9th International Conference on Sustainable Solid Waste Management, Corfu 15-18 June 2022

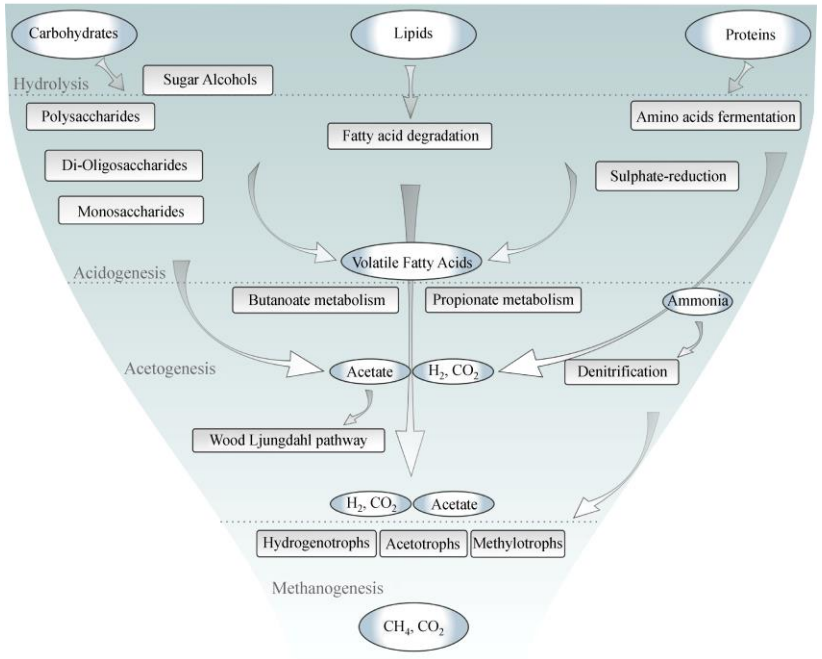
INHIBITORY EFFECT OF LONG CHAIN FATTY ACID ON BIOGAS PRODUCTION VIA A SINGLE PULSE: CHANGES IN MICROBIAL COMMUNITY DYNAMICS AND SIMULATION ASPECTS

M. Gaspari[a], M. Alvarado-Morales[b], P. Tsapekos[b], L. Treu[c], S. Campanaro[c], I. Angelidaki[b] & P.G. Kougias[a]

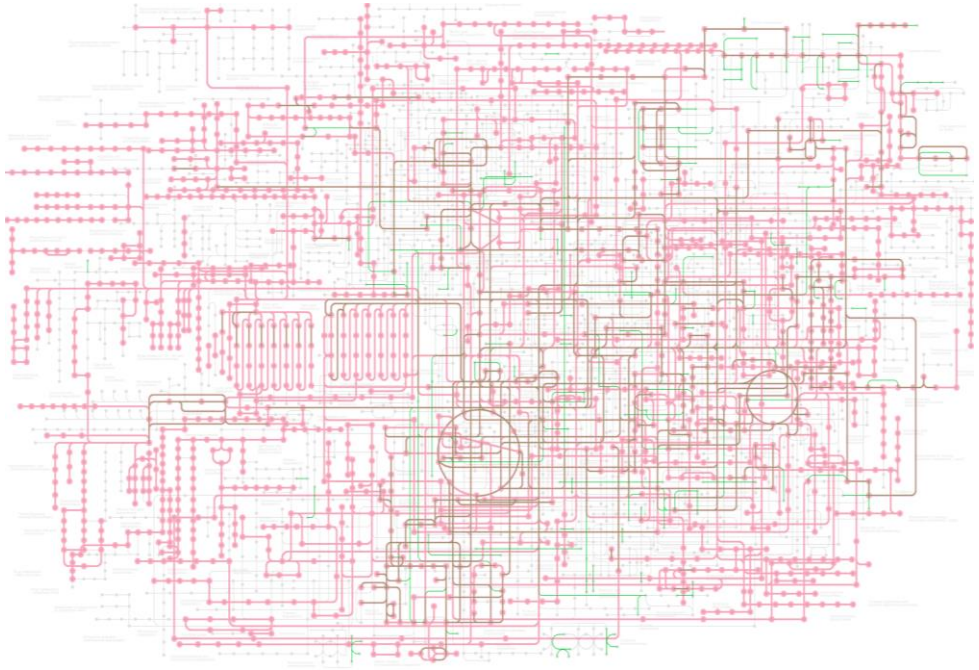
a. Soil and Water Resources Institute, Hellenic Agricultural Organization Dimitra, Thermi, Thessaloniki 57001, Greece
b. Department of Chemical and Biochemical Engineering, Technical University of Denmark, Lyngby DK-2800, Denmark
c. Department of Biology, University of Padova, Padova 35131, Italy

Introduction – Anaerobic Digestion

Anaerobic digestion (AD) is a biological process, mediated by different groups of microorganisms, mainly bacteria and archaea, which follow diverse metabolic pathways to produce biogas (40-75% CH_4 and 25-60% CO_2)



Kougias & Angelidaki, 2018. Biogas and its opportunities – A review



KEGG, Metabolic Pathways during Anaerobic Digestion

Problem Statement

Long Chain Fatty Acids (LCFA) Toxicity

- Lipids are especially impo
- LCFA are
- The anaer
  β-oxidatio
  bacteria a
- The inhibit
  thermodynamically-limiting

Substrat	Composition (%)
Carbohydra	50
Protein	50
Lipids	70
Ethanol	75

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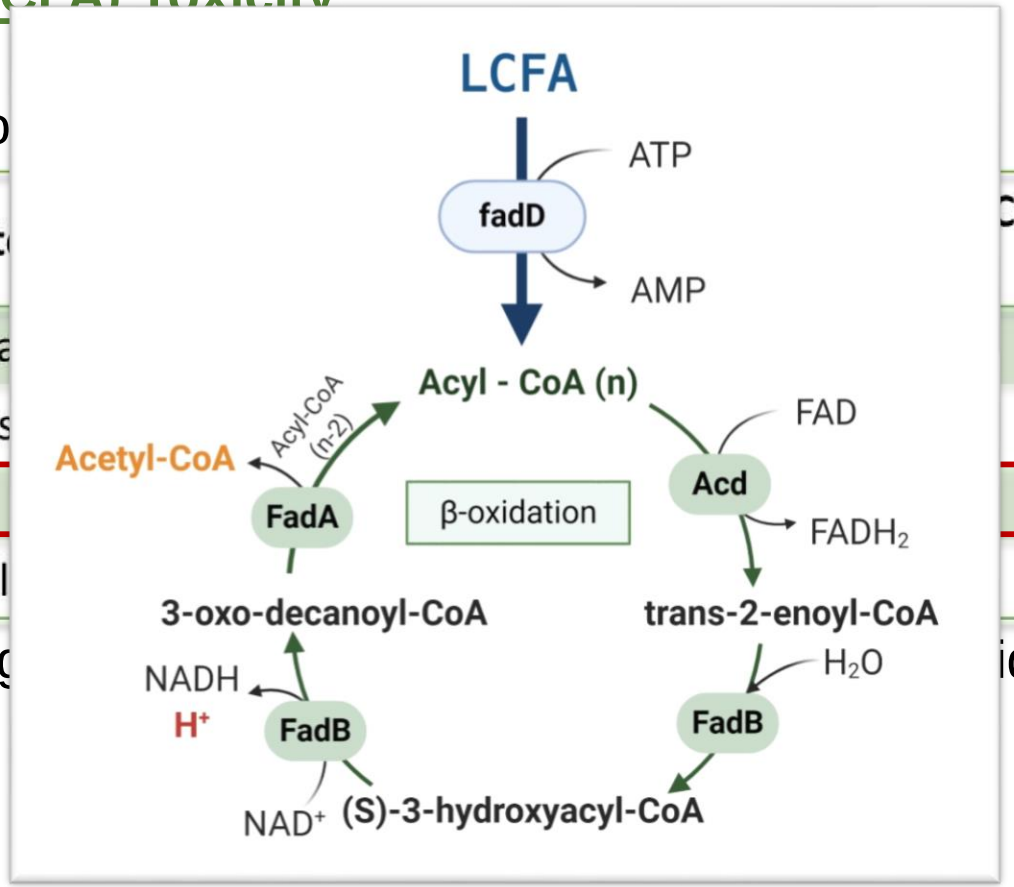


Aim & Objectives

Process Monitoring

Replicate reactor operation, Biochemical parameters

Molecular Techniques

Shotgun sequencing, Metagenomic analysis

Bioinformatic Pipeline

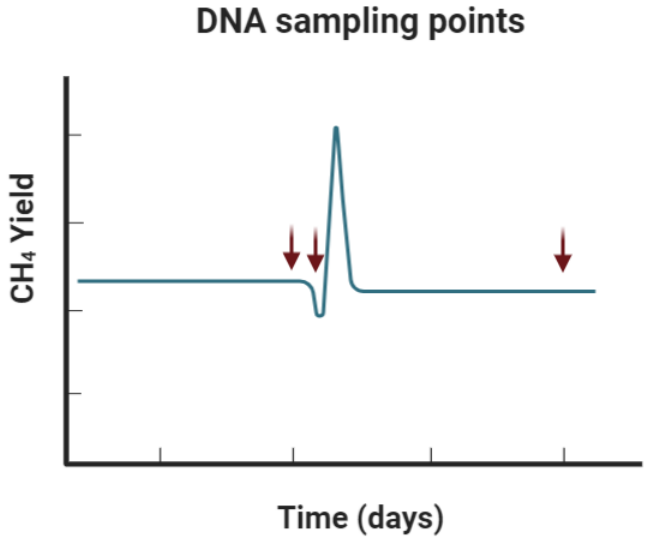
Dedicated pipeline for data analyses

Enlighten responses

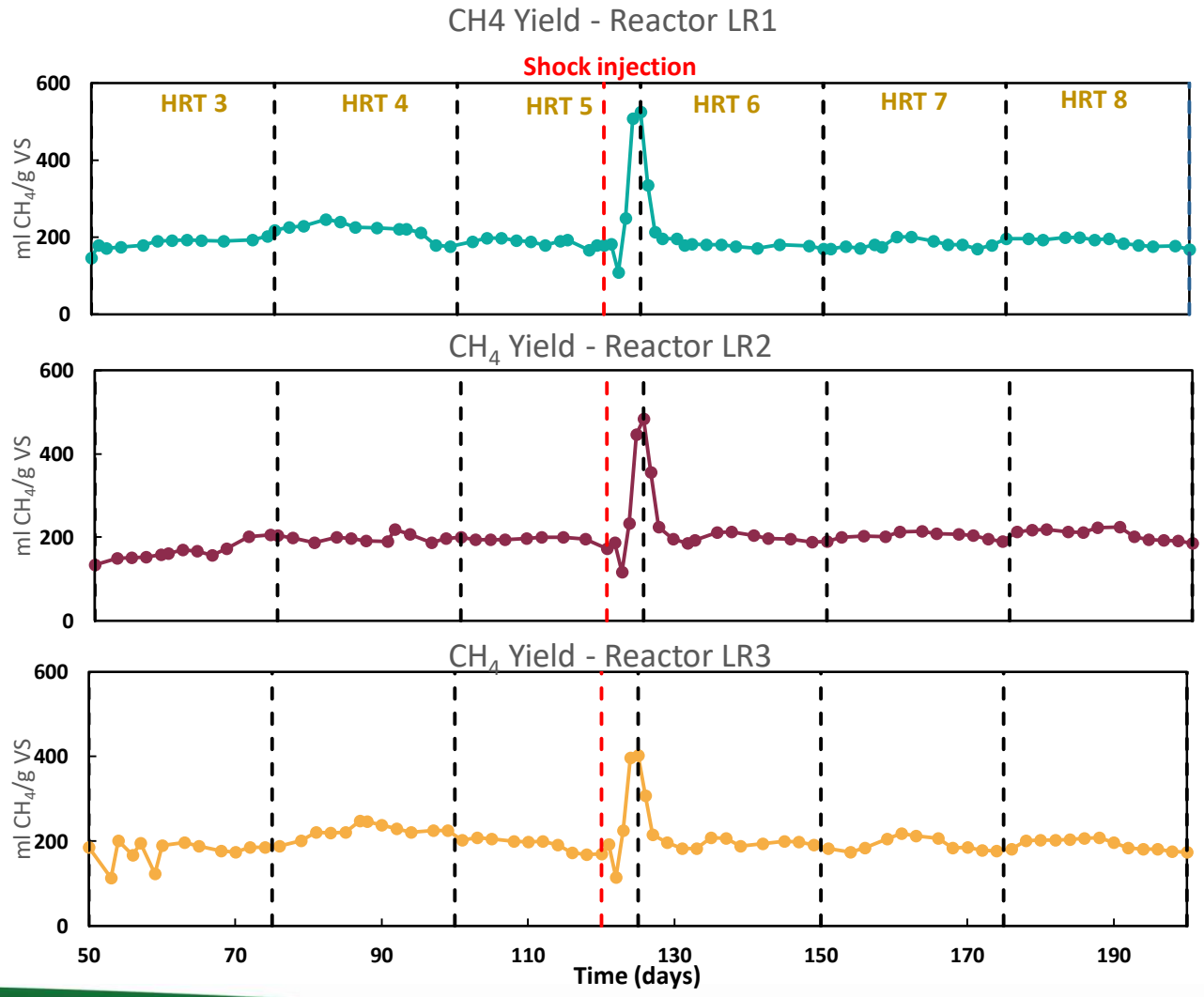
Identify microbes enhancing or constraining efficiency

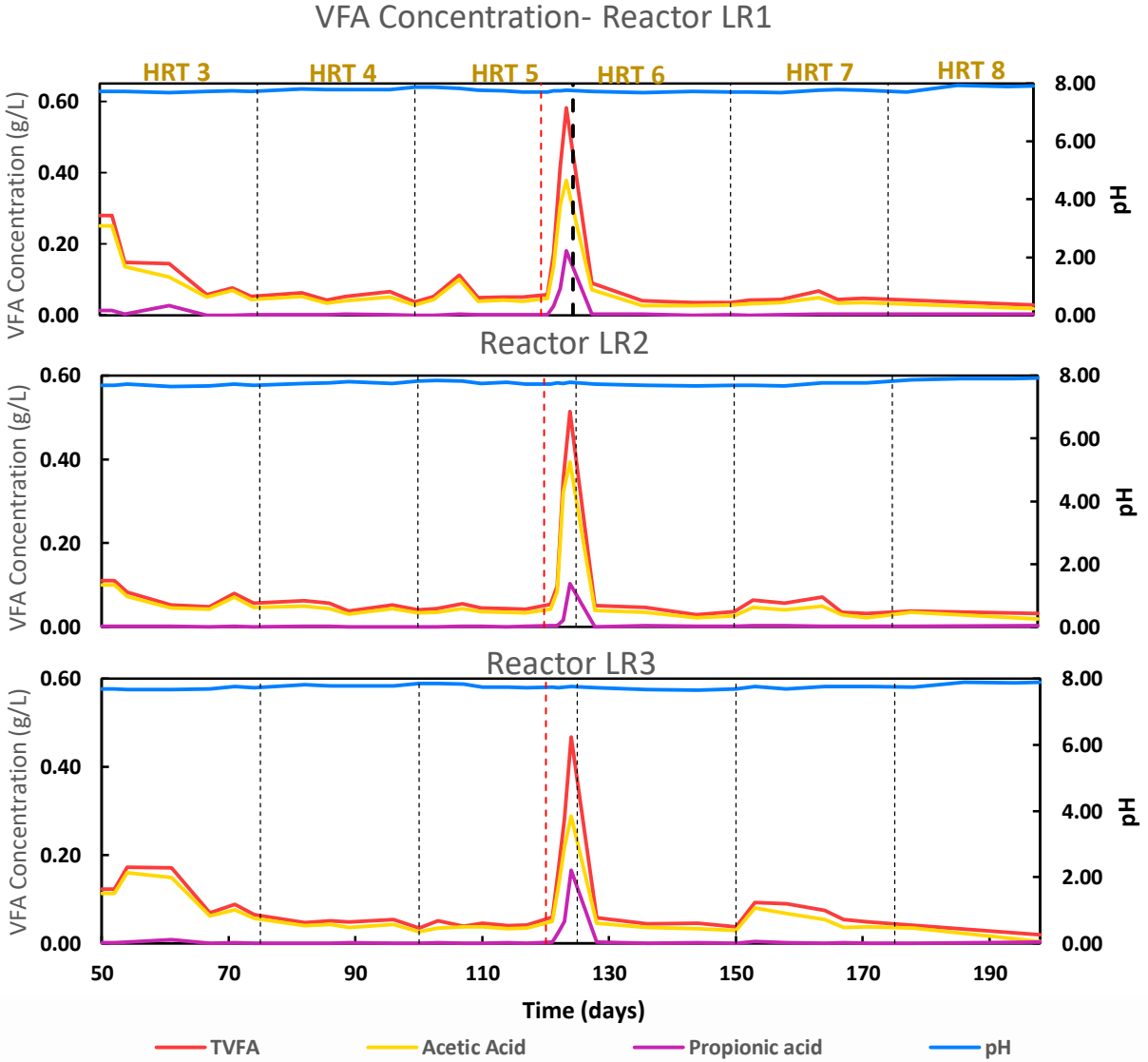
Bioreactors' Operation – CSTR Set-Up

- **3 Reactors – Biological Replicates**
- **Mesophilic Conditions (37 ± 1^{o}C)**
- **Cattle manure as Feedstock**
- **Single inhibitory shock load of 3g Na-Oleate/L_R**
- **3 time points for DNA**

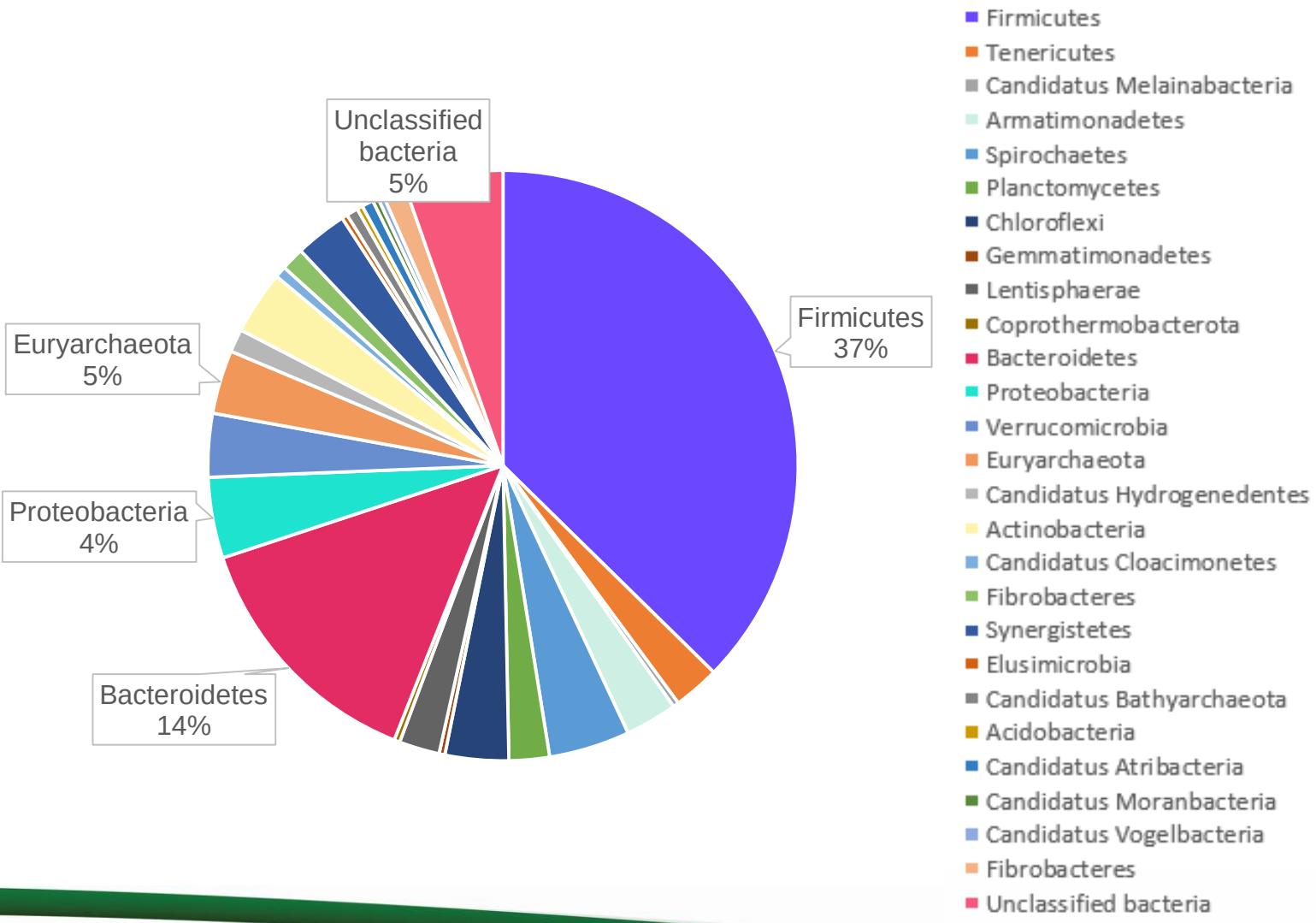


Biochemical Results



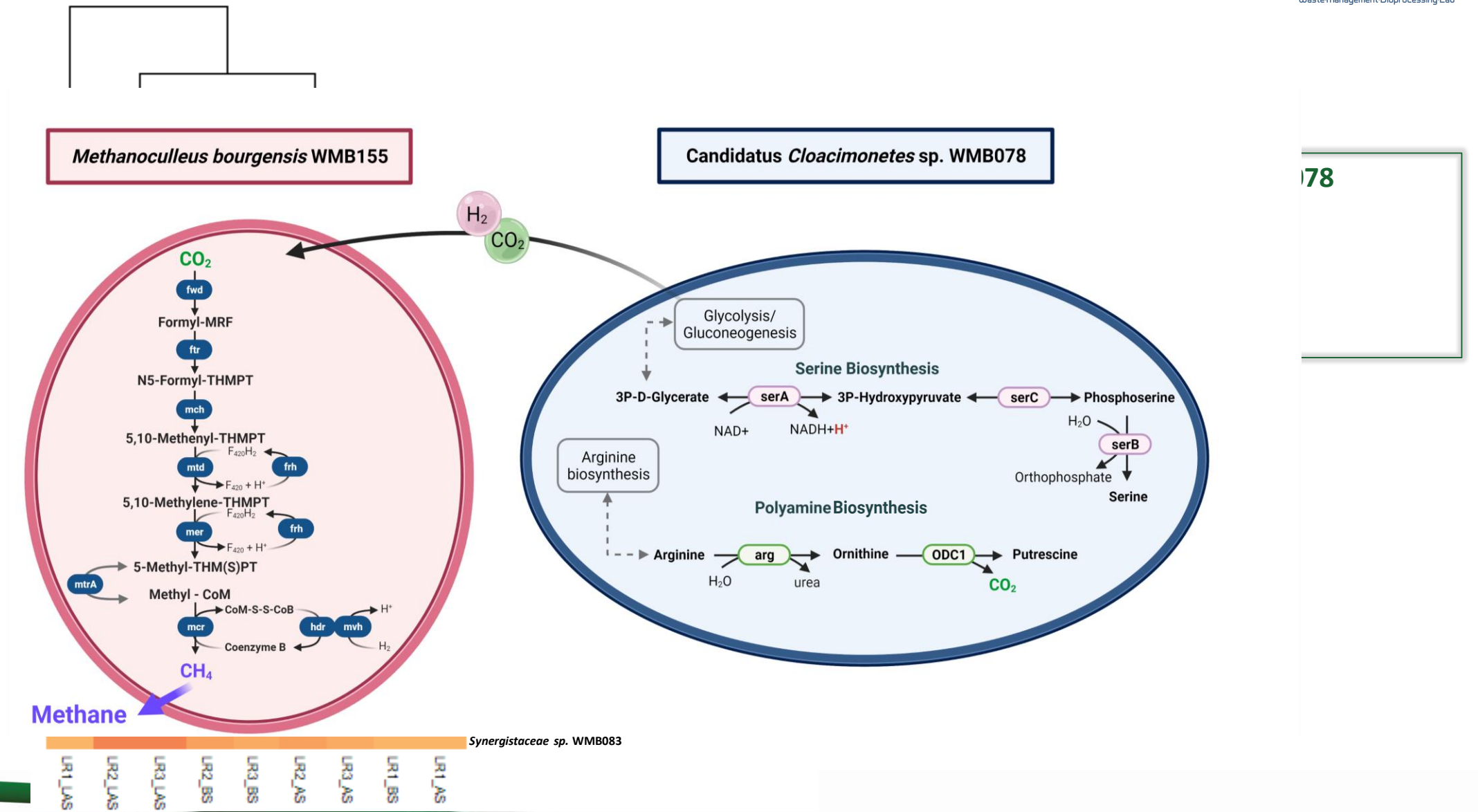


Microbial community overview



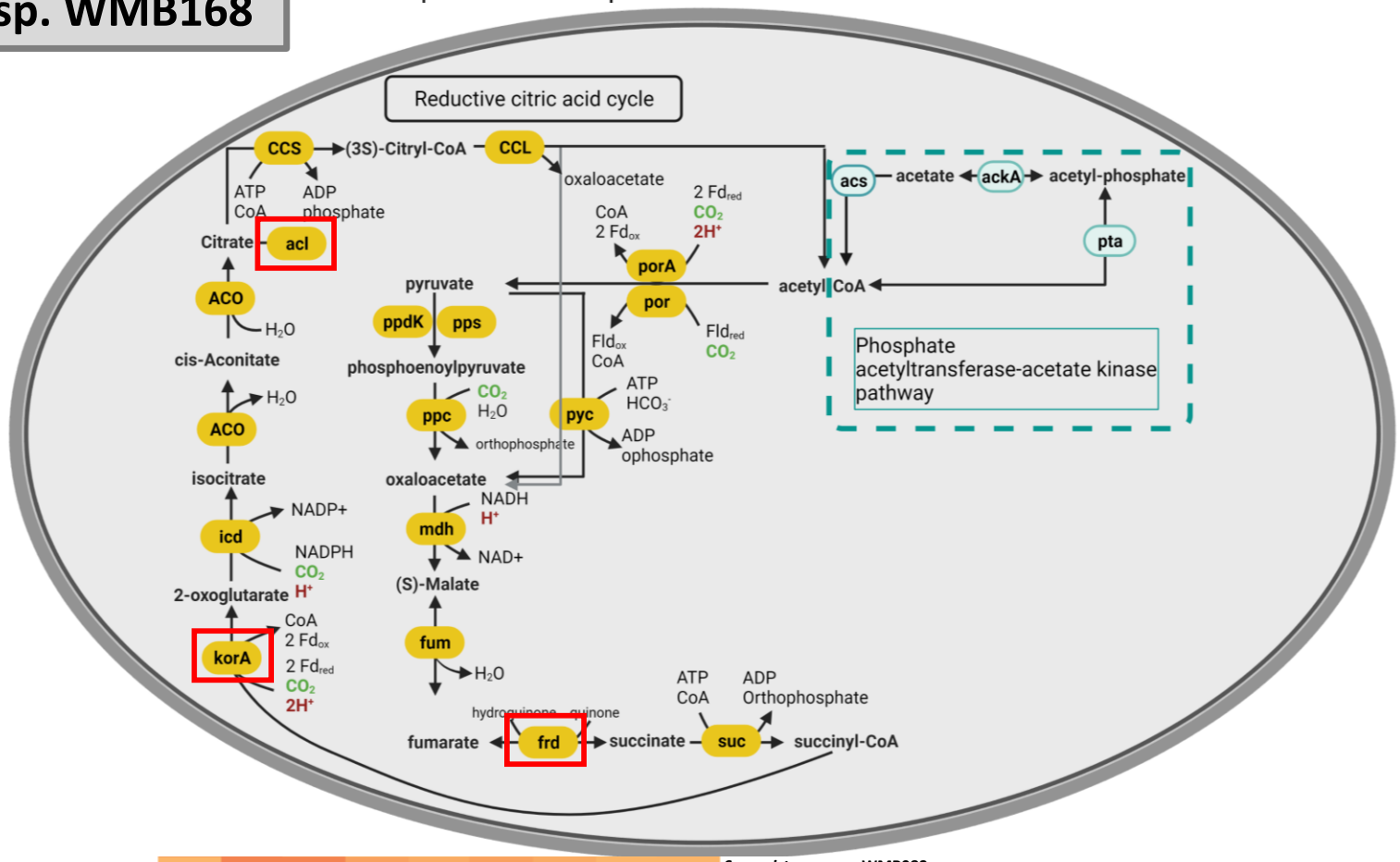
Parameter	Compl. (%)	Cont. (%)	No. MAGs
High Quality	≥90	≤5	**214**
Medium-High Quality	90>Cp ≥70	<10	**102**
Medium Quality	70>Cp ≥50	<10	**48**
Low Quality	<50	≥10	**73**
		TOTAL	**437**

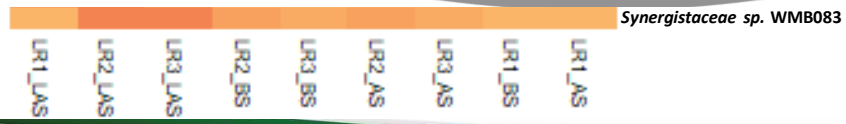
Syntrophies between uncharacterized bacteria and archaea



Novel microbe in Anaerobic Digestion food chain

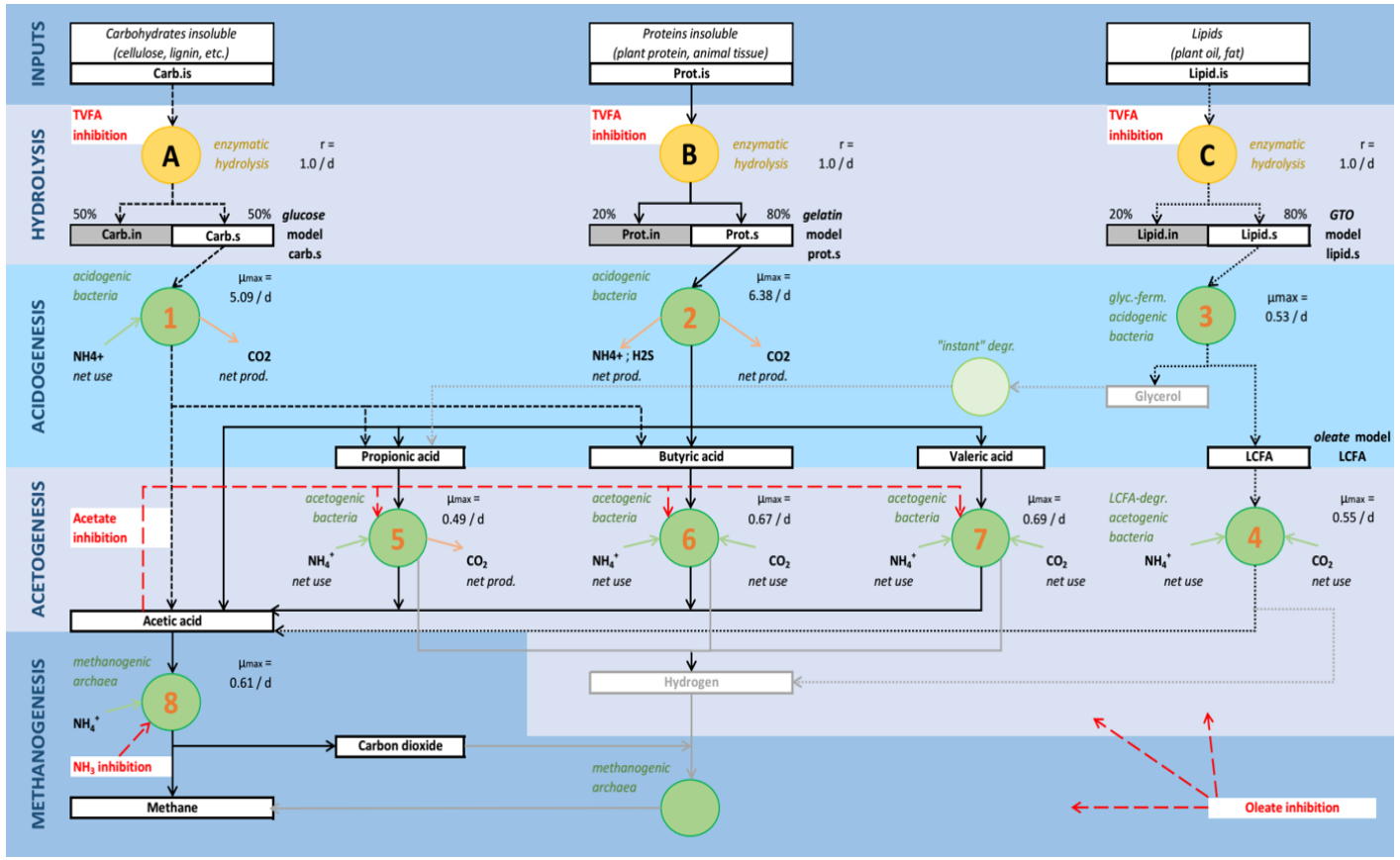
***Nigerium* sp. WMB168**





Synergistaceae sp. WMB083

Bioconversion Model – “BioModel”

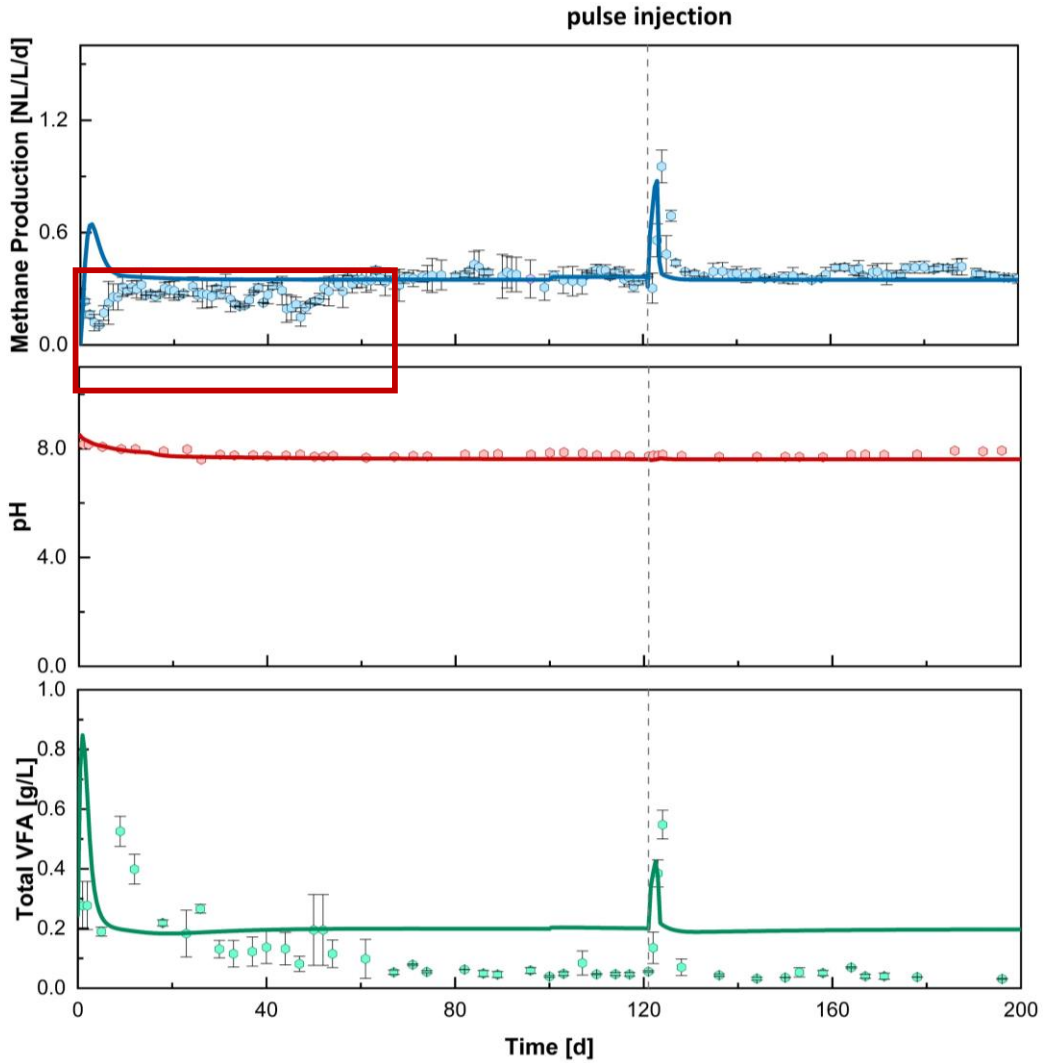


Tsapekos et al., 2018. Energy recovery from wastewater microalgae through anaerobic digestion process: Methane potential, continuous reactor operation and modelling aspects

- Anaerobic degradation of complex material, and co-digestion of different types of wastes
- Manure-based anaerobic digestion systems
- Mass-based unit system
- Model includes inhibition from LCFA

STAGE	INHIBITOR	INHIBITION TERM
Acidogenic glycose degradation	LCFA	$\frac{1}{1+\frac{[LCFA]}{Ki_{LCFA}}}$
Lipolysis	LCFA	
Acetogenic LCFA degradation	LCFA	$\frac{1}{1+\frac{K_S}{[LCFA]}+\frac{[LCFA]}{Ki_{LCFA}}}$
Acetogenic VFA degradation	LCFA Acetic Acid	$\frac{1}{1+\frac{[LCFA]}{Ki_{LCFA}}} \times \frac{1}{1+\frac{[HAc]}{Ki}}$
Acetoclastic methanogenesis	LCFA Free Ammonia	$\frac{1}{1+\frac{[LCFA]}{Ki_{LCFA}}} \times \frac{1}{1+\frac{[NH_3]}{Ki}}$

Simulations



*Points indicate the experimental data and continuous lines indicate the BioModel simulation. Dashed vertical line mark the shock load injection. Note: Each point is the mean value of the three reactors, therefore there is a standard deviation.

Conclusions

- Syntrophic interactions between uncharacterized bacteria and archaea was recorded.
- Strong evidences for alternative pathways for carbon fixation (rTCA) from novel bacteria.
- BioModel was capable to predict the process indicators “methane” and “pH” during lipid load.
- BioModel underestimated the VFA degradation but forecasted the alternation trend over time.

Acknowledgement

This project has received funding from the Hellenic Foundation for Research and Innovation (HFRI) and the General Secretariat for Research and Innovation (GSRI), under grant agreement No580

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Thank you for your attention!

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