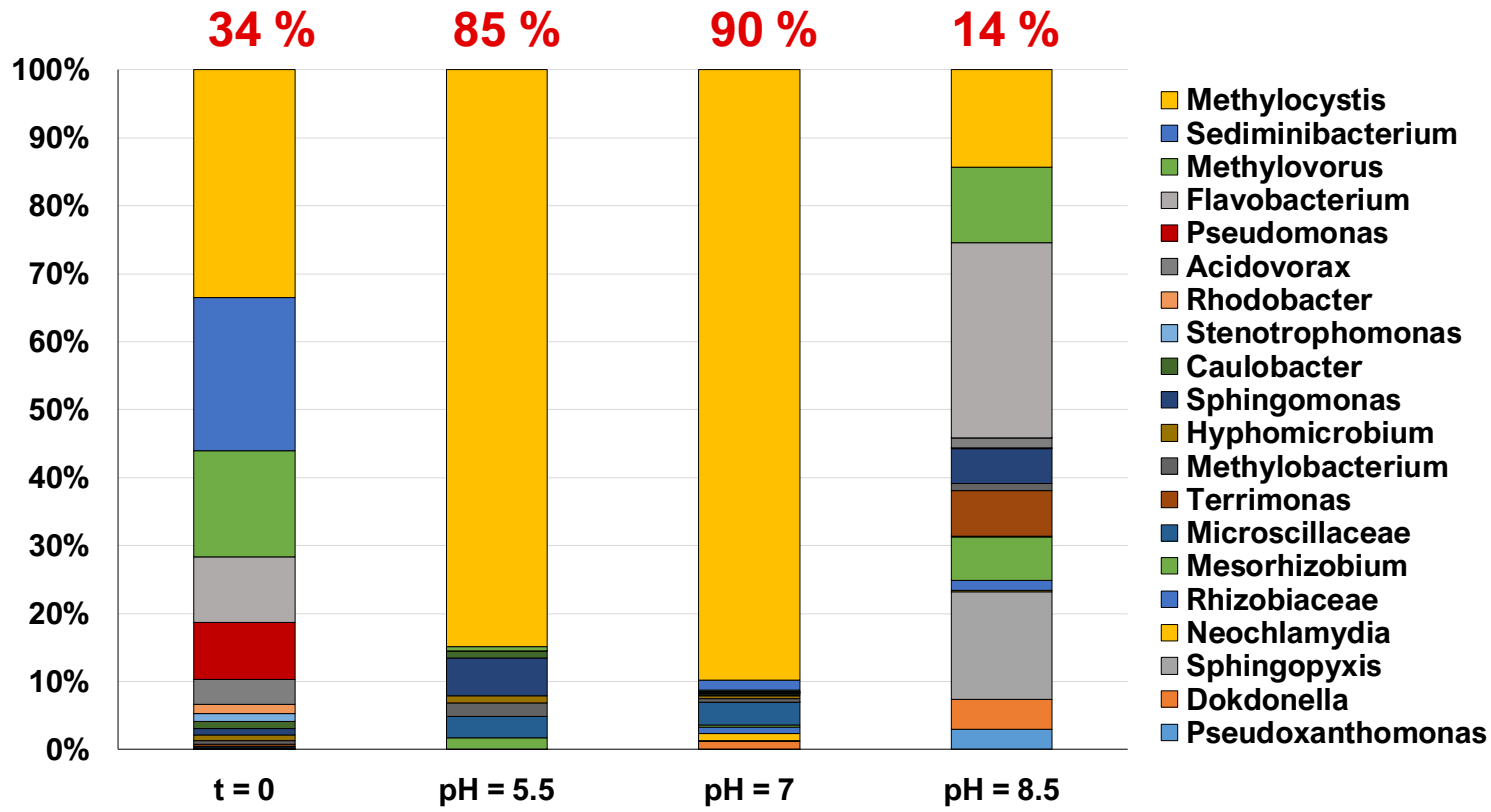




Results: Sequencing

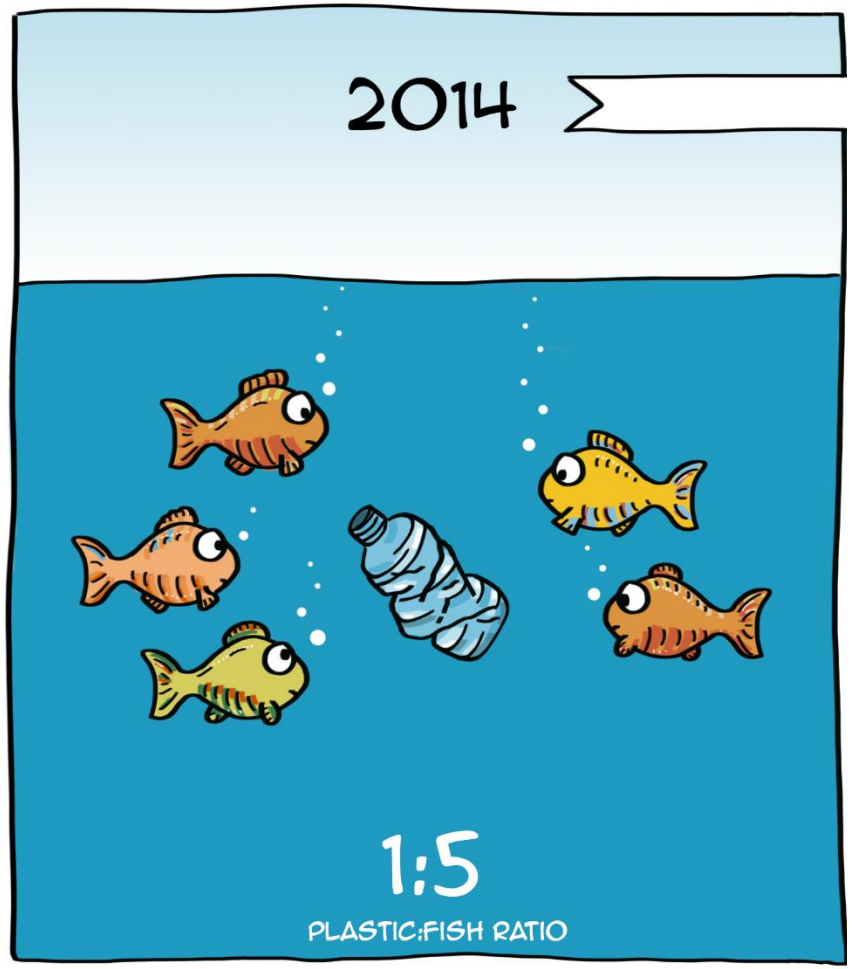
- *Methylocystis* 85-90 % at pH 5.5 and 7 explain the higher PHA accumulated

- Low pH constitutes a strong selective pressure for Type II methanotrophic bacteria.



Conclusions

- CH_4 abatement is enhanced at high pH by the higher salinity of the medium
- CH_4 abatement is maintained during growth and PHA accumulation stages
- Low pH values promote PHA accumulation
- Low pH induces a strong selective pressure for PHA accumulating microorganisms



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