BIOGAS PRODUCTION FROM SEWAGE SLUDGE AS AN ENERGY BALANCE ELEMENT OF THE WASTEWATER TREATMENT PLANT

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The management of sewage sludge at wastewater treatment plants is a very important technical, economic and ecological issue. One of the popular and ecological methods of processing sewage sludge is their methane fermentation. Methane fermentation is a complex biochemical process during which the organic matter decomposes in sewage sludge under anaerobic conditions. The final product of the biochemical decomposition of organic substances is biogas, which is a valuable energy raw material and digestate constituting an excellent organic fertilizer. Most often, biogas energy is used for the own needs of wastewater treatment plants, which are characterized by a high demand for electricity and heat [1, 2, 4, 5].

This article presents the production of biogas at the wastewater treatment plants in Zamość and Dębica (Poland). A detailed analysis of sewage sludge management in the wastewater treatment plants is presented, taking into account the balance of sewage sludge and biogas, in 2015-2016 years. The projected 24-hour capacity of the Zamość WWTP is $Q_{d\ av}$ = 25,000 m^3/d (rainless weather), and the maximum daily capacity is Q_{dmax} = 28,000 m^3/d (rainy weather). The equivalent number of inhabitants was determined at the level of 250,000 PE, while the plant's current capacity is at 135,720 PE. The daily capacity of the Dębica WWTP is $Q_{d\ av}$ = 21,000 m^3/d, and the maximum daily capacity is Q_{dmax} = 24,500 m^3/d. The wastewater treatment plant capacity in analyzed period is 108,350 PE. The technological system of biological wastewater treatment is similar and based on activated sludge in flow reactors. In both wastewater treatment plants the sewage sludge processing line is similar - thickener of initial sludge, thickener of excess sludge, anaerobic digestion tank and belt press for digested sludge. The produced biogas is burned in boilers and cogenerators and electric energy and heat energy are generated.

The volume of biogas from the fermentation process in wastewater treatment plants was presented in detail in Figures 1. Statistical analysis showed the production of biogas wasn't correlated with BOD_5 loading to the WWTPs (Fig. 2).

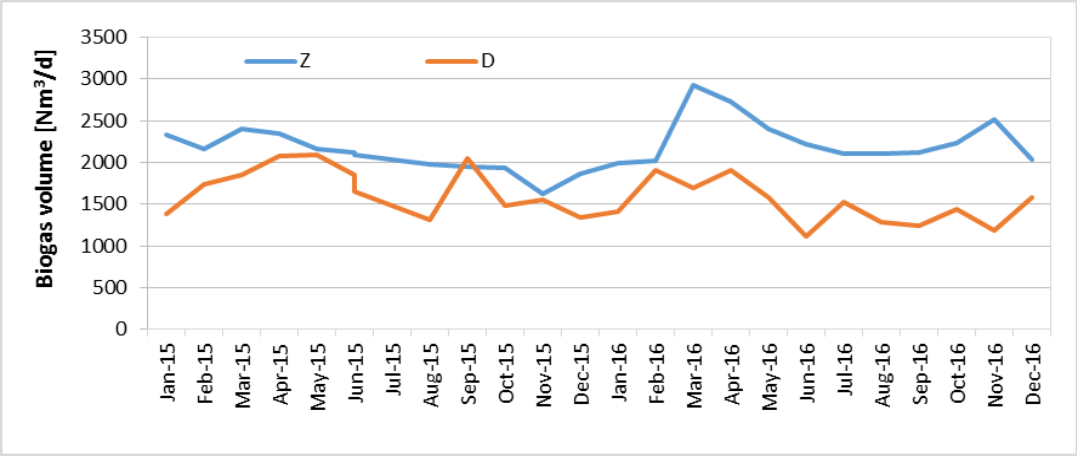

Fig. 1. Biogas volume generated in fermentation process at wastewater treatment plants

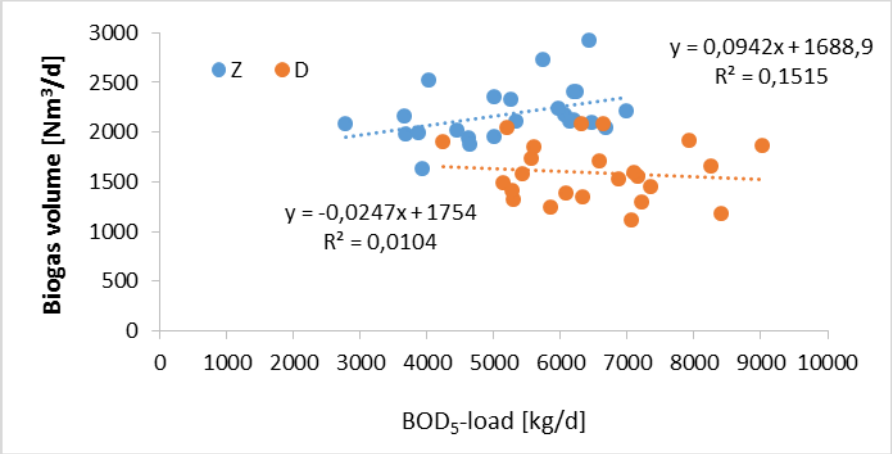

Fig. 2. Biogas volume generated in relation to BOD_5-loads.

The amount of biogas generated translated to a large extent on the production of electricity and heat. The unitary production of electricity was 0.36-2.13 kWh/Nm^3 biogas (the Dębica WWTP) and 0.52-2.21 kWh/Nm^3 biogas (the Zamość WWTP), on average 1.43 and 1.78 kWh/Nm^3 biogas, respectively (Fig. 3). At the region's other WWTPs, biogas electricity production rates were achieved at 1.9 ÷ 4.8 kWh/Nm^3 biogas (the Mielec WWTP) [3], 3.82 ÷ 4.51 kWh/Nm^3 biogas (the Krosno WWTP) [6] and 2.02 ÷ 2.48 kWh/Nm^3 biogas (the Rzeszów WWTP) [2].

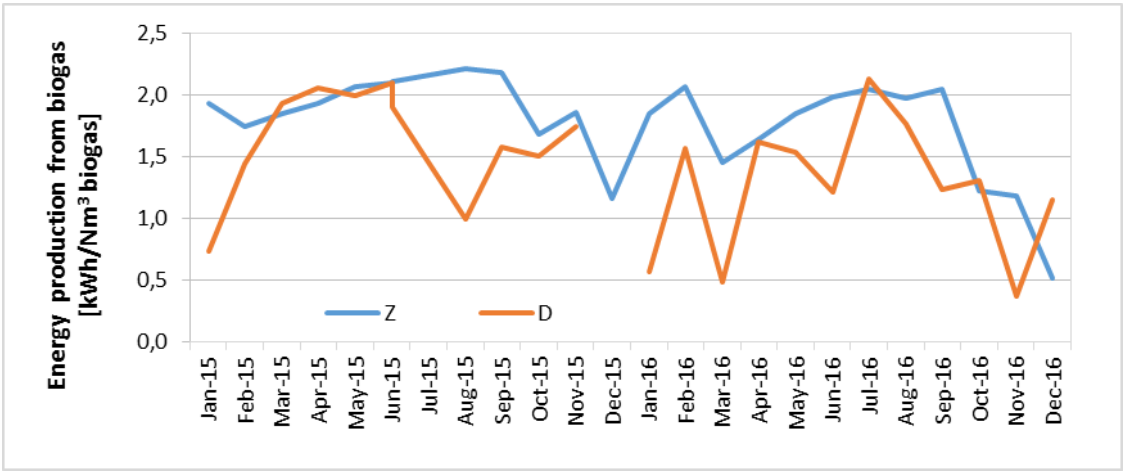

Fig. 3. Electricity production from biogas at wastewater treatment plants.

The effect of biogas combustion in boilers and in a gas co-boiler was a significant production of electricity. Work of boilers and co-generator allowed to cover 46.5 and 49.9% of electricity consumption in the Debica WWTP and Zamość WWTP, respectively (Fig. 4). Nevertheless, as a result of the intensification of the sewage sludge fermentation process by the addition of an organic substrate (eg. waste fat), it is possible to increase the biogas yield and, consequently, improve the energy efficiency of the whole sewage treatment plant.

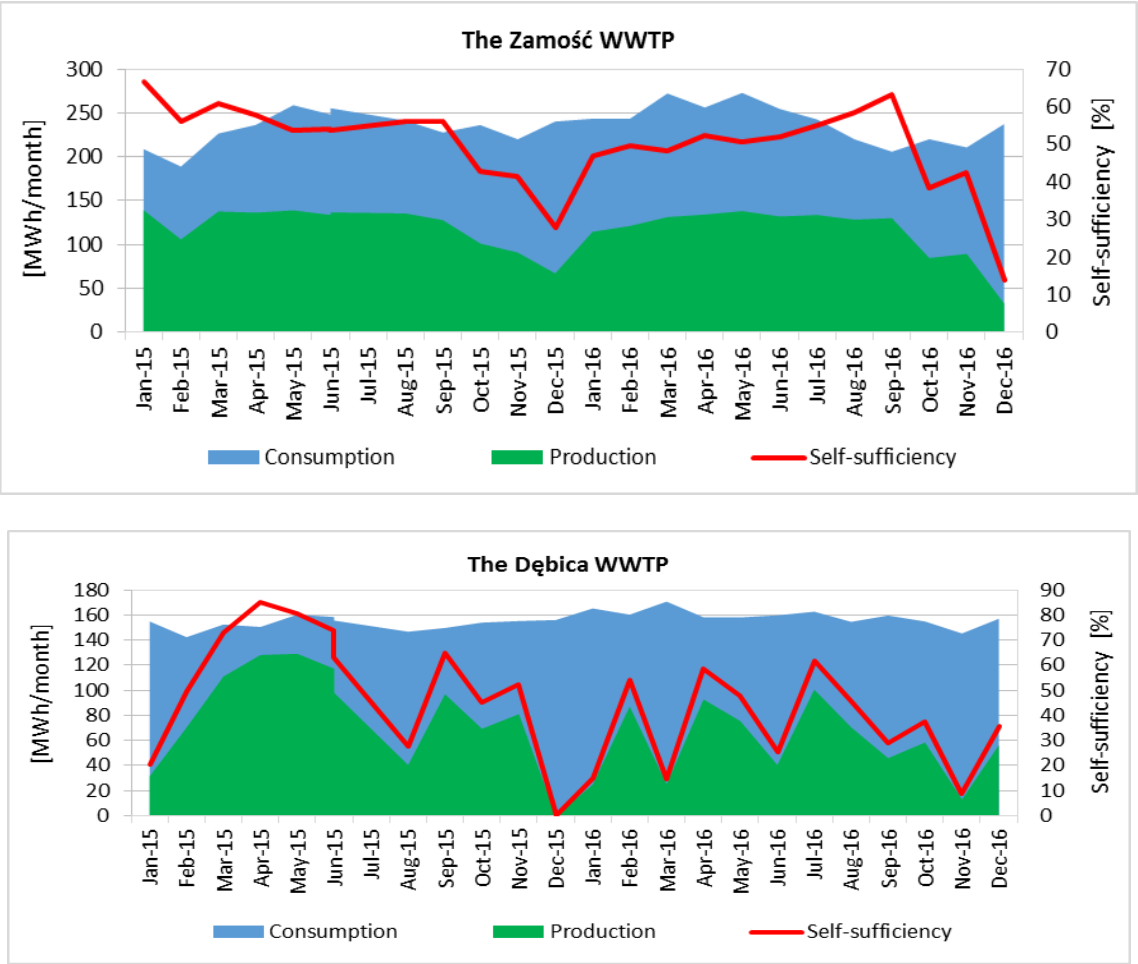

Fig. 4. Energy balance at the wastewater treatment plants.

The processing systems of sewage sludge in the Zamość WWTP and the Dębica WWTP functions with high energy efficiency. The analysis of sludge management in the wastewater treatment plants indicates very high biogas production from sewage sludge. Methane fermentation is a good energy recovery technology from sewage sludge, and the obtained biogas is a very valuable fuel that can be successfully used in the wastewater treatment plants.

References

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