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USE OF BIO- ENZYMATIC PREPARATIONS FOR ENHANCEMENT BIOGAS PRODUCTION

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Abstract

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Biogas is a renewable energy resource with high increasing developed in last few decades. It's big opportunity for stabilization rural areas, concretely agriculture sector. This technology can decentralize supply of energy. The number of operated biogas plants is rapidly increasing. Biogas plants require a high level of intensity and stableness of the process of anaerobic fermentation with biogas production for efficiency treatment, also for good quality of development biogas and fertilization effect of the rest of fermentation. If this is not completed the operator has problem to keep the process in optimal condition for anaerobic fermentation. Researchers have tried different techniques to enhance biogas production. In order to achieve the aforementioned state, it is essential to ensure increased activity of microorganisms that contribute to the anaerobic fermentation. The metabolic activity of microorganisms is preconditioned by availability of easily decomposable solids. Adding of bacterial and enzymatic cultures into a fermented substrate represents one of the possibilities. The enzymes contained in this preparation are responsible for better exposing methanogenic bacteria to the material. The tested bio-enzymatic preparation, APD BIO GAS, is a mixture that contains bacteria and enzymes which are essential for the efficient progress of anaerobic fermentation. The reference biogas laboratory of the Mendel University in Brno was used for the purpose of testing of APD BIOGAS in mesophilic conditions of anaerobic fermentation on a substrate consisting of a mixture of maize silage and liquid manure. The producer of this preparation declare enhancement of quality and quantity of developed biogas, elimination of smell level of the rest of fermentation its higher homogenity. For the test were used lab scale fermenters of batch type with work volume 0.12 m^3. An increase of biogas production by 15% was determined in connection with addition of the preparation, also with higher decrease of total solids and decrease of organic substance in total solids in the fermenter where were used this preparation.

biogas production, anaerobic fermentation, enzymatic preparations

Functionality of our society is currently dependent on exploiting of the limited amount of non-renewable resources of energy. The ever-increasing energy demands force us to look for a replacement of the non-renewable resources of energy by other (renewable) resources. One of the available alternatives pertains to use of biomass within the process of anaerobic fermentation resulting in creation of biogas that may be further used for energy-related purposes. Anaerobic technologies offer an attractive manner of use of biomass resources for the purpose of partial satisfying of the energy needs of our society (Yadvika *et al.*, 2004).

Anaerobic fermentation is a process typical for decomposition of organic matter without in an environment in which air is not present. It consists of four stages: hydrolysis, acidogenesis, acetogenesis and methanogenesis. In the course of individual stages high-molecular substances such as fat, carbohydrates, proteins, nucleic acids, etc., are decomposed into low-molecular substances including their subsequent transformation into the acetic acid, carbon dioxide and hydrogen.

These intermediate products of the process of anaerobic fermentation are further transformed (using methanogenic bacteria) to biogas, which consists mainly of methane and carbon dioxide. The total production of biogas comprises mainly transformation of acetic acid to methane and carbon dioxide (70%) while 30% represents transformation of hydrogen and carbon dioxide to methane and water (Martin Kaltschmitt *et al.*, 2009). Anaerobic fermentation is a spontaneous process; however, its intensity proves to vary depending on the respective conditions in the environment, properties of the decomposed materials and presence of microorganisms that contribute to it. As regards biogas production equipment, a high level of efficiency is required as only its high level presents economic benefits for operators. Possibilities of increasing the level of biogas production are divided into the following four categories: use of additives, reuse of the fermentation residue and its filtrate, change of the process conditions such as the delay time and partially also the amount of the substrate, use of bio-filters (Yadvika *et al.*, 2004). Additives might feature an organic or inorganic nature. Organic additives represent mixtures of bacterial strains which have positive effects on the activity of enzymes decomposing the organic matter. While mechanical and chemical methods of treatment of substrates have been thoroughly studied and exploited in the practice, there are only very few findings related to positive effects of the biological treatment of substrates with the principal objective of increasing the production of biogas (Hendriks and Zeeman, 2009). This fact served as a basis for focusing the submitted paper on the biological manner of treatment of substrates. Possibilities of increasing the level of biogas production are related to decomposition of polysaccharides to biologically easily degradable intermediate products (Egg *et al.*, 1993). In case that they do not degrade, an efficient production of biogas may not be expected. The degree of decomposition of sparingly degradable substances such as cellulose is also significant. As stated in (Tirumale and Nand, 1994), decomposition of cellulose using actinomycetes and a mixture of bacterial cultures resulted in an increased production of biogas. This fact may be explained by the subsequently better availability of intermediates for methanogenic bacteria, which results in a higher production of methane. Jewell *et al.* (1976) states that any method that might treat a substrate in a manner ensuring its accessibility to bacteria transforming the substrate to methane features a high potential as regards an increase of the production of energy. Biogas plants operated in the Czech Republic process mainly products of the primary agricultural production, i.e. the substrate comprises mainly a combination of maize silage and liquid manure (pigs or cows). Considering the high content of cellulose in the maize silage as well as other feed materials of vegetable nature such as grass silage and fodder, it is essential to optimize the process of anaerobic fermentation in a manner achieving the highest possible exploitation of the feed material. Use of a preparation containing bacterial and enzymatic cultures seems to be one of the possible solutions.

Our objective was to determine (verify) – on the basis of the present findings – the effects of APD BIOGAS (featuring the bio-enzymatic nature and containing a mixture of bacterial and enzymatic cultures) on the production of biogas in mesophilic conditions of anaerobic fermentation as well as decrease of the odour level of the fermentation residue.

MATERIALS AND METHODS

A) APD BIO GAS

The tested APD BIO GAS preparation is a bio-enzymatic preparation manufactured by BAKTOMA, s.r.o. The preparation consists of a mixture of bacterial and enzymatic cultures and nutrients which prove to have a significant importance as regards the activity of microorganisms participating in the process of methanogenesis. The resulting effects comprise an increase of the biogas production, elimination of the odour level by the means of decreasing the amount of ammonia, higher homogeneity of the substrate preventing creation of the surface incrustation and sediments, improved handling of the fermentation residue and its application on plots of land.

B) Description of the Tested Substrate

The laboratory test of APD BIO GAS was performed using a substrate consisting of a mixture of maize silage and liquid manure from the agricultural station in Čejč. The contents of total and organic solids at the beginning of the test were 6.5811% and 74.919%, respectively.

C) Testing Procedure

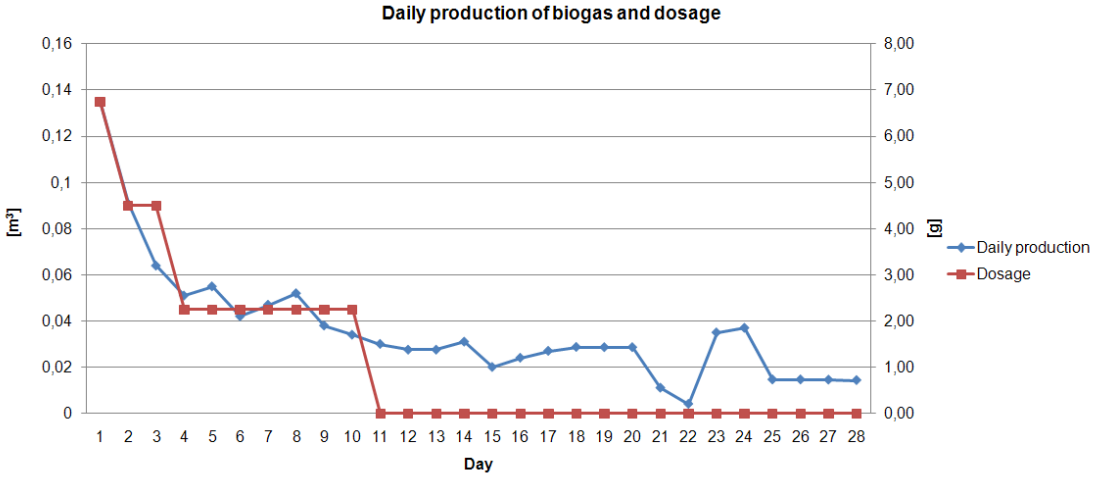
Testing of the preparation was performed in experimental laboratory reactors (volume: 0.1 m^3) – on the basis of a pair in case of which APD BIO GAS was dosed into one of the reactors while the other one served for reference purposes. The reactors are equipped with an automatic substrate stirring and heating device required for ensuring a constant temperature of the anaerobic fermentation in mesophilic conditions; during the test the temperature of the substrate was 40 °C in both the reactors. The IT control unit performed continuous recording of the temperature and pH of the substrate, using the sensors located in the reactors. Furthermore, the reactors are equipped with a sampling apparatus.

The amount of used preparation was decreasing in the course of the test – see Tab. I.

The aforementioned dosage decrease was selected in a manner correlating with the production of

I: *Amount of daily dosage*

Day	1	2	3	4	5	6	7	8	9	10
Dosage [g]	6.75	4.5	4.5	2.25	2.25	2.25	2.25	2.25	2.25	2.25



1: *Daily production of biogas and dosage of preparation*

biogas which proves to decrease after its initial increase – see Fig. 1.

The preparation was diluted in 100 ml of H_2O (temperature: 35 °C); following elapse of 45 minutes in the course of which the preparation was activated, the solution was inserted in the reactor while 100 ml of H_2O was inserted in the reference reactor.

Both the quantity and quality of produced biogas were monitored every day. The amount of produced biogas was measured using a gas meter. A DRAGER X – am 7000 gas analyzer was used for daily measurement of the following quality parameters: CH_4, H_2S, CO_2, O_2.

The amounts of total and organic solids in the substrate were measured continuously throughout the testing period – for the purpose of comparing the level of decomposition of organic matter with the reference reactor data. A Radwag AS 220/X analytical balance (measurement accuracy: 0.0001 g) and a LMH 07/12 muffle oven were used. Collection of the required amount was followed by homogenization of the sample, its dosing into pre-weighted laboratory dishes and drying of the sample at the temperature of 105 °C in order to reach its constant weight. Following its cooling, the sample was weighed once again and the total amount of solids was calculated by the means of deduction from the original weight. Subsequently, the sample was burned at the temperature of 550 °C in order to reach its constant weight. Following its cooling, the sample was weighed using the analytical balance and the content of organic solids in the sample was determined by the means of deduction from the weight of solids.

RESULTS

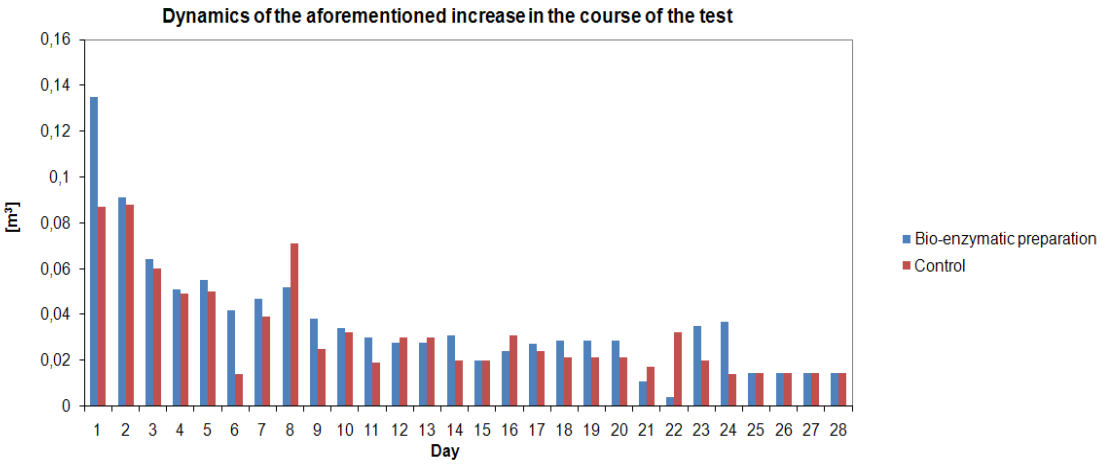
As regards our specific laboratory conditions, a 15% increase in the biogas production was determined in the reactor containing APD BIO GAS in comparison with the reference reactor. The total biogas production values measured in the reactors were 1.0269 m³ and 0.8939 m³ respectively. Fig. 2 presents dynamics of the aforementioned increase in the course of the test.

Fig. 3 presents the cumulative amount of produced biogas.

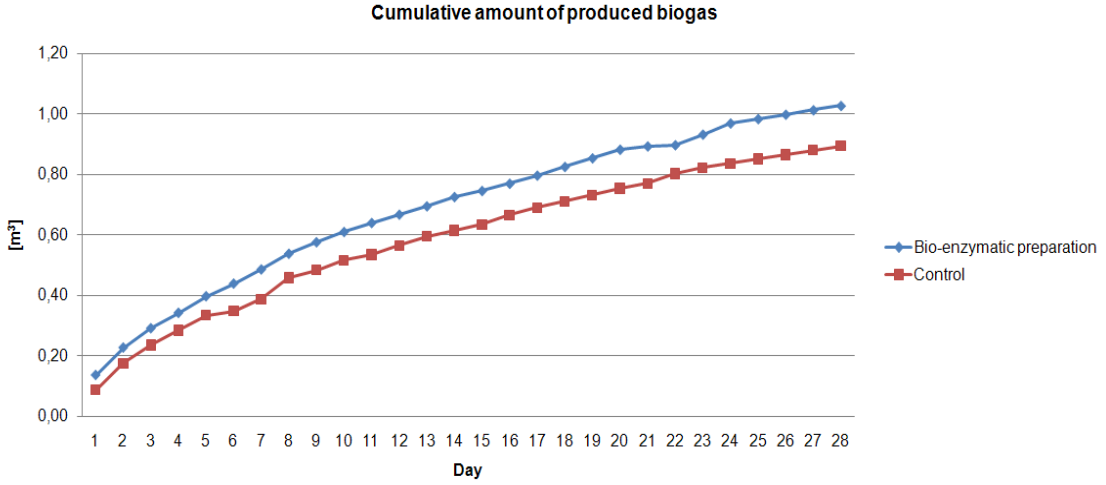
The reactor into which the preparation was inserted featured a higher volumetric content of CH_4. The average difference between CH_4 content values throughout the whole testing period was 1% (vol.); the most significant deviations – in comparison with the reference reactor – were determined at the beginning of the test when the preparation was administered.

As regards other monitored quality parameters, no major differences in the content in the test and reference reactors were determined. The values of H_2S were, in the course of testing, insignificant in both the reactors (only a few ppm); no significant dynamics was determined in case of pH – in the course of the test the respective values ranged between 7.3 –7.87.

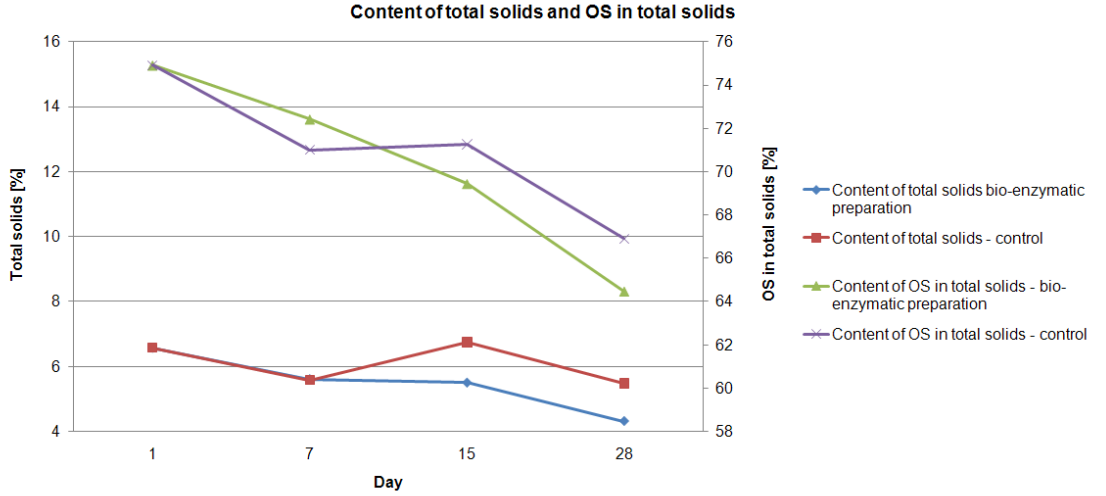
Following the originally identical amounts of total solids and organic substances (OS) in the solids of the substrate, deviations of both the total content of solids and OS in the solids were determined in the course and at the end of the test. In spite of a slight increase of the content of total solids (apparently caused by an incorrect measurement or collection of an unrepresentative sample), the values of both the parameters were lower in case of the reactor containing APD BIO GAS, in comparison with the



2: *Dynamics of the aforementioned increase in the course of the test*



3: *Cumulative amount of produced biogas*



4: *Content of total solids and OS in total solids*

reference reactor. For a presentation of dynamics of the content of total solids and OS in the solids see Fig. 4.

The reactor in which APD BIO GAS was administered showed a decrease in the content of total solids by 2.3% (from 6.6% at the reactor input

to 4.3% at the reactor output); the value of OS in the solids decreased by 10.5% (from 74.9% at the reactor input to 64.4% at the reactor output). As regards the reference reactor, the decrease in the content of total solids was by 1.1% (from 6.6% at the reactor input to 5.5% at the reactor output); the value of OS in the solids decreased by 8% (from 74.9% at the reactor input to 66.9% at the reactor output).

DISCUSSION

The objective of the paper was to verify the effects of APD BIOGAS on the process of anaerobic fermentation, mainly as regards the amount and quality of produced biogas as well as quality of the fermentation residue. In case of our laboratory conditions the substrate consisting of a mixture of maize silage and liquid manure showed, after adding of APD BIOGAS, a 15% higher production of biogas than the reference reactor containing the reference sample excluding the aforementioned preparation. The increased biogas production is caused by a higher activity of microorganisms participating in the process of anaerobic fermentation, being a result of higher availability of easily decomposable intermediates required for their activity which is based on adding of decomposition enzymes forming a part of the preparation. Furthermore, the lower contents of total and organic solids suggest a higher level of decomposition of the substrate. An increase of biogas production from the respective substrate by 11% was determined (H. Vervaeren *et al.*, 2010) on the basis of testing of an enzymatic preparation that supports anaerobic decomposition of maize. It is to be emphasized that, according to the currently available findings, preparations such as APD BIOGAS are to be of the heterogeneous nature since (Plöchl *et al.*, 2010) did not determine an increase of methane production resulting from administration of an additive comprising solely lactic fermentation bacteria. The value of pH corresponds to the previous scientific findings; it is stated (Schulz *et al.*, 2004) that during an anaerobic fermentation the optimum value of pH fluctuates around 7.5; the values of pH measured in the course of the test ranged between 7.3 and 7.87. It is stated that the optimum amount of H_2S is under 300 ppm (Kaltschmitt *et al.*, 2009); this value was not exceeded – the amount of H_2S was only a few ppm. In the course of the whole test the determined values of H_2S were so low that it was not possible to verify efficiency of the preparation in connection with elimination of odour of the fermentation residue. The achieved results suggest a positive influence of the enzymatic preparation on the quantity of produced biogas. However, a significant effect related to the quality of biogas was not determined.

SUMMARY

Goal of this work was to confirm the effects of APD BIOGASS on the process of anaerobic fermentation. APD BIOGAS is a bio-enzymatic preparation, consists of a mixture of bacterial and enzymatic cultures and nutrients which prove to have a significant importance as regards the activity of microorganisms participating in the process of methanogenesis. There was made a lab scale test in batch reactors, of volume 0.12 m^3 operated in mesophilic conditions, exactly the temperature during the test was 40 °C. One reactor was experimental and the second one reference. In the first days of the test were dosed the preparation, the amount of dosed preparation degreased during the test. The aforementioned dosage decrease was selected in a manner correlating with the production of biogas. As inoculum was used material from agriculture biogas plant in Čejč, consists from silage maize and swine liquid manure. The contents of total and OS in total solids of inoculums at the beginning of the test were 6.58% and 74.92% respectively. The amounts of total and organic solids in the substrate were measured continuously every week throughout the test. Quantity and quality of developed biogas were measured every day. In our laboratory conditions was found increase of produced biogas in reactor with APD BIOGAS preparation of 15% in comparison with reference reactor. The reactor into which the preparation was inserted featured a higher volumetric content of CH_4. The average difference between CH_4 content values throughout the whole testing period was 1% (vol.). The other monitored quality parameters of biogas were on the same level in both reactors. At the end of the test there was a lower contents of total solids and OS in total solids in the substrate from experimental reactor, contents of total solids and OS in total solids were 4.3%, 64.3.% respectively in experimental reactor to 5.5% and 66.9% in reference reactor. This corresponded to higher biogas production from experimental reactor.

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