Effect of co-digestion of agricultural substrates on the energy balance of the Wastewater Treatment plant

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Introduction

Biogas plants are part of a circular economy, which aims to use the by-products of production for reuse, e.g. by recovering raw materials or energy. Medium and smaller wastewater treatment plants face a shortage of substrates to ensure stable conditions for methane fermentation. At the same time, they are very often located in rural areas, which are rich in agricultural waste available all year round (e.g. slurry or maize silage). These wastes are successfully used in agricultural biogas plants. In the case of sewage treatment plants they can be a source of additional substrate (so-called co-substrate), which may justify the adoption of such a method of sludge management. A potential problem associated with the use of these substrates is the increased concentration of contaminants, especially in the wastewater from digested sludge dewatering. It is estimated that in typical municipal wastewater treatment plants nitrogen returned to the main treatment line accounts for up to 15-20% of the total load. The increased nitrogen load increases energy consumption for aeration, which reduces or even cancels out the positive energy effect of increased biogas production.

The aim of the work

- determine the effect of selected agricultural wastes on the increase in biogas production;
- determination of the increase in nitrogen concentration in the reject water from digestate dewatering.

Material & Methods

- 20 % of the volume - Inoculum (sludge from the digestion chambers)
- 80 % of the volume – co-substrate as: slurry (cow manure) and corn silage

Fermentation:
Volume : 10 L (active 8L)
Time : 10 days
Temperature : 37°C
Mechanical separation into solid and liquid fraction (4000 rpm, 30 min)
The volume of produced biogas was measured with use of graduated measuring tubes.
Periodically, the composition of biogas in the tubes was measured (in the range of CH_4, CO_2, O_2, NH_3, H_2S)

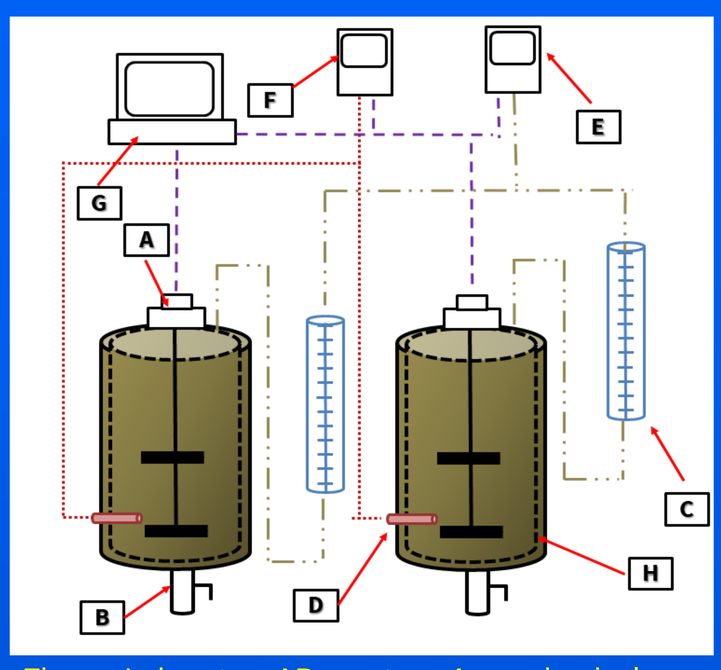

Figure: Laboratory AD reactors: A- mechanical stirrer, B - sampling point, C - tubes for measuring the volume of produced biogas, D - temperature E - biogas composition meter, F - temperature meter, G - control system, H - water jacket.

Results & Discussion

In all tests performed, the pH varied from 7.40 to 7.95, so it remained within the recommended range.

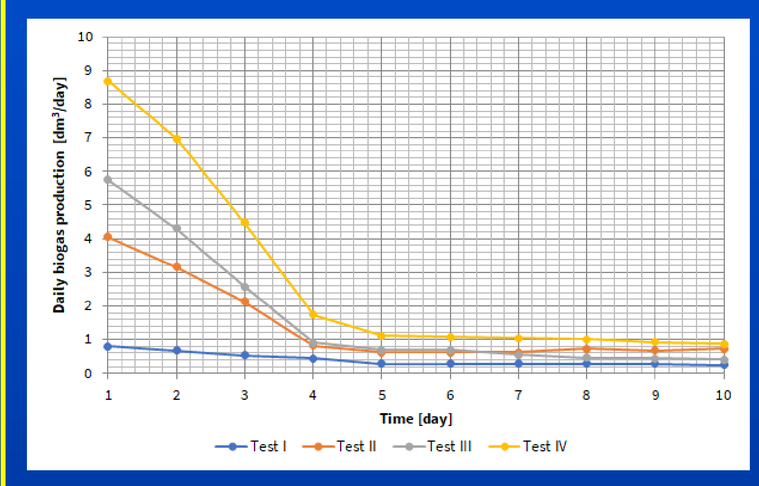

Figure: Daily production of biogas.

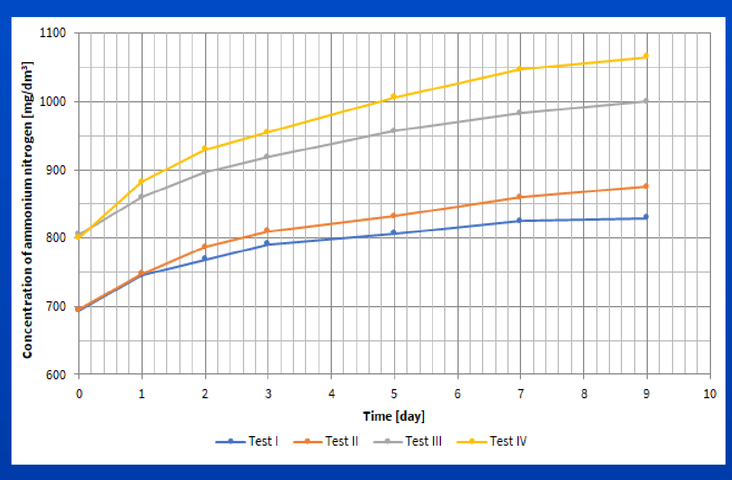

Figure: Changes in ammonia nitrogen concentration during co-fermentation tests.

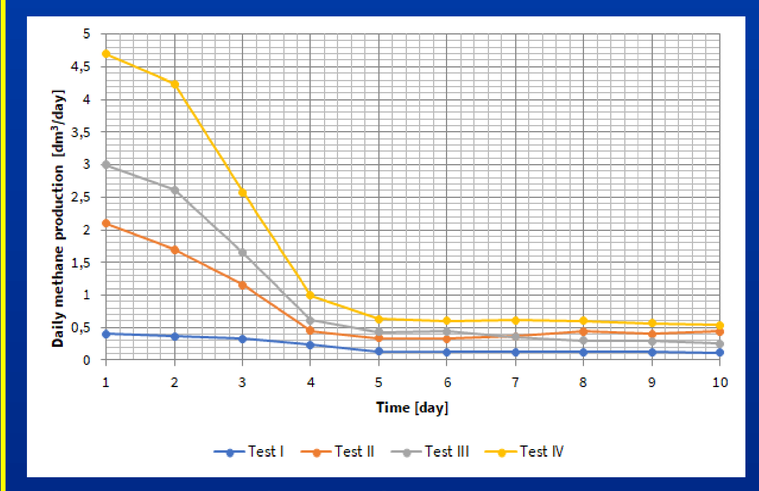

Figure: Daily production of methane.

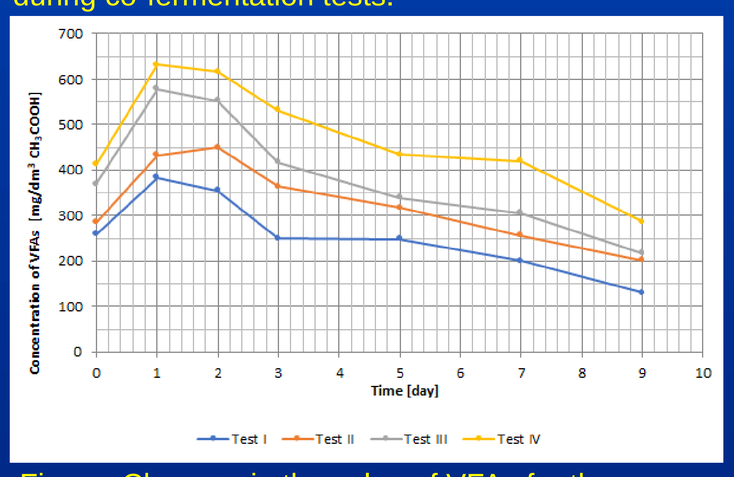

Figure: Changes in the value of VFAs for the analyzed tests.

Table : Unit production of biogas and methane during methane fermentation (T=36°C, t=10d)

Input	Test I	Test II	Test III	Test IV
	The biogas production rate [dm_3/kg Vs_{added}]			
All added substrates	52.12	149.13	145.99	213.18
Corn silage	-	639.51	-	-
Slurry	-	-	352.47	-
Corn silage + slurry	-	-	-	461.67
	The methane production rate [dm^3 CH_4/kg VS_{added}]			
All added substrates	26.57	81.72	86.64	122.85
Corn silage	-	306.82	-	-
Slurry	-	-	218.89	-
Corn silage + slurry	-	-	-	270.55

Conclusions

1. In all tests, biogas production was most efficient up to the 8h day of the batch test. The waste used in the tests contributed to a significant increase in the production of biogas, as well as to a significant increase in the share of methane in it (approx. 70-73%).

2. On the basis of the mass balance, the BPR and MPR values related to 1 kg of organic dry matter of the respective co-substrate were determined, as well as the mineralisation rate of organic dry matter, which was 31% and 20.8% for corn silage and slurry, respectively.

3. The addition of cow manure or corn silage did not inhibit the methane fermentation process.

4. Inhibition of the methane fermentation process did not occur in any of the tests. Also, the hydrolysis of nitrogen-containing organic compounds contained in the feedstock into PON, CON and DON fractions proceeded without significant interference. This is indicated by a significant increase in the concentrations of these fractions during the first 2-4 days relative to fermentation of the inoculum alone (from over 100 to almost 200%).

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