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ENERGY AND ECONOMIC MODEL OF BIOGAS DIGESTION AT THE WASTE WATER TREATMENT PLANTS

Summary

At present, effective sewage sludge treatment processes are being sought, allowing to eliminate or reduce the content of organic micro-contaminants and obtain an environment safe product. One of the methods of sewage sludge processing is methane fermentation, which results in decomposition of complex high molecular organic compounds, subsequently leading to stabilization of the sediment properties.

Modern wastewater treatment plants are complex engineering and technological objects, which functioning is often no longer limited only to wastewater treatment and disposal of sewage sludge. The currently observed trend is the creation of energy self-sufficient facilities, by optimizing technological processes and placing a special emphasis on the production of its own energy, using its own and easily available substrates.

The above-mentioned situation is related to the scientific problem described in this work, which can be formulated in the form of a question: what should be the combination of the substrates and plant parameters allowing high-yield and economically profitable biogas production using sludge and external co-substrates?

Therefore, the aim of this doctoral thesis will be to develop an open energy and economic model of biogas digestion at the waste water treatment plants, for three different size treatment plants, and to confirm its validity on the basis of laboratory tests and also on a technical scale.

The research part of the work was performed in the Ecotechnology Laboratory of the Institute of Biosystems Engineering at the Poznań University of Life Sciences. The computational part was based on energy calculation procedures when planning biogas installations developed in recent years at the Institute of Biosystems Engineering. The present net value (NPV) and the discounted payback period (DPBP) were used as decision indicators.

Based on the results of the work, it has been stated that the constructed energy-economic model allows for the configuration of any substrates available in a given location - so as to give the investor the best energy efficiency and obtain the most effective economic balance of the planned investment. Moreover, the responses to the given scientific problem have also been formulated, differing for individual categories of the analyzed sewage treatment plants:

In case of a small wastewater treatment plant, only the fermentation of the sewage sludge produced on the site was analyzed and it was found that in order to be equal to 0 in the maximum of 10 years, the best option would be to use the following proportion of substrates: total sewage sludge, 500 Mg/year of fat waste , 445 Mg/year of dairy waste, 46 Mg/year of bakery waste.

On the other hand, for the average sewage treatment plant, only the sewage sludge produced on the site has been analyzed. To ensure that the plant's own needs are optimally configured, the following proportions should be used: total sewage sludge production, 500 Mg / year of fat waste, 2600 Mg / year of dairy waste products, 500 Mg / year of bakery waste. In case of a large wastewater treatment plant, only the fermentation of sewage sludge produced on the site was analyzed and it has been proved that if all available co-substrates are used, the object may show a very large overproduction of electricity and heat.

During the experimental part of the work, a very large difference in the methane performance of sewage sludge was found (from 2.67 m^3/Mg of F.M. to 22.38 m^3/Mg of F.M.), as well as within co-substrates, which generally showed higher methane production (from 53.35 m^3/Mg of F.M. to 724.3 m^3/Mg of F.M.).

It has been proved that the price (cost) of acquiring a substrate or accepting a fee for it (revenue) plays a very important role in the analyzed economic balances. For example, the use of expensive maize silage (price 135 PLN/Mg) does not allow to generate revenues that allowing obtainment of a positive economic balance. Moreover, it should be emphasized that the developed energy-economic model is open, which means that it has a very high flexibility and the ability to enter data by the user. It gives a wide range of possibilities of conducting comparative analyzes, both taking into account sensitivity analysis (only one variable value) as well as a wide spectrum of scenario analysis (many variables at the same time). It means that the model can be widely used in biogas co-fermentation installations planned for construction or modernization at sewage treatment plants, enabling simple, quick and thorough analysis of investment assumptions as well as ongoing verification of the results obtained during operation.

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