

Inhibition of anaerobic digestion of urban sewage sludge by sodium propionate: biogas production and microbial community shift in continuous reactors

J.A. AGUMAH¹, C. SOULARD¹, X. LIU¹, L. ANDRE², A. PAUSS¹, S. GUERIN³, V. ROCHER³, C. LACROIX³, O. CHAPLEUR⁴, A. BIZE⁴, C. ROOSE-AMSALEG⁵, T. RIBEIRO²

¹ Université de technologie de Compiègne, ESCOM, TIMR, Centre de recherche Royallieu CS 60319, 60203 Compiègne Cedex

² Institut Polytechnique UniLaSalle, Université d'Artois, ULR 7519, 60026 Beauvais, France

³ Direction Innovation SIAAP – Service public pour l'assainissement francilien, 92700 Colombes, France

⁴ Université Paris-Saclay, INRAE, PROSE, 92160, Antony, France

⁵ CNRS, ECOBIO-UMR 6553, Université Rennes, 35000 Rennes, France

CONTEXT

Anaerobic digestion (AD) represents one of the most common ways to treat sewage sludge.

However, VFA accumulation, especially propionic acid usually inhibits the AD process thereby reducing biogas production and may lead to reactor failure.

The understanding especially regarding the level of concentration of VFA that inhibits the process as well as the microbial targets is limited. Further research is needed to understand this inhibition and identify the microbial biomarkers predicting the potential reactor failure.

OBJECTIVE: Assess the impact of propionic acid (and its dissociated form, propionate) on biogas production and microbial community shift in order to identify potential microbial biomarkers

METHODOLOGY

Experiment I (Previous study) – Batch mode



Biochemical methane potential (BMP) test: AMPTS II

Amendment at the beginning of the incubation:

- propionic acid (HPro)
- sodium propionate (NaPro)

Experiment II (current study) – Continuous mode



R1
[NaPro]=0 g/L
eq. [HPro]=0 g/L



R2
[NaPro]=1,95 g/L
eq. [HPro]=1,5 g/L



R3
[NaPro]=7,78 g/L
eq. [HPro]=6,0 g/L



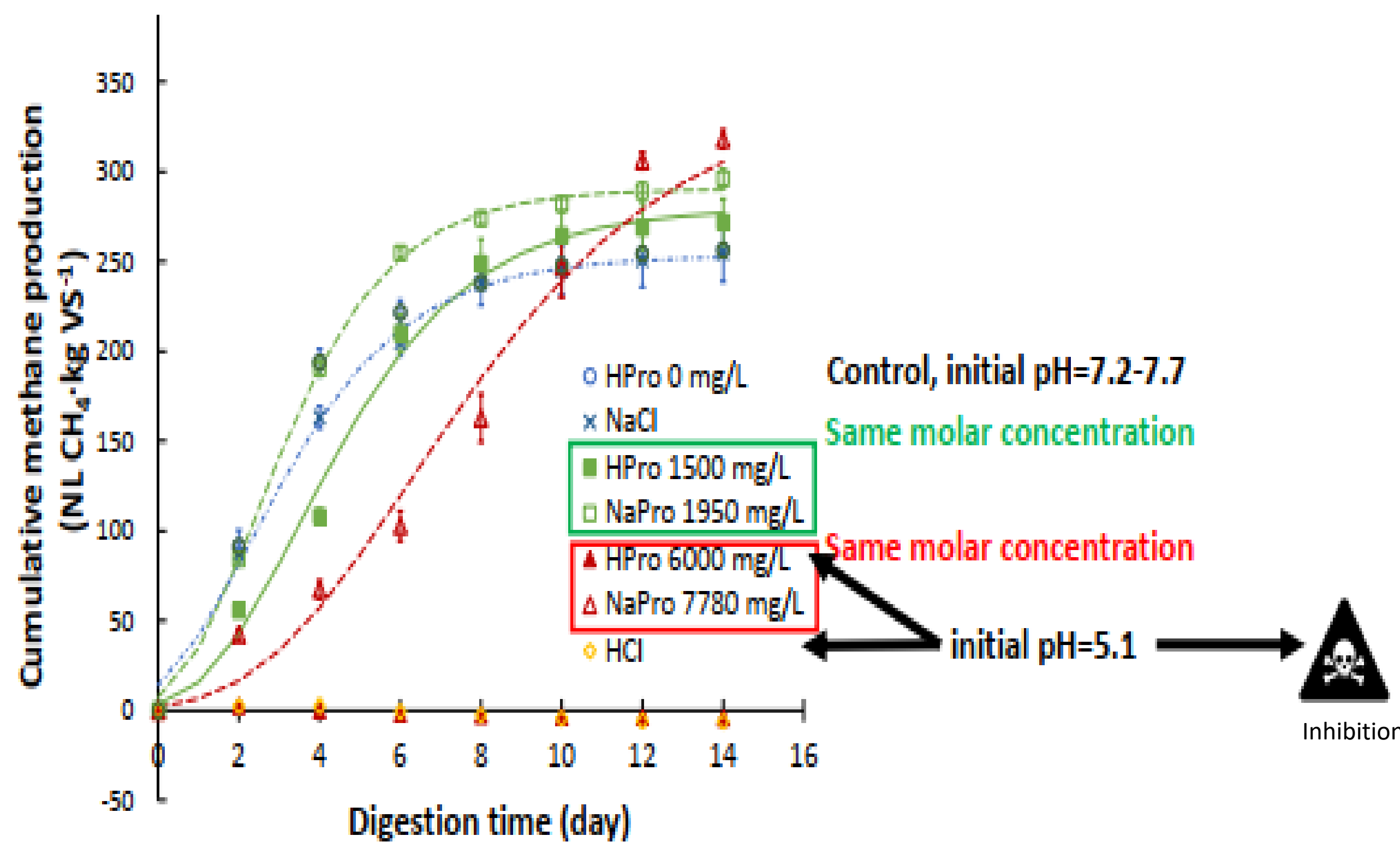
R4
[NaPro]=13,0 g/L
eq. [HPro]=10 g/L

4 Continuous Stirred Anaerobic Reactors

- Substrate: no digested sludge, with different amounts of sodium
- HRT: 20 days
- Volume: 5 L

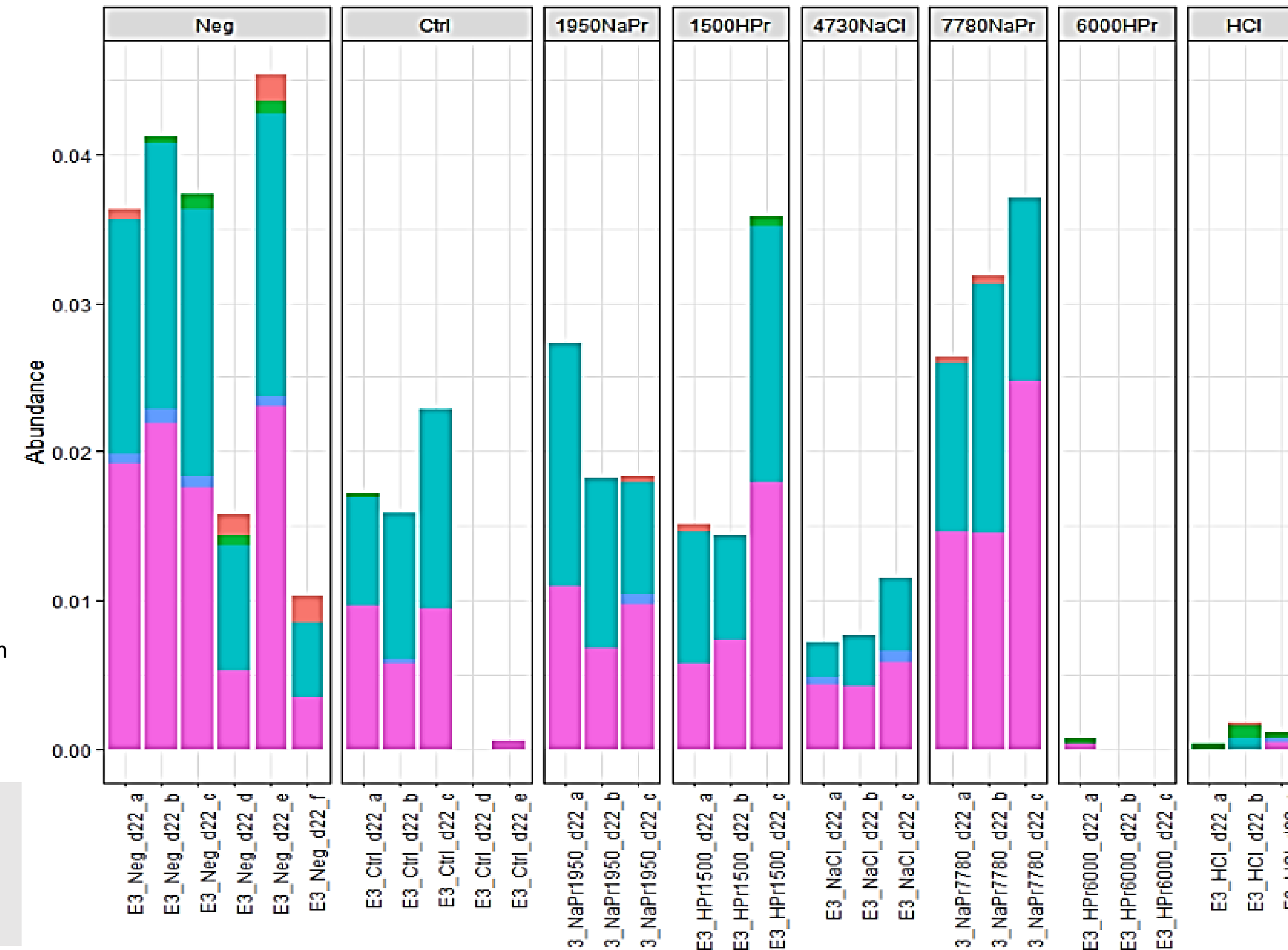
RESULTS AND DISCUSSION

Experiment I – AMPTS



- No CH₄ production at HPro (6 g/L), while slight inhibition for equivalent concentration in NaPro (7.78 g/L)
- No inhibition at 1.95 g/L NaPro (1.5 g/L HPro)

Composition within Archaea (9 top Genus)



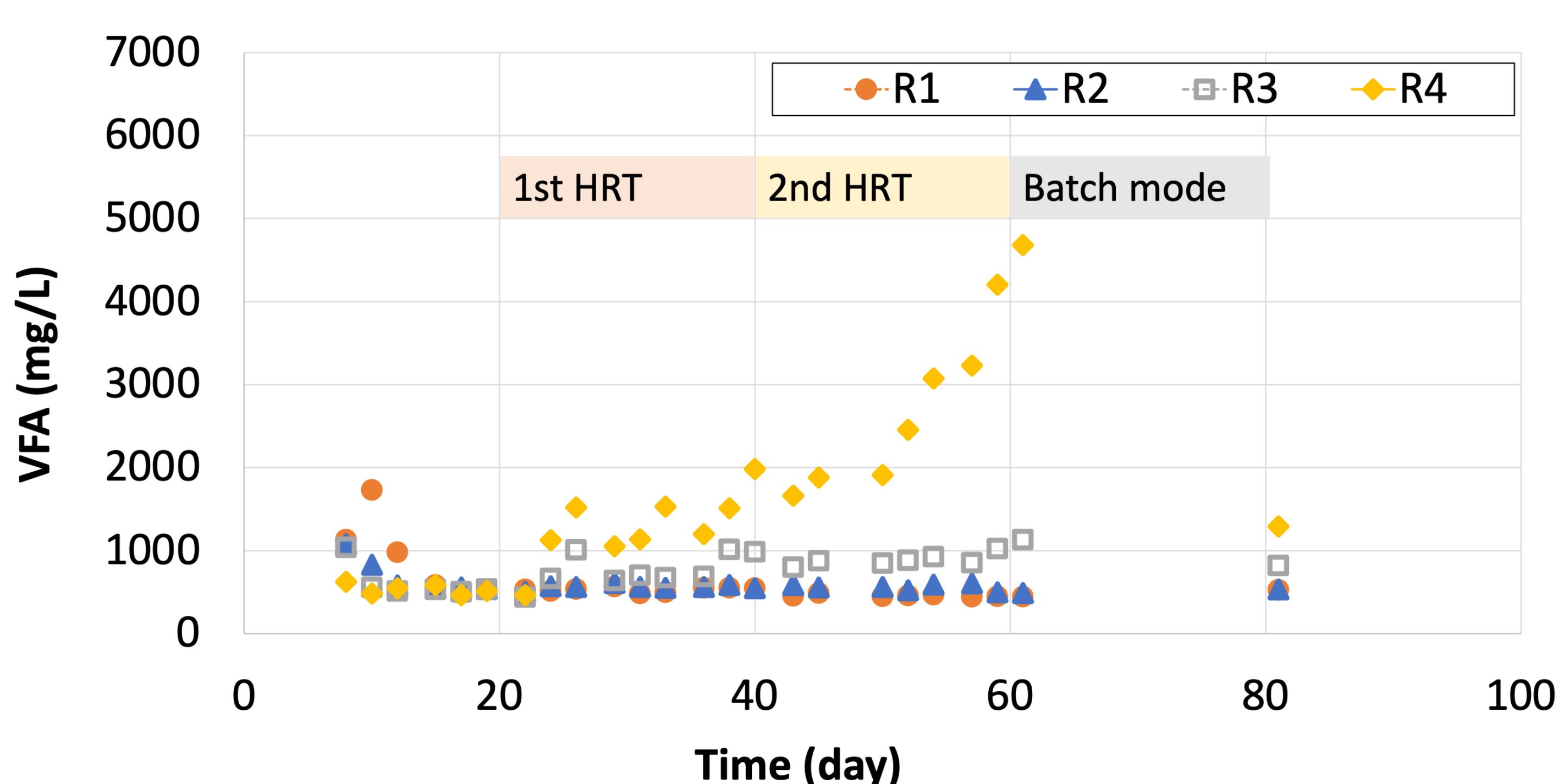
- Quantification RNA 16S
- Package Vegan de R
- Package DESeq de R

Mean number of reads per sample: 30,700

- Resilience of archaeal community with NaPro up to 7.78 g/L
- Resilience of archaeal abundance with HPro except at 6 g/L due to acidification as a result of the HPro

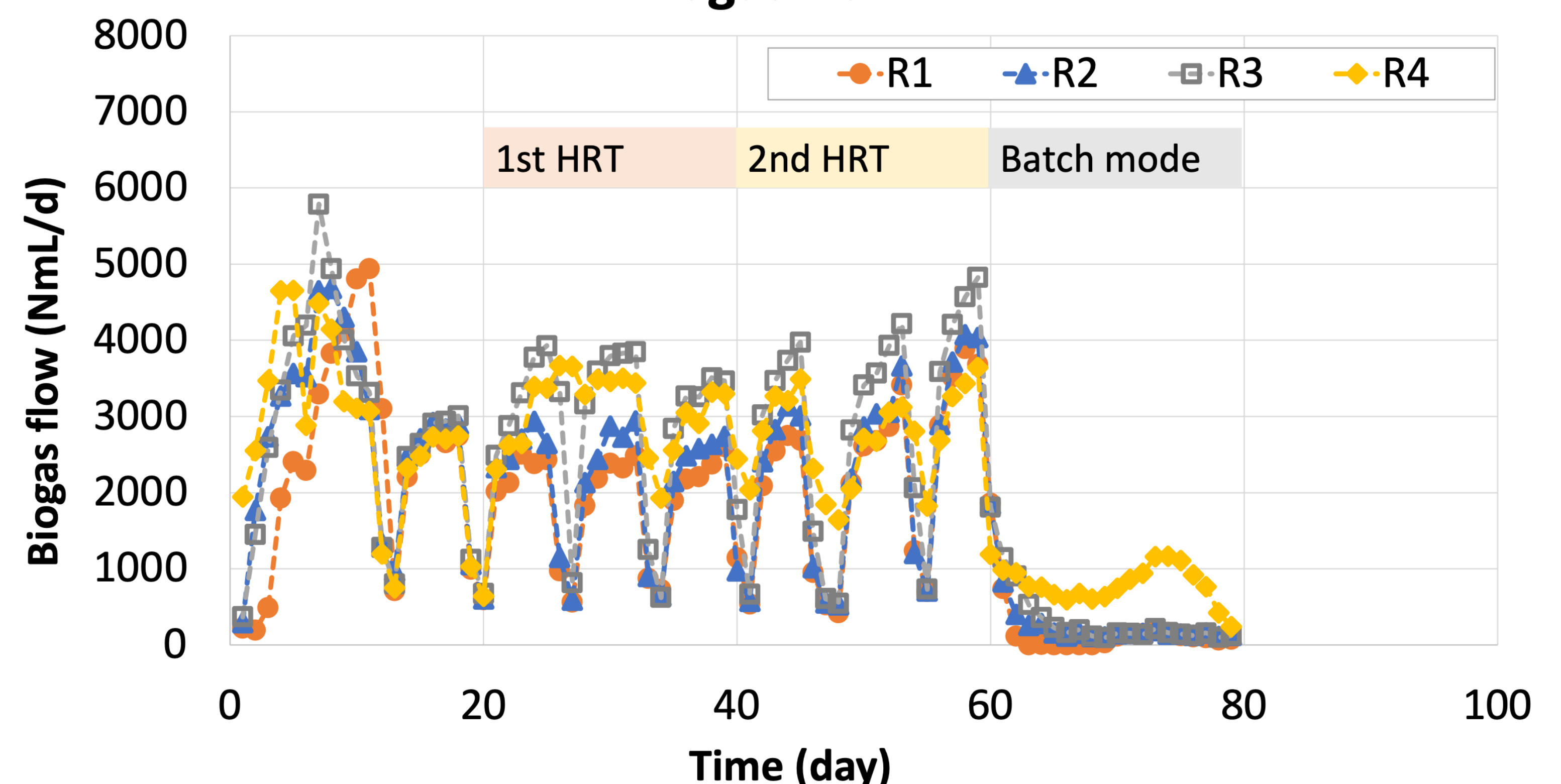
Experiment II – Continuous mode

VFA



- No inhibition in R2, minimal inhibition in R3, similar to the AMPTS test
- Highest VFA accumulation was observed in R4

Biogas flow



- R4 (NaPro 13g/L), though with the highest substrate addition, produces less biogas due to inhibition
- R4 exhibited a significant 40% reduction in CH₄ compared to expected value

CONCLUSION

- No inhibition at 1.95 g/L NaPro, slight inhibition at 7.7 g/L, and significant at 13 g/L (40% CH₄ reduction)
- Still methane production even at quite high level of NaPro
- Results consistent with prior batch experiments
- Analysis required for microbial shift understanding

ACKNOWLEDGMENTS

Thanks to project MOCOPEE for funding this work. Thanks to John Cockerill, Sources and Le Ministère de l'Enseignement Supérieur et de la Recherche (MESR) for funding this PhD grant.

REFERENCES

