Harnessing biogas plants for the production of value-added products

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  - Volatile fatty acid (VFA) production in biogas plants
- Materials and Methods
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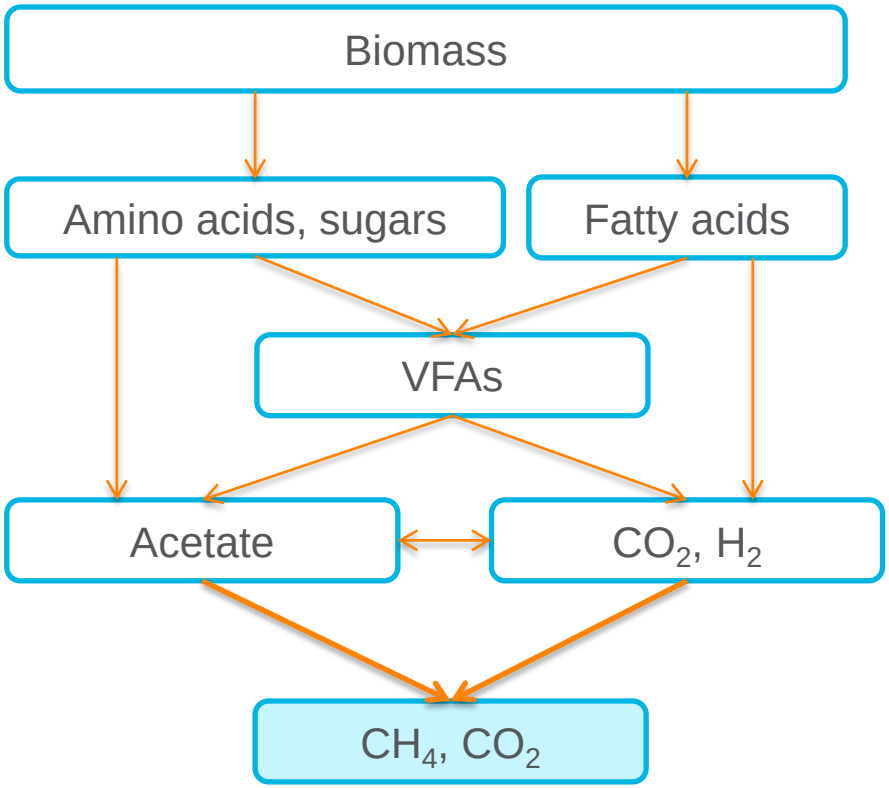
- Conclusions

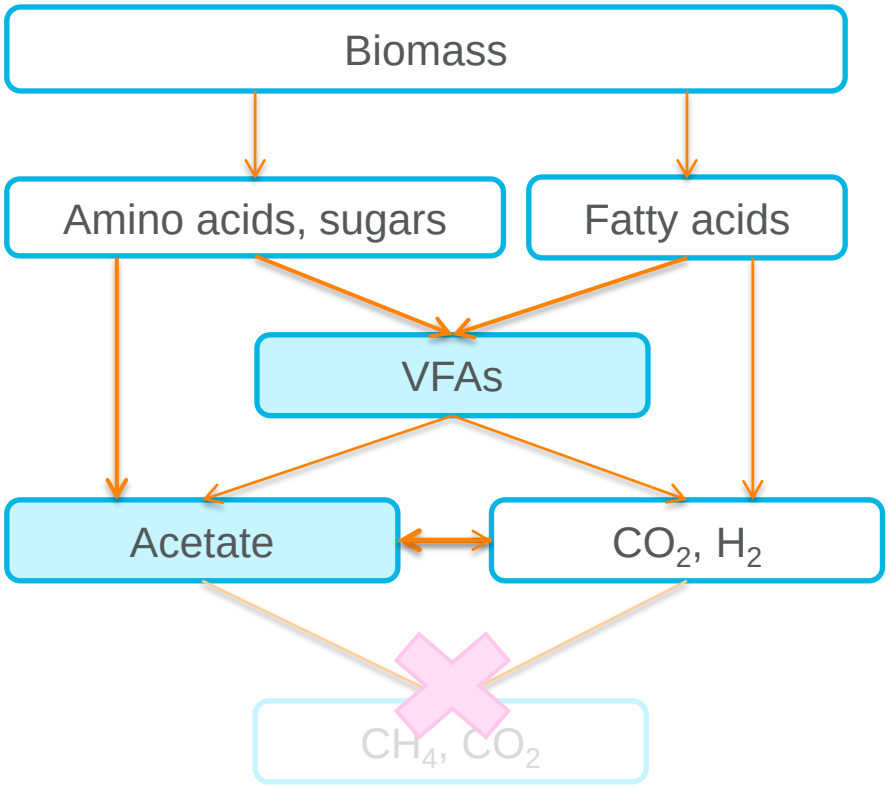
Introduction

- Anaerobic digestion
  - Biogas
  - Digestate



Introduction

- Volatile Fatty Acid fermentation
  - VFAs
  - Digestate
  - CO_2, H_2

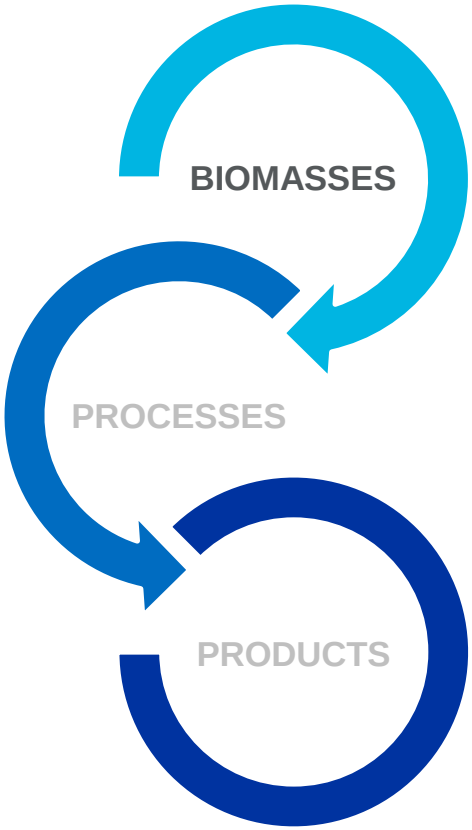


Introduction

- Start-up of VFA production in anaerobic digester using ”biogas inoculum”
  - Inactivation/inhibition of CH_4 producing methanogens
    - Chemical inactivation
      - 2-bromoethanesulfonate (BES, $C_2H_4BrO_3SNa$)
    - Thermal treatment
    - Optimization of process conditions
      - Change of pH
      - Organic loading rate (OLR), hydraulic retention time (HRT)

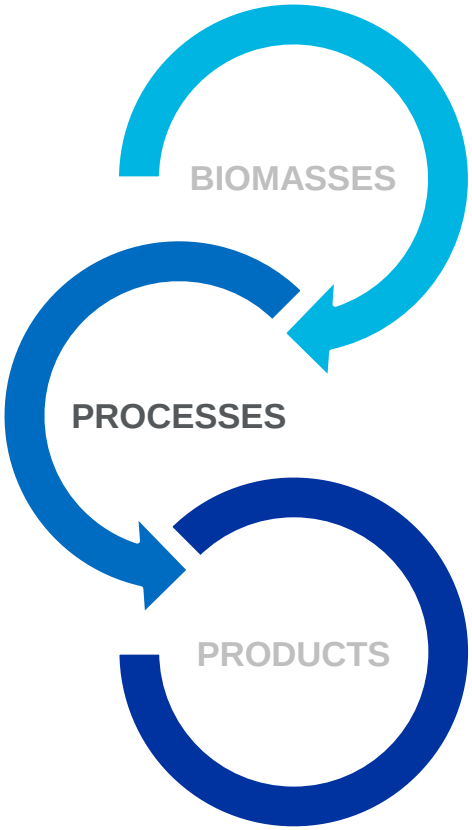
Introduction

- Biomasses for biogas plants:
  - From municipalities
    - Biowaste
    - Sewage sludge
    - Industry wastes
  - From agriculture
    - Manure
    - Plant biomass
  - From forestry
    - Sludge
    - Ligno-cellulosic waste



Introduction

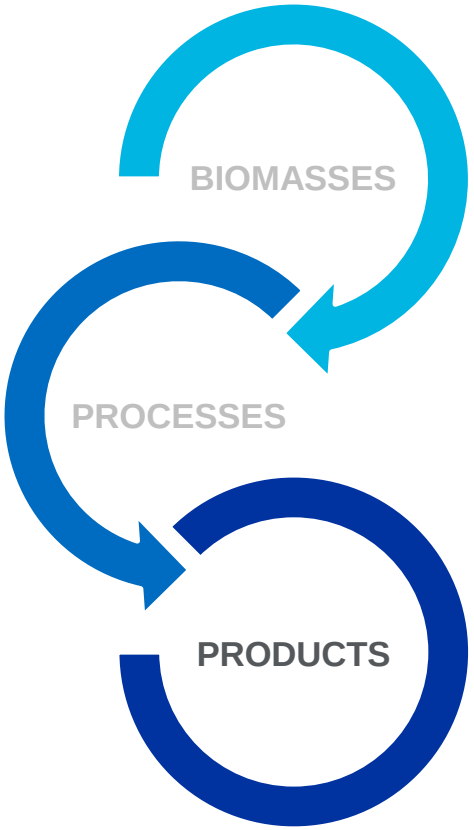
- Biogas process
- Biogas process with value-added products
  - VFA fermentation = Carboxylate Platform = Targeting bio-production of VFAs



Introduction

- Biogas/Methane gas
  - 0,3 $/m^3 (NG)[1]
  - 1,45 €/kg (CBG)[2]

- Volatile fatty acids (VFAs)
  - short chain carboxylic acids
  - substrates for various organic compounds including alcohols, biohydrogen, bioplastics, microalgal lipids, bioelectricity
  - 600-4250 $/t[3]



[1]U.S. Energy Information Administration (EIA) 2017. https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm
[2]Gasum Finland 2017. https://www.gasum.com/yksityisille/tankkaa-kaasua/tankkaushinnat/
[3]Calt 2015. Products produced from organic waste using managed ecosystem fermentation. Journal of Sustainable Development 8.

Aim of the study

- Start-up of VFA fermentation in continuous anaerobic digester
- Use of robust and low-cost inactivation of methanogens
  - OLR, HRT
- Biowaste as feedstock
- 2 experiments with different process parameters
  - Experiment A
  - Experiment B

Materials & Methods

- Biowaste feedstock
  - Feed material to a full-scale digester
  - Mixture of biowaste + circulation water

	Biowaste
TS (%)	10.6 ± 0.17
VS (%)	8.3 ± 1.13
VFAtot (g/L)	15.0 ± 2.5
sCOD (g/L)	62.2 ± 4.7
NH4-N (g/L)	2.1 ± 0.66
BMP (m^3_{CH4}/t_{VS})	670 ± 10

- Inoculum
  - Obtained from a biogas plant treating municipal biowaste
  - One week acclimation prior to experiments
    - HRT 30 d
    - OLR 2-3 kgVS/m^3d

Materials & Methods

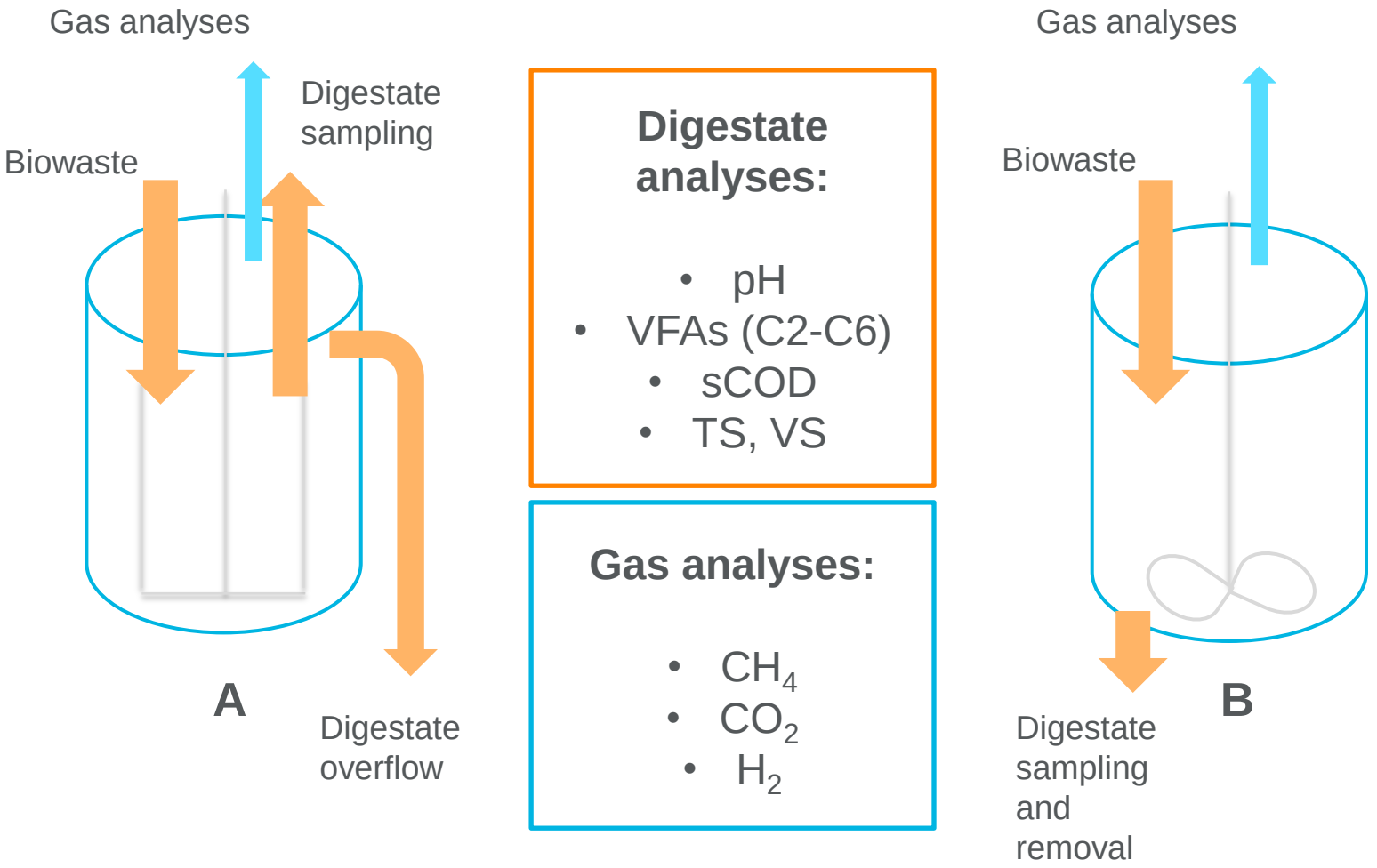
- Continuous mesophilic reactor experiments
  - Experiment A
    - 2 * 11 L reactors
  - Experiment B
    - 2 * 6 L reactors

Photos: Satu Ervasti

	Experiment A	Experiment B
HRT (d)	6[1]	9
OLR (kgVS/m³d)	7[1]	9.2
Days	1-18	1-33

[1]Distilled water added to adjust parameters.

Materials & Methods



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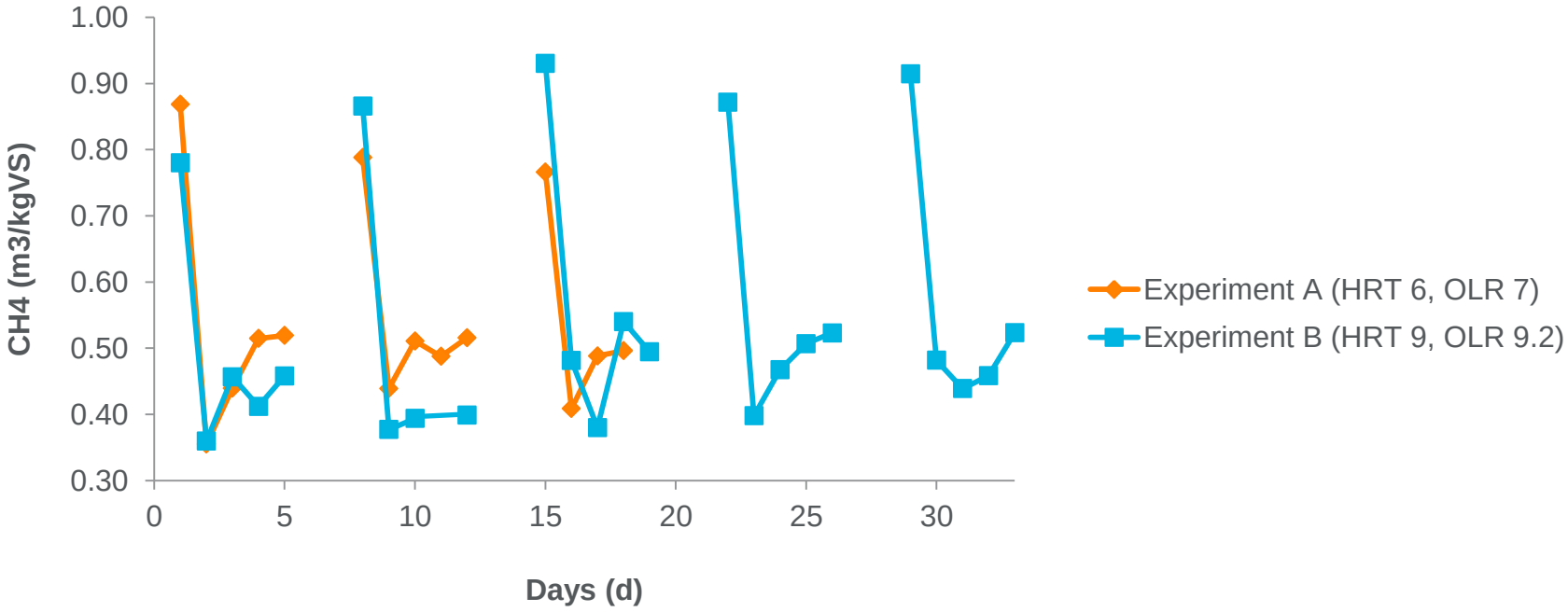
Results

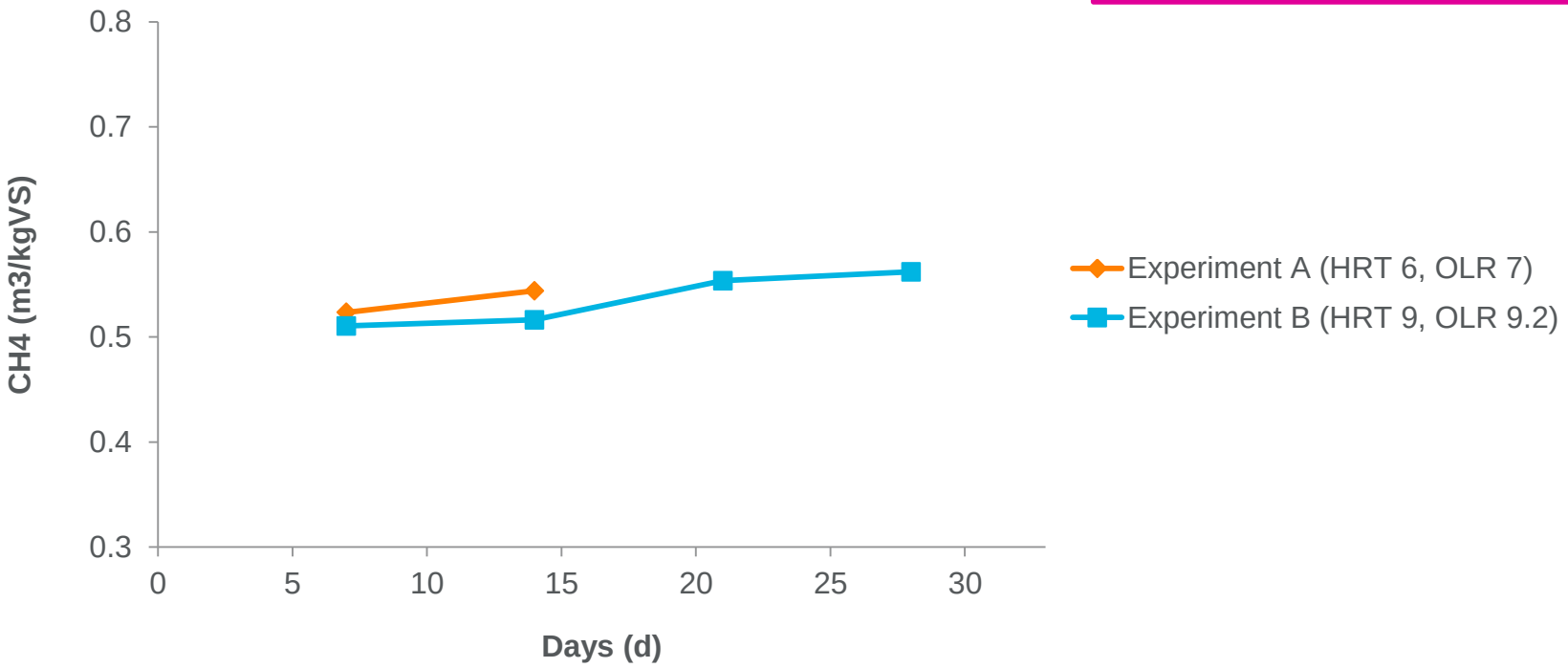
- Daily methane yield during tests



Results

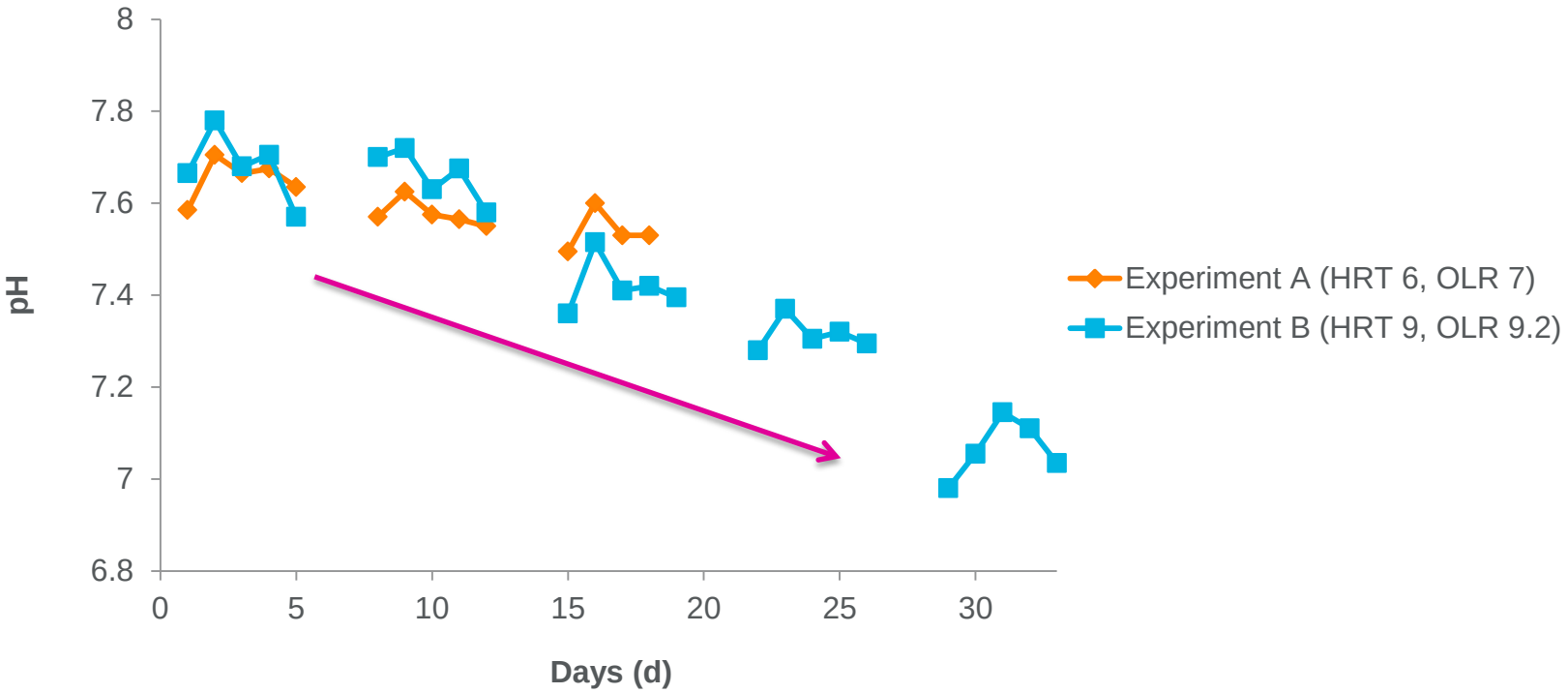
- Weekly methane yield during tests

Methane content 65%



Results

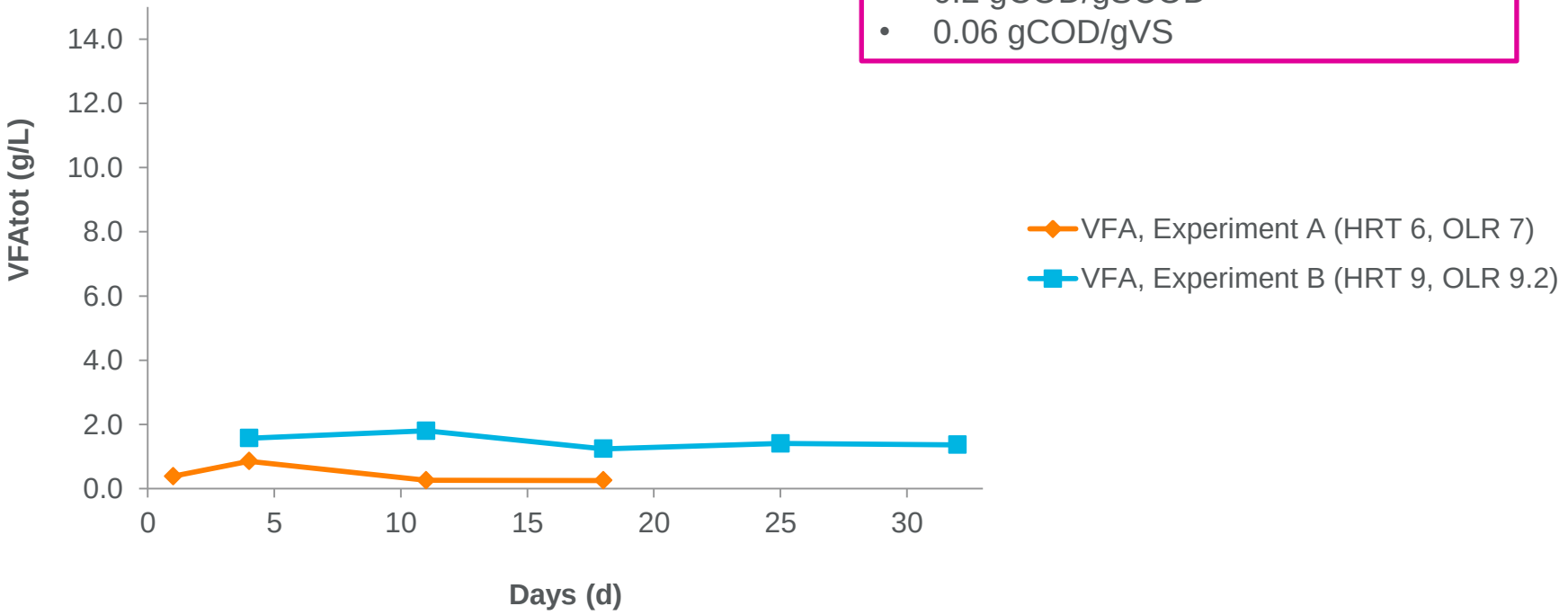
- pH evolution during tests



Results

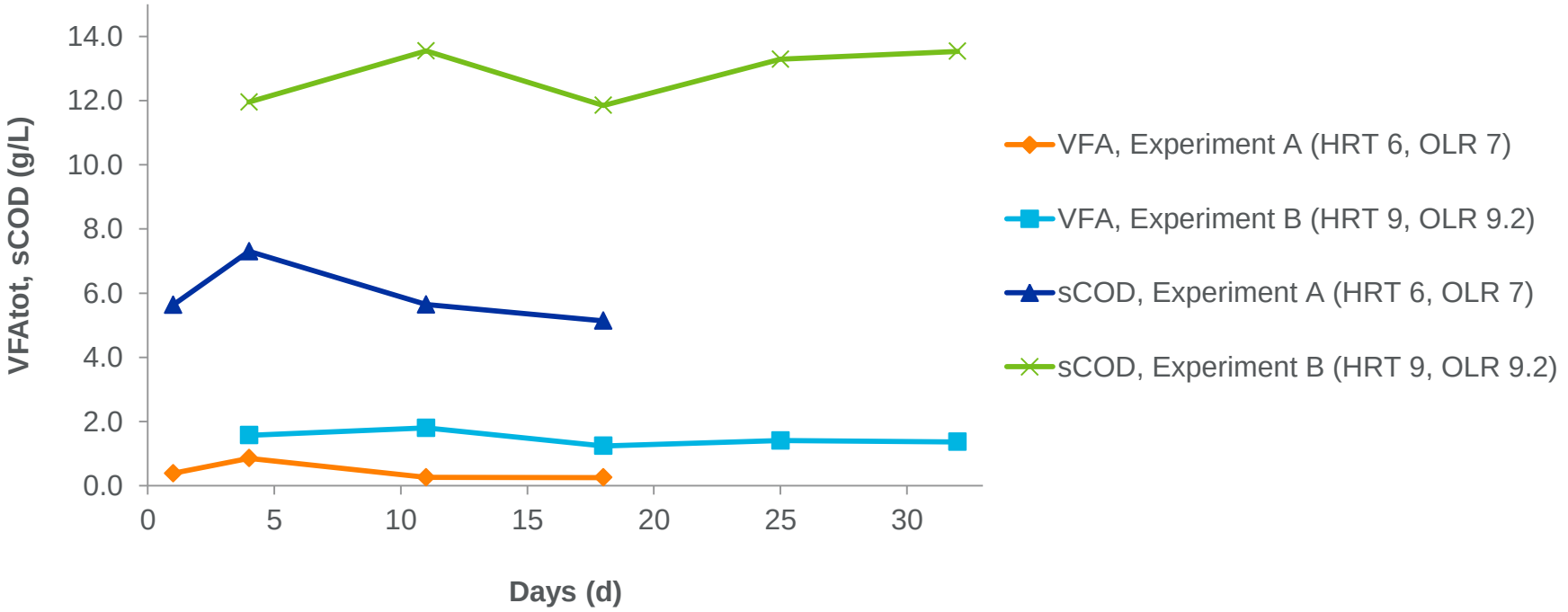
- VFA evolution during tests

VFA yield of <2 g/L in Experiment B
- 3 gCOD/L
- 0.2 gCOD/gSCOD
- 0.06 gCOD/gVS



Results

- VFA and sCOD evolution during tests



Conclusions

- VFA fermentation start-up with biogas plant inoculum was not successful in 18 and 33 days continuous experiments
  - HRT decrease and OLR increase as inactivation method for methanogens
    - High methane content in biogas (65%)
    - High methane yield (0.5-0.55 m^3/kgVS)
    - Low VFA production (< 2 g/L)

    -> Feed: mixture of biowaste and circulation water

    -> Methanogens in the feed

Conclusions

- How to manage start-up of VFA fermentation
  - Use of other means to inactivate methanogens
    - pH control
    - Inoculum treatment
  - Longer start-up time needed
    - pH decrease was observed during 33 days experiment

Research group and project funding

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OSKAR ÖFLUNDS STIFTELSE

Thank you!

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