Task 2.2 - Side-stream vacuum stripping of raw digestate on internal recirculation line

Objective

The objective of Task 2.2 was to optimize side stream vacuum stripping to ensure that the ammonia content in the digestate decrease below the inhibitory level upon recirculation. Two anaerobic digesters, a test and control reactor (R-control and R-test), were fed with nitrogen rich chicken manure and operated in parallel at high organic loading rates. In R-test, ammonia was stripped from the digestate on an internal recirculation line by applying vacuum. The goal was to lower ammonia concentration below the inhibition level, thereby increasing CH_4 production per unit volume in R-test.

Set-up/Parameters

Two laboratory-scale anaerobic reactors were set up each with an active volume of 6 litres, one as control (R-control) and the other equipped with an integrated vacuum stripping unit (R-test). Both reactors operated in parallel for 400 days under mesophilic conditions (36±1 ℃), with a hydraulic retention time of 30 days.

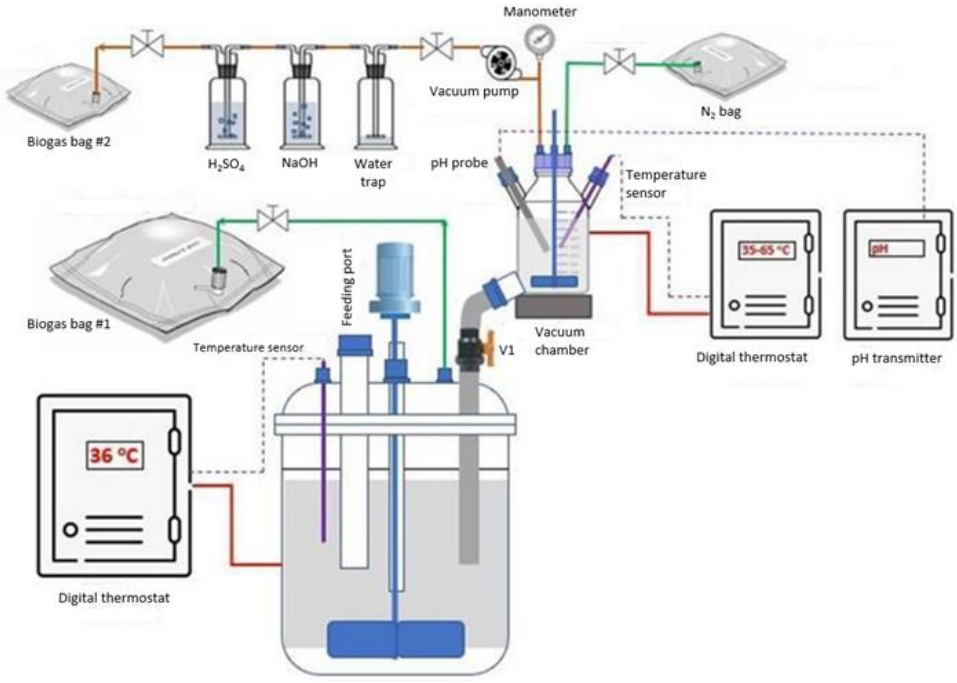

Figure 1: Set-up of R-test equipped with a side-stream vacuum stripping unit.

The seed used to start up the reactors was obtained from a laboratory-scale anaerobic digester fed with sewage sludge. The reactors were fed with chicken manure (CM) taken from an egg laying hens farm in İzmir, Türkiye. TAN, TKN, TS, and VS concentrations of the raw CM were 6.938±64 mg/L, 15.245±542 mg/L, 22,4% and 14,6%, respectively. The schematic of R-test is shown in Figure 1.

R-test, operated with side-stream vacuum stripping, was connected to a 2 L glass vacuum chamber (Figure 1) while R-control was operated without vacuum operation. Ammonia stripping was performed using a vacuum pump connected to the vacuum chamber. Before initiating the vacuum application, the digestate's temperature in the chamber was adjusted to the desired level.

Throughout the vacuum ammonia stripping experiments, the pressure was monitored using a manometer. To condense and trap watervapor as water, a cold watertrap was placed in the gas outlet line of the vacuum chamber. After vacuum application, the digestate in the chamber was returned to the digester.

Results

Due to some operational problems, it took 244 days to reach steady state conditions and to achieve similar methane yields in both reactors. The vacuum application on the recirculation line of R-test started on day 245, involving stripping 1/10 of the reactor (digestate) volume for 30 minutes every day, without pH and temperature adjustment, until day 281. A few days after side-stream vacuum stripping in R-test, the difference between TAN concentrations in both reactors began to increase.

From day 281 onward, the duration of vacuum stripping was extended to 45 minutes daily, maintaining constant organic loading rates, excluding weekends. Between days 345 and 400, the organic loading rate was gradually increased from 2 to 3,25 kg VS/m^3/day. While the TAN concentration in R-control gradually increased with the rising OLR, it had no detrimental effect on R-test's performance between days 281 and 400 with vacuum stripping.

On day 400, TAN concentration was approximately 3.904±527 mg/L in R-control and 2.862±222 mg/L in R-test. The ammonia removal efficiency in the vacuum unit was calculated as 16,2±5,7%. The average methane production of R-test was 26,9% higher than that of R-control, attributed to the 16% higher methane content in the biogas produced by R-test (Table 1).

Table 1: R-control and R-test data between days 245 and 400.

	R-control	R-test	% change
CH_4 yield, (m^3 CH_4/kg VS)	0,24±0,03	0,31±0,05	26,9%
CH_4, %	60,6±1,4	70,3±2,5	16,0%
TAN (mg/L)	3.904±527	2.862±222	-26,7%
pH	7,71±0,04	7,72±0,07	0,1%
Total VFA (mg COD/L)	479±612	443±766	-7,5%
Alkalinity (mg $CaCO_3$/L)	25.679±2.210	21.195±1.213	-17,5%
Soluble COD (mg/L)	7.002±2.033	4.973±270	-29,0%

Conclusion

- In R-test, 26,7% of the ammonia was removed from the digestate with side-stream vacuum stripping.
- In R-test operated with side-stream vacuum stripping, the CH_4 content of biogas was 70,3%, while in the R-control it was 60,6%.
- While vacuum application alleviated the NH_3 inhibition in R-test, the TAN concentration in R-control exceeded the inhibition level with increasing OLR, causing CH_4 production to decrease.

Contact: Prof. Dr. Barış ÇALLI baris.calli@marmara.edu.tr

The findings of Task 2.2 will be published in the following research paper:

Şengür Ö., Bayrakdar, A., Akgül, D., Çallı, B. “Effects of long-term vacuum stripping on AD of chicken manure” In Preparation.

More information about the project: check out the project website.
Project partners: Biogas-E, KU Leuven, Ghent University, Marmara University, VCM, OSTIM
With the support of:

cornet AGENTSCHAP INNOVEREN & ONDERNEMEN Vlaanderen is ondernemen TÜBİTAK