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PROCESSING OF SEWAGE SLUDGE WITH ENERGY RECOVERY IN A WASTEWATER TREATMENT PLANT

Sewage sludge management in wastewater treatment plants is an important and very current issue. The paper presents an example of a well-resolved technological process of re-use and management of sewage sludge according to operating data from the Gubin–Guben wastewater treatment plant. The sewage sludge is subjected to methane fermentation process with biogas recovery. Electricity obtained from the biogas at 55%, and the produced heat in 100% covers the treatment plant energy demand. Physicochemical and bacteriological parameters of stabilized sludges indicate the possibility of their use in natural and agricultural area.

1. INTRODUCTION

Sewage sludge (preliminary and secondary) are the products of wastewater treatment and are the result of physical, physicochemical and biological processes occurring in wastewater treatment plants (WWTP). The amounts and composition of sewage sludge are very variable and depend on many factors including the type of wastewater and used treatment processes. Processing and disposal of sewage sludge are important elements of properly implemented waste management in WWTP [1–3].

The Polish legislation on waste management, including sewage sludge is in force the Waste Act from 2001 [4], and the Regulation of the Minister of Environment on municipal sewage sludge dated July 13, 2010 [5]. These wastes are classified [6] in the 19th group as waste of installations and facilities for waste management from sewage treatment plants, drinking water treatment and water for industrial purposes. In the group – waste from sewage treatment plants not included in others groups with the code 19 08, for stabilized municipal sewage sludges was assigned the code 19 08 05.

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Existing legislation forces on producers (exploitators of WWTP) management of stabilized sludge and adequate preparation for the order and manner of their further use. During treatment processes in sewage treatment plants, sludge is subjected to processes of dewatering and stabilization using biological, chemical or thermal methods. According to KPOSK [7] forecast for 2015 amount of dry stabilized sludge, which arises in municipal wastewater treatment plants, will reach 642.4 thousand Mg (dry mass). It is estimated that in 2015 approximately 58% of the total quantity of sludge produced in Poland will rise in agglomerations with Population Equivalent (PE) > 100 000, approximately 29% in agglomerations with PE from 15 000 to 100 000 and approximately 13% in urban areas with PE from 2000 to 15 000 [7].

Several methods of sludge management in Poland include agricultural application, landfilling, thermal conversion and land reclamation. Re-use of sludge reduces or completely prevents the heavy metal contents and the presence of pathogenic organisms. Restrictions on landfilling and the agricultural application of sewage sludge are determined by searching for other methods of its management. Optimistic forecasts assume that the dominant method of final fitting of sewage sludge will be the thermal transformation and by 2018 it will have reached an approximately 60% [8, 9]. Statistics show that Polish treatment plants in 2009 produced 563.1 thousand Mg dry mass of sludge [7].

Sewage management by disposal reached 14.5%, the use of sludge for land reclamation reached 13.8% and in agriculture 21.9% of sludge was used. Thermal methods were 1.6% and in sewage sludge dominated (31.1%) other methods. The use of sewage sludge for various purposes, according to the NWMP in 2010 is shown in Fig.1 [10].

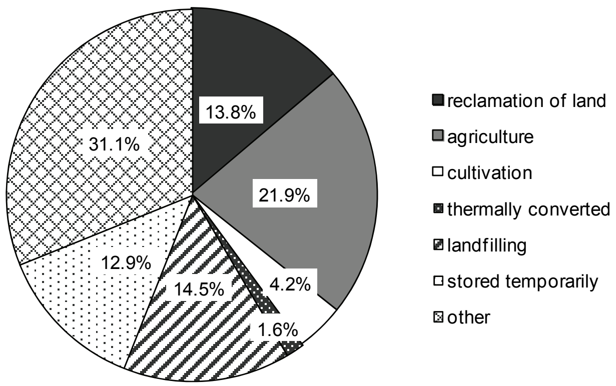

Fig. 1. Management of sewage sludge from municipal wastewater treatment plants in 2009 in Poland (based on the NWMP 2010)

The primary sequence of sludge treatment followed in the majority of Polish sewage treatment plants is: thickening, stabilization (anaerobic, aerobic, chemical), dewatering, hygienisation, drying. In recent years, special attention was paid to the application allowing water removal from sewage sludge in the processes of: thickening, dewatering, drying and burning. The adopted chain of technological processes of sludge treatment depends on the amount of the sludge, its characteristics and methods of final disposal [11–13]. The final disposal of sludge is the removal outside the wastewater treatment plant and using it individually prepared for each treatment method. Sewage sludge could be used in agricultural applications or subjected to heat treatment. Management of sewage sludge should be considered as one of the most important problems to solve in the national waste management [14].

2. CHARACTERISTIC OF THE RESEARCH OBJECT

The object of this study was a mechanical-biological Wastewater Treatment Plant Gubin–Guben designed for Q = 12 000 m^3/day. Figure 2 shows the scheme of the WWTP [15, 16].

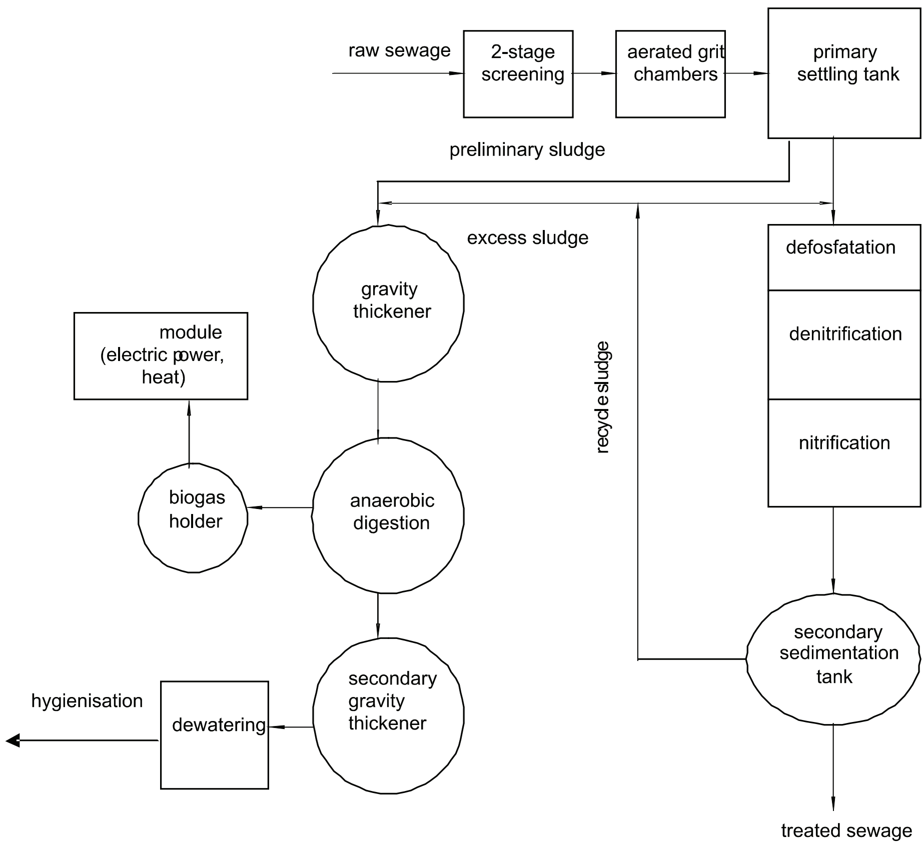

Fig. 2. Technological scheme of the Gubin–Guben wastewater treatment plant

Sewage both from Guben and Gubin are delivered To the WWTP and their rural surroundings. Amount of wastewater delivered to the treatment averages: from Guben – 5800 m^3/day, and from Gubin – 5200 m^3/day. During the 12 years of work, the treatment plant Gubin–Guben has achieved an average efficiency in removal of pollutants from sewage at the level: COD 93% (required 75%), BOD 99% (required 90%), TKN 83% (required 80%), PO_4^{3-} 90% (required 85%, all values in accordance with regulation [17]).

3. AMOUNT AND CHARACTERISTICS OF PRELIMINARY SEWAGE SLUDGE IN THE GUBIN–GUBEN TREATMENT PLANT

An average of daily quantity of preliminary sludge produced after treatment in the period January–June 2010 is shown in Fig. 3. The quantities of preliminary sludge shaped in the range from 40 to 48 m^3/d.

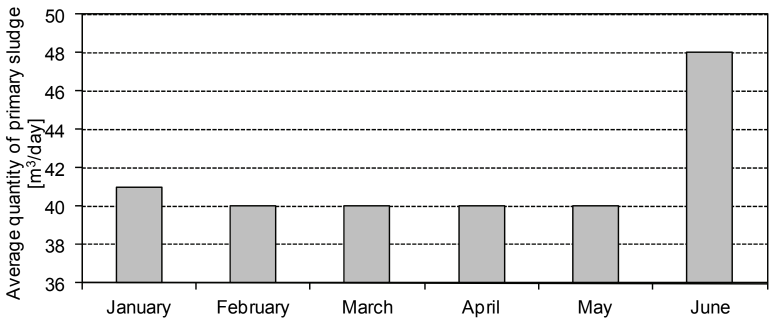

Fig. 3. Quantity of preliminary sludge produced in treatment in the period January–June 2010

Sludges were characterized by pH = 6, the moisture from 96.4 to 94.8% and organic matter content from 75.0 to 79.0% d.m. Changes in these parameters, as average values are shown in Fig. 4.

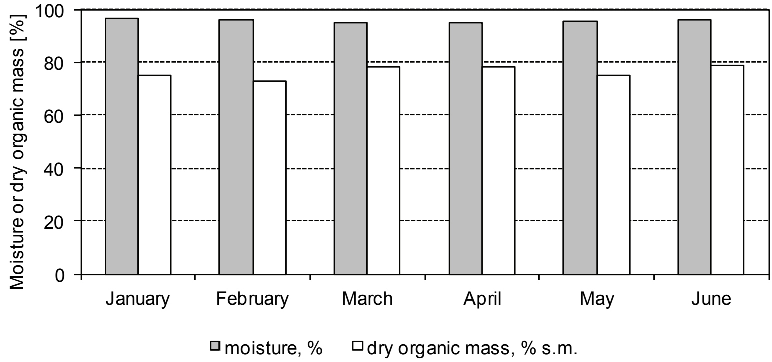

Fig. 4. Characteristics of preliminary sludge

4. THE AMOUNT AND CHARACTERISTICS OF EXCESSIVE SLUDGES IN WASTEWATER TREATMENT PLANT GUBIN–GUBEN

The quantity of excessive sludge is determined by the growth of biomass in activated sludge and the load of suspension in the wastewater after mechanical treatment. The daily average quantity of excessive sludge produced in Gubin–Guben wastewater treatment plant is shown in Fig. 5.

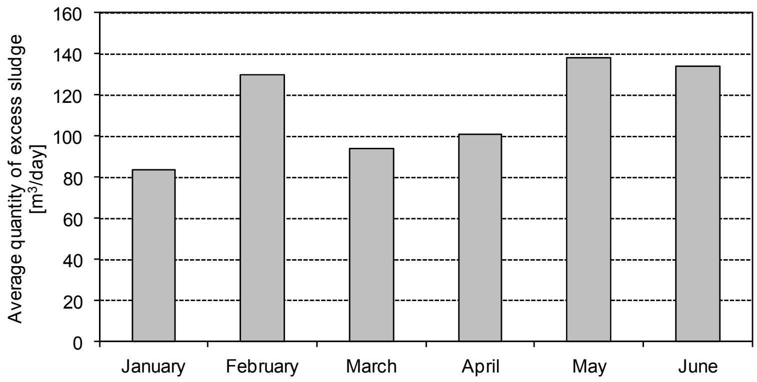

Fig. 5. Quantity of excessive sludge produced in the period January–June 2010

In the analyzed months of 2010 the volume of produced excessive sludge was in the range from 84 to 138 m^3/day. Sludges were characterized by moisture of 98.5% and the content of organic matter ca. 75.0% d.m. Changes in excessive sludge parameters are shown in Fig 6.

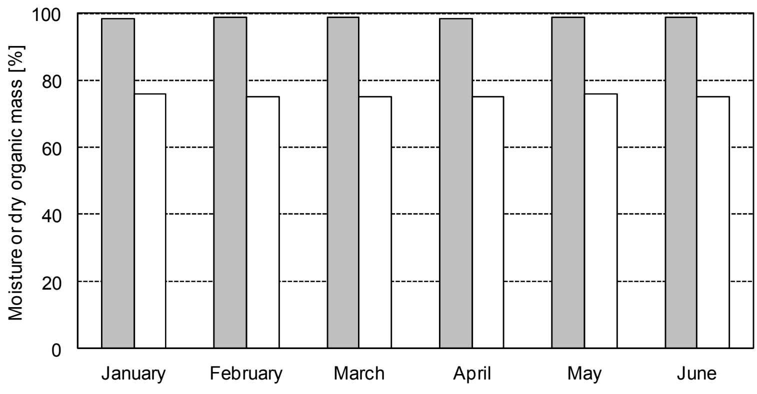

Fig. 6. Characteristics of excessive sediments

5. THE ECONOMY OF THE SEWAGE SLUDGE

The sequence of sludge treatment includes the following processes:
- thickening of preliminary sludge in a gravity thickener,
- thickening of excessive sludge in the mechanical rotary drum thickener,
- stabilization of sludge in the mesophilic fermentation process at 35–37 °C,
- gravitational thickening of fermented sludge,
- dewatering sludge at centrifugal separators,
- hygienisation by lime.

6. PRODUCTION OF BIOGAS FROM THE SEWAGE SLUDGE

Biogas produced in the fermentation tank is stored in non-pressure tank (capacity of 500 m^3). Then it is supplied to the gas receivers, which are: gas engine generator of electricity, central heating boiler and the torch to burn the excess of produced biogas. The amount of biogas produced in sewage sludge treatment plant Gubin–Guben in successive months of 2010 is shown in Fig. 7. Biogas production reached the level from 23 869 m^3 in October to 39 309 m^3 in May.

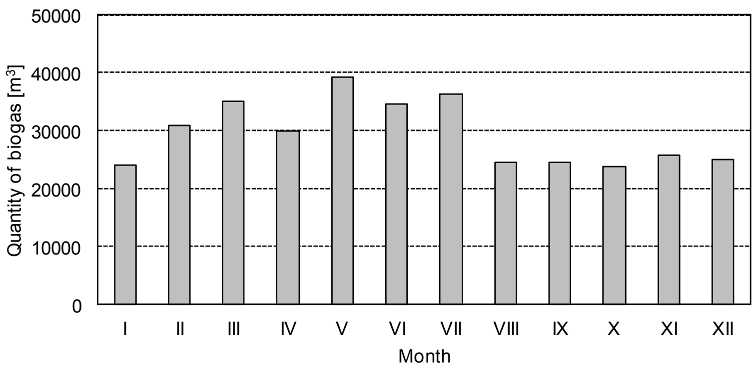

Fig. 7. Quantity of biogas produced from the sewage treatment plant Gubin–Guben in 2010

The use of biogas to produce electricity and heat and the amount of biogas combusted in a flare in the treatment plant Gubin–Guben in 2010 is shown in Fig. 8.

Quantities of biogas containing approximately 55% of methane, directed to the production of electricity and heat in a cogeneration gas engine in the analyzed period of time reached from 14 031 m^3 to 36 267 m^3. The installed gas engine produces ca. 190 kW of electricity and ca. 335 kW of heat. The torch burns the excess of biogas during the failure of working devices or in the case of the overproduction of biogas. Quantity of biogas combusted in the flare were very different in particular months.

Energy balance takes into account the total demand for electricity in the plant, its own energy production and the amount of energy purchased for the wastewater treatment plant Gubin–Guben (Fig. 9).

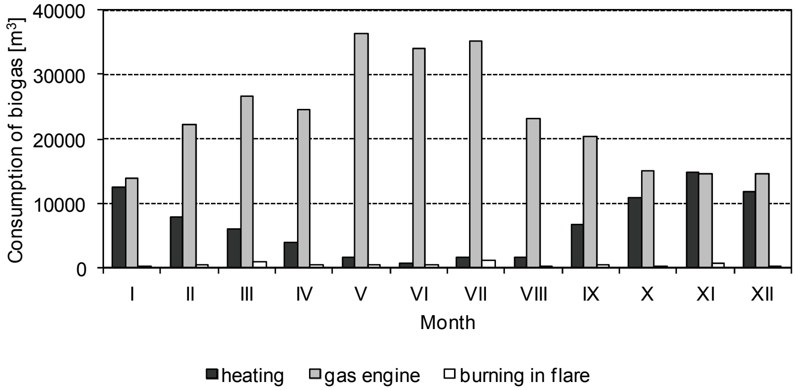

Fig. 8. The use of biogas in the treatment plant Gubin–Guben in 2010

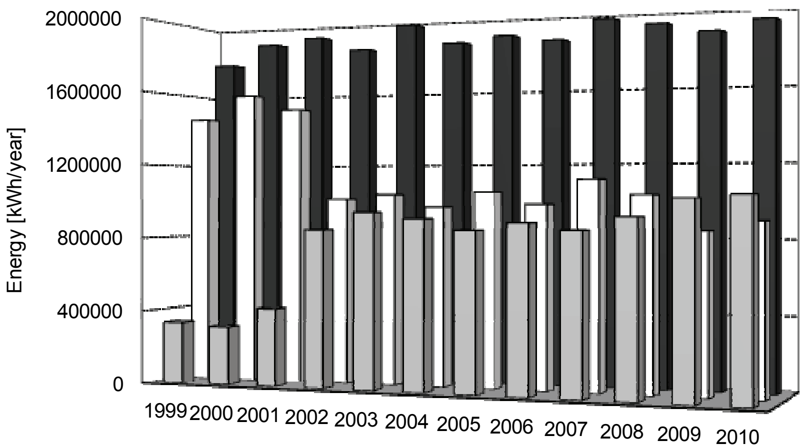

Fig. 9. Energy balance in the treatment plant Gubin–Guben in the years 1999–2010

Electricity obtained from biogas in approximately 55% and the produced heat in 100% cover the overall energy demand of the treatment plant. Much own production of electricity has a significant impact on operating costs of wastewater treatment plant. Taking into account the increase in purchase prices of the media which are necessary for the operation of the plant (cost of purchase of electricity, natural gas, lime, coagulants, polyelectrolytes, services), benefits arising from the use of biogas provide tangible economic benefits.

7. THE QUANTITIES OF SLUDGES TO RE-USE

On average, the daily amount of fermented sludge in the period January–June was from 102 to 138 m^3/day (Fig. 10).

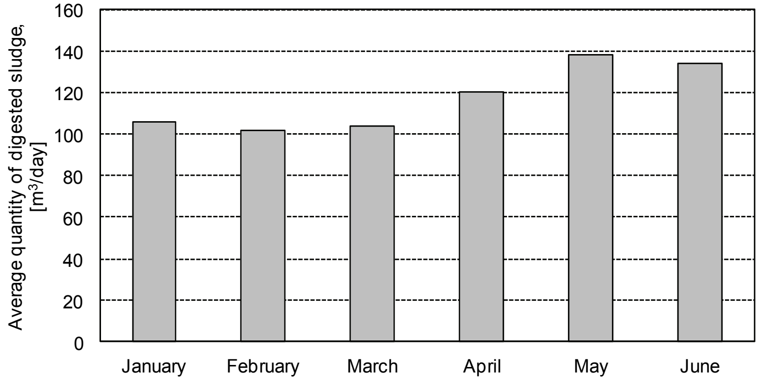

Fig. 10. Quantities of digested sludge produced in 2010

Quantities of anaerobically stabilized and dewatered sludge and intended for further use in 2010 reached from 100 to 390 m^3/month (Fig. 11). The final level of dewatered sludges was 81%. Sanitary conditions and heavy metal content do not limit the natural and agricultural use of sewage sludge from the Gubin–Guben WWTP.

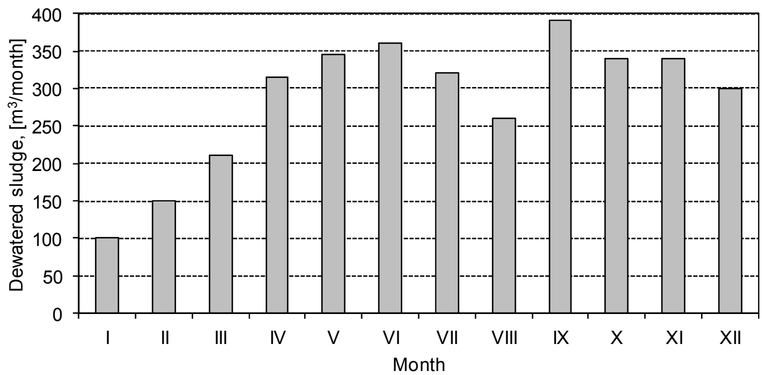

Fig. 11. Quantities of dehydrated sediments to use in the treatment plant Gubin–Guben in 2010

8. SUMMARY AND CONCLUSIONS

• Combined production of electricity power and heat from biogas conducted in the sewage treatment plant leads to obtaining a large surplus of heat in relation to its demand in the wastewater treatment plant, and coverage of approximately 55% of the total demand of electricity for the whole plant. This became possible thanks to the continuous optimization of wastewater treatment technologies and dedicated work of well-trained staff of the plant.

• Anaerobic techniques allow one not only to solve the environmental problem associated with sewage sludge but also provide economic benefits resulting from the production of high-energy fermentation gas.

• Such solutions should become an alternative to the Polish plants. Technological chains of sludge treatment technology with the use of biogas as an unconventional energy source can be inspiration in the search for optimum solutions in the sewage sludge economy.

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