energies

Supplementary Material

Improving the Anaerobic Digestion of Swine Manure through an Optimized Ammonia Treatment: Process Performance, Digestate and Techno-Economic Aspects

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S.1 Theoretical calculations of CH_4 yields of NP and AAS digesters based on BMP tests

Assuming that the hydrolysis is the limiting step of the AD, the hydrolysis constants, k_h, of manure fibers (NP and AAS) were calculated by equation S1. The conditions and set up of the BMP tests can be found in Lymperatou et al. [14].

$$B = B_0 * (1 - e^{-k_h \cdot t}) \quad \text{(S1)}$$

where: B, the CH_4 yield after t days of digestion in mL/g TS; B_0, the ultimate CH_4 yield in mL/g TS; k_h, hydrolysis constant; and t, the duration of digestion in d.

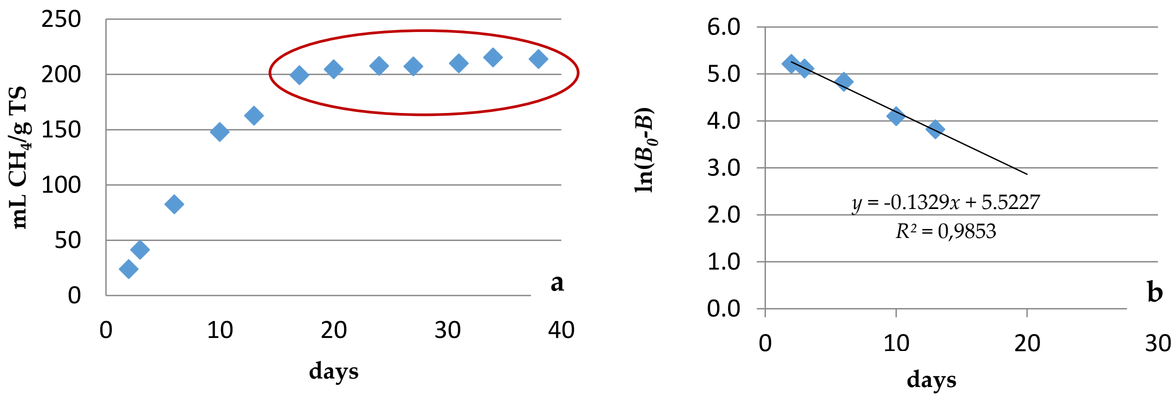

Figure 1. BMP tests of optimally AAS-treated manure fibers: (a) Evolution of cumulative CH_4 yield [14]; (b) Hydrolysis constant determination by Equation S1 from BMP test.

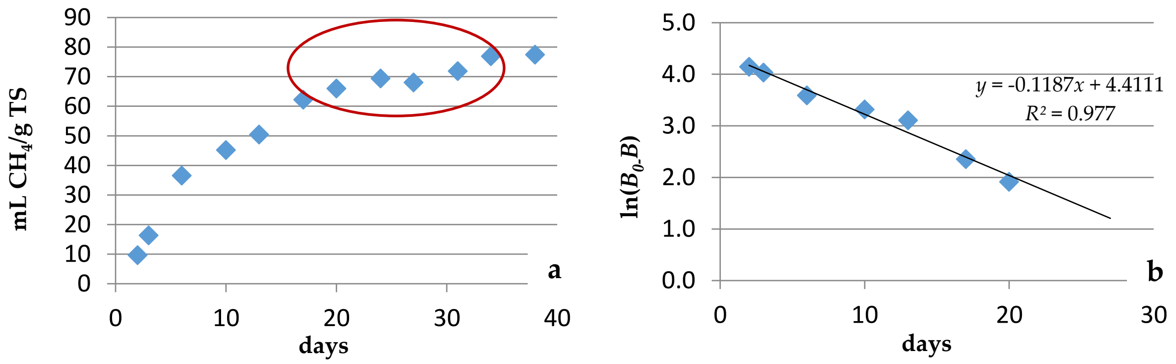

Figure 2. BMP tests of optimally NP manure fibers: (a) Evolution of cumulative CH_4 yield of NP manure fibers [14]; (b) Hydrolysis constant determination by Equation S1 from BMP test.

Table S1. Ultimate CH_4 yield (B_0) and hydrolysis constant (k_h) of NP and AAS manure fibers as resulted from equation S1.

Substrate	B_0	k_h
NP fibers	72.72	0.1187
AAS fibers	208.34	0.1329

Based on the k_h (Table S1), the expected CH_4 yields of the NP and AAS fibers were calculated at the respective SRT of each digester (NP and AAS) from the continuous experiments based on Equation 5. The data are presented in Table S2.

Table 2. CH_4 yield of NP fibers and AAS fibers (without manure) calculated by Equation 5 in original paper.

Substrate	*B*	B_0	k_h	*t (SRT)*
NP fibers	55	72	0.1187	26.7
AAS fibers	161	208	0.1329	25.9

Finally, assuming that the CH_4 yield of manure in the NP and AAS digester corresponded to 204 mL/g TS (average CH_4 yield of the Reference digester), and given the TS ratio of manure: fibers in the NP and AAS digesters corresponded to 2:1, the CH_4 yield of the NP and AAS digester were calculated to be 151 mL/g and 189 mL/g TS, respectively (Table S3).

Table S3. Expected CH_4 yield of NP and AAS digesters based on the share of substrate.

Digester	mL CH_4 /g TS manure	mL CH_4/g TS fibers	g TS manure/g TS fibers	Expected mLCH_4 /g TS
NP digester	204	55	2/1	151
AAS digester	204	161	2/1	189

S.2 Calculations of biogas output of AD of solely manure (scenario 1) and AD of manure enriched with NP fibers (scenario 2) for comparison to the simulation

Table S4. Characteristics of Scenario 1 (manure mono-digestion) and Scenario 2 (AD of manure and NP fibers).

Characteristic.	Scenario 1 (10kg manure)	Scenario 2 (10kg manure + 3kg NP fibers)
HRT	20	20
Kg TS manure/h	0.6	0.6
Kg TS fibers/h	-	0.9
mL CH_4/ gTS from manure	212	212
mL CH_4/ gTS from fibers[1]	-	51.2
L CH_4/h from manure	127.2	127.2
L CH_4/h from fibers[1]	-	46.1
Total L CH_4/h	127.2	173.3
Kg CH_4/h	0.0913	0.1243

[1]Calculated based on eq.5 for *t* = 20.

Based on the calculations presented in Table S4, Scenario 1 results in 0.0913 kg CH_4/h and Scenario 2 results in 0.1243 kg CH_4/h. The estimation of CH_4 production for Scenario 3 (manure + AAS fibers) from the HYSYS simulation resulted in 0.2140 kg CH_4/h. Thus, the resulted increase of CH_4 production in Scenario 3 corresponds to 135% as compared to Scenario 1 and 72% as compared to Scenario 2.

S.3 Preliminary results of BMP tests for evaluating the efficiency of AAS at low temperature and efficiency of AAS with the addition of centrifuged effluent instead of water

Table S5. Increase of CH_4 yield achieved from BMPs of digested manure fibers for evaluating the efficiency of AAS at low temperature and with the addition of centrifuged effluent.

Experiment[1]	AAS conditions	BMP duration (days)	% increase CH_4 yield[2]
AAS Effluent	5% w/w NH_3, 3 days, 0.16kg/L	29	+261
AAS tap water	5% w/w NH_3, 3 days, 0.16kg/L	29	+247
AAS miliQ water	5% w/w NH_3, 3 days, 0.16kg/L	29	+244
AAS ambient temperature	5% w/w NH_3, 2.5 days, 0.33kg/L	23	+57
AAS 4°C	5% w/w NH_3, 2.5 days, 0.33kg/L	23	+56

[1] AAS-Effluent, AAS-tap water and AAS miliQ water correspond to AAS-treated digested fibers diluted with centrifuged AD effluent, tap water and miliQ water prior to NH_3 removal respectively and before BMP tests. [2] As compared to the CH_4 yield of NP digested manure fibers.