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

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BACKGROUND AND RELEVANCE

The development of public awareness in the field of environmental protection and the increased demand for electricity results in increased interest in the use of renewable energy sources. An example is the recovery of energy contained in sewage through methane fermentation of sewage sludge in municipal biogas plants (located at the wastewater treatment plant). These biogas plants fit in with the circular economy idea, which aims to use the by-products generated during production for reuse, e.g. through the recovery of raw materials or energy. Medium and smaller sewage treatment plants struggle with the problem of substrate shortages to ensure stable conditions for methane fermentation. At the same time, they are very often located in rural areas, rich in agricultural waste (e.g. slurry or corn silage), available all year round. These wastes are successfully used in agricultural biogas plants. In the case of sewage treatment plants, they may be a source of an additional substrate (the so-called co-substrate), which may justify the adoption of such a method of sludge management. A potential problem with the use of these substrates is the increased concentration of impurities, especially in reject water from digestate dewatering. It is estimated that in typical municipal wastewater treatment plants, nitrogen returned to the main sewage treatment line constitutes as much as 15-20% of the total load (Fux et al., 2004). The increased nitrogen load increases the energy consumption for aeration, which lowers or even eliminates the positive energy effect resulting from increased biogas production (Zaborowska et al., 2017).
The study aims to evaluate the possibility of using agricultural substrates to increase the possibilities of biogas production in wastewater treatment plants, taking into account their impact on the increase in nitrogen concentration in the leachate.

MATERIAL AND METHODS

Co-fermentation studies were carried out in laboratory conditions, in reactors with an active capacity of 8L. Four batch tests were carried out, aimed at checking the impact of individual components of the input in the co-fermentation process on the increase in biogas production and on the composition of leachate. Each test differed in the share of the analyzed waste in the reactor charge (Table 1). Two agricultural substrates were used as the input material: slurry (cow manure) and corn silage. The sediment from the fermentation chambers of the wastewater treatment plant located in central Poland was used as the inoculum. Before and during the fermentation, the digested samples were mechanically separated into solid and liquid fractions in the centrifugation process (4000 rpm, 30 min).

Table 1. The composition of the feedstock in the reactors for each test.

Reactor charge	Test I	Test II	Test III	Test IV
Inoculum	6.5 L	6.5 L	6.5 L	6.5 L
Slurry	-	-	0.6 L	0.6 L
Corn silage	-	55.5 g	-	55.5 g

RESULTS

Based on measurements of the quantity and quality of biogas produced, biogas and methane accumulation curves (Fig. 1A) were drawn for the hydraulic retention time (HCR) range from 0 to 10 d. It was shown that the fermentation process proceeded correctly, and the obtained values of biogas production for the analysed substrates (Table 2) are within the ranges presented in the literature. This indicates that there is no need adaptation period of bacteria present in the digesters of the wastewater treatment plant to the decomposition of the agricultural substrate. There was also a significant increase in ammonium nitrogen concentration (Fig 1B) in the effluents from the dewatering of the digestate when slurry was used as a substrate (by more than 20%) or a

mixture of slurry and corn silage (almost 30%). The use of corn silage alone resulted in a much lower increase in ammonia nitrogen concentration (about 5%).

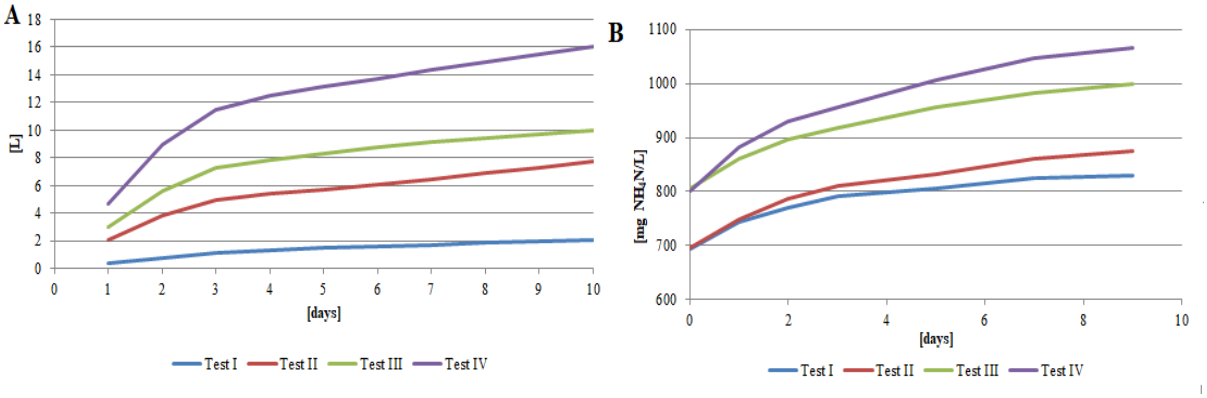

Figure 1. Accumulation curves of methane production (A) and ammonium nitrogen concentration in reject water (B).

Table 2. Specific production of methane, biogas and increase of ammonium nitrogen

Input	Biogas L/kg VS_{add}	Methane L/kg VS_{add}	NH_4-N g/kg VS_{add}
Inoculum	52.2	26.6	1.71
Slurry	639.5	360.8	2.94
Corn silage	352.5	218.9	4.76
Slurry with corn silage	461.7	270.5	4.58

Based on the results obtained, an energy balance analysis was performed for the analysed feedstock composition and different variants of nitrogen removal from the effluent of digestate dewatering.

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