Task 1.2 – Evaluation of post-digestion under high organic loading rate

Subtask 1.2.2 – Long-term semi-continuous tests

Objective

Following the lab-scale batch BMP assay results, the most promising condition is subjected to a longer-term test to evaluate the AD performance under high organic loading rate (OLR). The goal is to obtain a 10-20% higher ultimate CH_4-yield after feeding stripped digestate to a post-digester.

Set-up

Two semi-continuous bench-scale (70L total volume - 45L active volume) anaerobic digesters are operated in parallel (cfr. Figure 1). The first digester (R1) is fed with fresh substrate (i.e., dairy manure), which represents the main digestion step, and its digestate is subjected to ammonia stripping. The stripped digestate is subsequently fed to the second digester (R2), which represents the post-digestion step.

Figure 1: continuous bench-scale anaerobic digesters

<u>Anaerobic digestion conditions:</u>

- SRT = 20 days
- T = 37°C
- OLR = 3-4 gVS/L.day

<u>Stripping conditions:</u>

- pH 8
- T = 70°C
- G/L = 1000 (flow 8L/min)

<u>Acclimatisation phase (phase 1 – 93 days)</u>: the two reactors, filled with digestate from a dairy manure digester, are fed with manure until running steady-state to ensure that both reactors are comparable.

<u>Experimental phase (phase 2 – 62 days):</u>

- R1: feed with fresh manure
- R2: feed with stripped digestate from R1 (= post-digestion = post-AD)

Results

Table 1 and Table 2 summarise the results of the parameter analyses. In phase 1, both reference and post-AD-reactor, are fed with manure (identical composition). This results in a similar amount of biogas produced. Also, the parameters analysed on the digestate of the reference and post-AD show results of the same order of magnitude.

Table 1: parameter analyses phase 1

Parameter	Feed	Reference	Post-AD
Phase 1 (duration: 93 days)			
OLR, kg VS/m3.d	-	4,14 ± 0,81 (n=4)	4,14 ± 0,81 (n=4)
Biogas production rate, L/kg OFM.day	-	1,14 ± 0,07 (n=20)	1,30 ± 0,45 (n=20)
Biogas yield, L/kg manure		21,80 ± 0,11 (n=20)	23,28 ± 0,24 (n=20)
VS degradation, %	-	20,43 ± 7,14 (n=13)	24,05 ± 5,38 (n=13)
pH	7,25 ± 0,12 (n=3)	7,85 ± 0,11 (n=11)	7,90 ± 0,11 (n=11)
TS, g/kg	107,98 ± 20,76 (n=4)	72,46 ± 14,26 (n=13)	68,47 ± 10,54 (n=13)
VS, %	79,90 ± 1,03 (n=4)	75,66 ± 0,74 (n=13)	74,80 ± 0,47 (n=13)
TC, g C/kg	41,72 ± 12,77 (n=4)	25,26 ± 4,32 (n=13)	25,16 ± 4,07 (n=13)
sTOC, g/L	9,07 ± 1,09 (n=3)	5,86 ± 0,62 (n=12)	5,66 ± 0,45 (n=12)
VFA, mg/L	45 (n=1)	726 ± 378 (n=3)	570 ± 266 (n=3)
TN, g N/kg	4,79 ± 0,65 (n=4)	4,24 ± 0,35 (n=13)	4,27 ± 0,34 (n=13)
TAN, g/kg	2,02 ± 0,41 (n=4)	2,60 ± 0,31 (n=12)	2,59 ± 0,29 (n=12)
FOS/TAC	-	0,26 ± 0,03 (n=13)	0,23 ± 0,02 (n=13)
C/N ratio		8,60 ± 1,96 (n=3)	8,60 ± 1,96 (n=3)

In the second phase, i.e., the experimental phase, the reference reactor is fed with fresh manure and the post-AD reactor is fed with stripped digestate from the reference reactor. As depicted in Table 2, an increase in C:N ratio is noticed after stripping of the digestate. The composition of both digestates has the same order of magnitude for many parameters. A significant difference for TN and TAN is analysed in both reactors.

Table 2: parameter analyses phase 2

	Reference		Post-AD	
	IN	**OUT**	**IN**	**OUT**
Phase 2 (duration 62 days)				
OLR, kg VS/m3.d	4,08 ± 0,16 (n=2)		3,94 ± 0,84 (n=5)	
Biogas production rate, L/kg OFM.day	0,77 ± 0,15 (n=20)		0,76 ± 0,48 (n=20)	
Biogas yield, L/kg manure	10,72 ± 0,74 (n=20)		6,46 ± 0,67 (n=20)	
VS degradation, %	33,08 ± 3,56 (n=7)		20,97 ± 6,37 (n=6)	
pH	7,36 (n=1)	7,85 ± 0,10 (n=6)	8,93 ± 0,22 (n=6)	7,79 ± 0,13 (n=6)
TS, g/kg	102,26 ± 3,51 (n=2)	85,16 ± 1,19 (n=5)	105,42 ± 19,88 (n=5)	83,23 ± 22,12 (n=5
VS, %	82,99 ± 0,35 (n=2)	77,06 ± 0,78 (n=5)	75,92 ± 2,32 (n=5)	73,93 ± 1,93 (n=5)
TC, g C/kg	38,56 ± 0,57 (n=2)	25,91 ± 2,95 (n=6)	37,03 ± 4,03 (n=6)	24,09 ± 2,54 (n=6)
sTOC, g/L	9,73 (n=1)	8,72 ± 1,55 (n=9)	12,63 ± 1,59 (n=9)	7,64 ± 0,85 (n=9)
VFA, mg/L	-	-	-	-
TN, g N/kg	5,09 ± 0,18 (n=2)	4,65 ± 0,07 (n=6)	3,27 ± 0,38 (n=6)	3,62 ± 0,51 (n=6)
TAN, g/kg	2,1 (n=1)	2,57 ± 0,04 (n=6)	0,48 ± 0,07 (N=6)	1,72 ± 0,45 (n=6)
FOS/TAC		0,35 ± 0,05 (n=6)		0,31 ± 0,07 (n=6)
C/N ratio	7,59 ± 0,38 (n=2)		11,39 ± 1,19 (n=6)	

After switching from phase 1 to phase 2, Figure 2 shows a decrease in biogas production rate in the post-AD reactor due to the change in feed from fresh manure to stripped digestate. Two retention times later the biogas production rate in the post-AD increased to the level of the reference reactor.

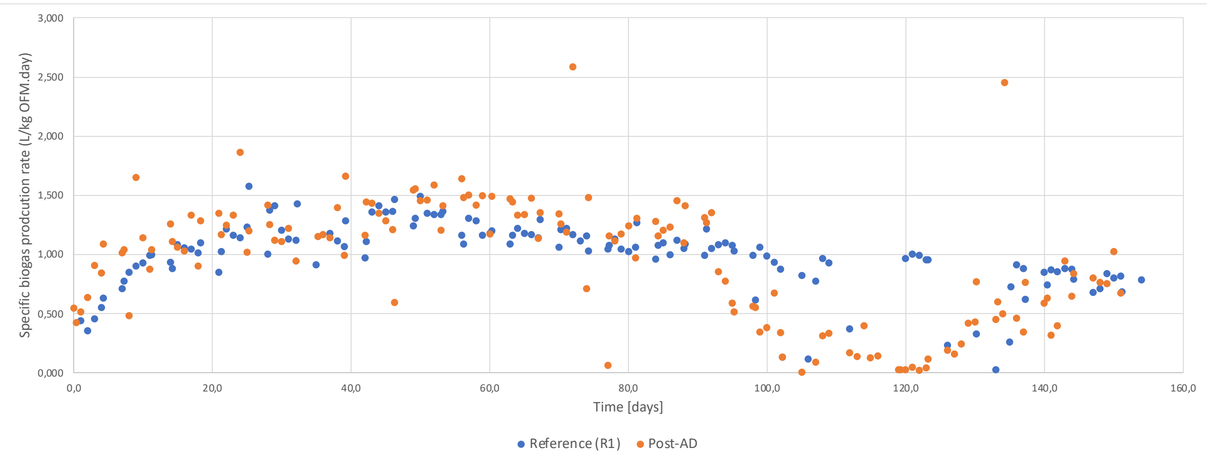

Figure 2: specific biogas production rate

Conclusion

The target additional biogas production (10 - 20%) is achieved in the long-term semi-continuous test. In the post-AD reactor, a biogas yield of 6,46 L/kg manure is noted. Thus, introducing stripped digestate of the reference reactor into the post-AD reactor provides an additional biogas production of about 60%, which is much higher than the predetermined target.

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A biorefinery approach to exploit digestate as key feedstock in the energy – nutrient nexus

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More information about the project: check out the project website.

Project partners: Biogas-E, KU Leuven, Ghent University, Marmara University, VCM, OSTIM

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