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ORGANIC WASTE USED IN AGRICULTURAL BIOGAS PLANTS

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ABSTRACT
Treatment of organic waste is an ecological and economical problem. Searching method for disposal of these wastes, interest is methane fermentation. The use of this process in agricultural biogas plants allows disposal of hazardous waste, obtaining valuable fertilizer, while the production of ecologically clean fuel – biogas. The article presents the characteristics of organic waste from various industries, which make them suitable for use as substrates in agricultural biogas plants.

Keywords: agricultural biogas plants, organic waste, anaerobic digestion, biogas.

INTRODUCTION

An indispensable element of existence and human activity is the production of waste. With the development of civilization and the associated lifestyle followed the evolution of consumption growth and change in the model, as a consequence of the emergence of more and more waste and its becoming more diverse in terms of composition [Bliht 1999, Yamamura 1983].

Waste, regardless of their type, are a serious problem in both environmental and economic perspective [Kucharczyk at al. 2010].

Disposal of the waste consists of subjecting biological, physical or chemical processes, in order to bring them into a state that does not pose a threat to human life or health and the environment.

Proper waste management is of great importance in achieving sustainable development. If conditions permit, the type of building, it is important to promote local solutions, and even individual, such as backyard composting. Such activities contribute to the maintenance of local circulation of matter and shape the environmental awareness of residents. The recommended method, among others, for large farms may be the use of methane fermentation. It ensures to obtain positive results, both in terms of waste disposal, as well as a valuable source of renewable energy.

OPPORTUNITIES TO DEAL WITH BIODEGRADABLE WASTE

Municipalities must meet a number of obligations in the field of biodegradable waste. This will include: weight reduction of biodegradable municipal waste, transferred to storage, organization of their selective collection, providing construction, maintenance and operation of regional plant for processing waste.

Biodegradable waste can be subjected to composting, mechanical-biological treatment, anaerobic digestion, incineration, or can be stored. Storage of waste poses a number of dangers to the environment. These include the pollution of groundwater, surface water, soil and air.

Therefore, it is necessary to limit the amount of biodegradable municipal waste going to landfills and enhance the use of alternative methods of disposal.

Composting is one of the methods of biological waste, leading to the formation of compost. It occurs in the biochemical processes involving the decomposition of organic matter. Due to the low cost of this method it attracted a lot of interest in many countries. Using specialized measuring apparatus, it is possible to maintain optimal process parameters: temperature and humidity, as well as oxygen necessary for the growth of microorganisms. It also requires the selection of the appropriate fractions and pre-selected waste [Kucharczyk at al. 2010]. The development of the main product of the composting process, i.e. compost, creates more and more problems. Protection of soil, including agricultural products, pollution has forced the introduction of very strict requirements regarding the content of harmful substances in all materials applied to the soil. This mainly concerns the content of heavy metals and some organic pollutants. The material must also be safe in terms of sanitary-epidemiological [Manczarski 2012].

Mechanical-biological waste treatment is a process of "other" municipal waste, unsorted or any other bio-waste unsuitable for composting or anaerobic decomposition in order to stabilize and reduce their volume [Manczarski 2012].

Incineration, as one of the main ways of waste management can be implemented both in waste incineration plants, as well as power boilers [Kotlicki, Wawszczak 2010].

The most technologically advanced incinerators may be too expensive for many countries, but the costs are just one of the major factors limiting the use of this technology. It is difficult to achieve complete combustion. The big problem is the formation of trace amounts of products of incomplete combustion [Marchwińska, Budka 2014]. During the incineration of waste produced highly toxic chemicals mainly dioxins and furans, which if spilled into the environment, pose a danger. It is also high dust emissions into the atmosphere and hydrocarbons that are threats. The removal of the exhaust gases can be very difficult and costly.

Fermentation is a biochemical process involving microorganisms, wherein the organic substances are transformed into several phases to methane and carbon dioxide. In order to hinder the processes microbes and their enzymes are used [Pilarski, Adamski 2009].The fermentation process can be divided into four phases. In phase I, insoluble organic compounds (proteins, fats and carbohydrates) are processed by hydrolyzing bacteria that produce suitable enzymes-hydrolases. Proteases break down proteins, glycosidases-carbohydrates, lipase-fat. The action of these enzymes leads to the formation of soluble monomers or dimers. These processes are responsible for the speed of fermentation process, which in turn determines the phase distribution of the remaining methane-generating formation. Not all organic matter is decomposed in the process of hydrolysis. About 40–50% is not biodegradable because of lack of suitable enzyme-degrading polymers or monomers dimers. In phase II (acydogenezie) monomers and dimers, produced in phase I, are metabolized to short organic acids, having from one to six carbon atoms in a molecule. The most commonly produced acids include: formic, acetic, propionic, butyric, valeric, caproic. Alcohols are also generated: methyl and ethyl esters, aldehydes formic acid and acetic acid. The by-products of the reaction are carbon dioxide and hydrogen gas. Conversion of the products to acetic acid authors occurs only with external energy supply. However, it may occur freely (exothermic reaction) while hydrogen is continuously discharged, that is, in an environment where the partial pressure is suitably low, which takes place during the reduction of carbon dioxide to methane [Schlesinger 1997]. Lower hydrogen partial pressure, and the formation of reduced products more – the more desirable. In the system of methane to obtain a stabilized primarily by lead acetate, hydrogen and carbon dioxide, and the remainder of the acids and aldehydes correspond to a marginal role. This provides a fermentation process to produce more energy and the possibility of direct use of the substrates for the production of methane by the methanogenic bacteria. If the fermentation process produce large amounts of acids containing more than two carbon atoms, they cannot be used by methanogenic miroorganisms and are converted in the next step [Schink 1997]. In octanogenezie (phase III) organic acids, typically containing from three to six carbon atoms, are converted by the action of suitable bacterial strains to acetic acid, hydrogen and carbon dioxide. They can serve as substrates metanogennym bacteria for the production of methane. This phase is very energy-intensive and should, therefore, be most difficult. If the reactions were to occur spontaneously hydrogen should be removed from the system, and the partial pressure cannot exceed 400 Pa. In order to obtain octanogenesis, one must seek a synthrophy of actagenes with hydrogen absorbing methagenes. In phase IV (methanogenesis), which is the last phase, methane is produced. Stoichiometric calculations indicate that about 65–70% of the methane produced in the reduction process acetates [Smith at al. 1980]. Acetates are, therefore, one of the key intermediate formation of methane-generating substrates [Pilarski, Adamski 2009].

Fermentation has a triple role [Ledakowicz, Krzystek 2005]:

- allows you to convert the energy contained in the waste into useful fuel (biogas) that can be stored and transported,
- ensures recycling of organic waste into stable soil improvers, valuable liquid fertilizer and energy,
- allows inerting of waste, which aims to reduce the adverse impact on the environment.

AGRICULTURAL BIOGAS PLANTS

Agricultural biogas plants are gaining more and more supporters among agricultural producers. The reasons for this phenomenon must be sought in more widely available information on agricultural biogas applications, pressure emerging delivery companies, changes in energy law and necessity, resulting from directives for EU, proper handling of slurry and manure. The biogas plant, taking into account rising production costs and declining profitability of animal and plant production, is the perfect means of income sources diversification [Gniazdowski 2009].

The biogas plant is an installation in which a controlled biomass methane fermentation process, is biogas. Biomass, as defined by the European Union, means the biodegradable fraction of products, waste and residues from agro-industry, forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste [Pilarski, Adamski 2009, Dyrektywa 2001/77/WE].

Biogas is a mixture of methane CH_4, carbon dioxide CO_2, and trace amounts of hydrogen sulphide, nitrogen, oxygen, hydrogen and other substances. Percentage of individual components is presented in Table 1.

The elements found in most biogas plants are pre-dam biomass, fermentation tank, covered airtight membrane, post-fermentation tank or lagoon CHP system generating electricity and heat, plumbing, safety, electrical, including control systems that integrate all the elements in functional unit, connection to the grid and heat. The technological process and the use of the substrates affect the composition of the resulting biogas, including methane content, which provides a gross calorific value of biogas. The larger the percentage of methane, the higher the calorific value of biogas. The ability to adjust the contribution of each waste for the generation of biogas of high.

Table 1. The chemical composition of biogas from agricultural biogas plant [Steppa 1988]

Component of biogas	Concentration [%]
Methane (CH_4)	52 – 85
Carbon dioxide (CO_2)	14 – 48
Hydrogen sulphide (H_2S)	0.08 – 5.50
Hydrogen (H_2)	0.0 – 5.5
Carbon monoxide (CO)	0.0 – 2.1
Nitrogen (N_2)	0.6 – 7.5
Oxygen (O_2)	0.0 – 1.0

The functioning of biogas carries a number of benefits. The use of organic waste in an unfermented form emits significant amounts of methane. Obtaining methane in biogas by the controlled fermentation and used for energy production can reduce emissions of methane and other greenhouse gases from the decomposition of animal manure. Wastes subjected to anaerobic digestion are a better fertilizer than unfermented manure. Combustion of the biogas is characterized by the significantly lower emissions of sulfur dioxide and nitrogen oxides, as compared to the combustion of fossil fuels. In addition, the formation of biogas plants provide additional jobs, the creation of a local source of energy, especially heat energy, which can be used to heat public buildings.

Technical possibilities of utilization of the energy contained in the biogas include the following variants [Dudek, Zaleska-Bartosz 2010]:

- direct combustion of gas boilers, thermal devices,
- production of electricity in gas engines with power generator,
- cogeneration or trigeneration (production of heat and electricity in combination)
- the production of biomethane, which can be injected into the natural gas distribution networks, used in industrial processes or as a transport fuel.

ORGANIC WASTE USED IN BIOGAS PLANTS

The primary sector, of which organic waste can be used in biogas plants include the [Curkowski at al. 2013]:

- agriculture,
- meat industry,
- breweries,
- distilleries,

- dairies,
- fruit and vegetable processing.

The main waste generated by agriculture are natural fertilizers such as manure, urine and manure from pig farms and cattle. The possibility of their agricultural use are limited by periods of fertilization and the requirement is not exceeded the limit dose. Is meaningful for biogas installations due to the fact that they are good stabilizers of the fermentation process and to reduce the need for dilution water because the increase hydration of the batch.

The meat waste can include, among others, the contents of the gastrointestinal tract and blood. Depending on the detailed classification in terms of epidemics, the feed can be subjected to thermal utilization. An alternative might be to use some of the waste in biogas plants. They have a high energy value and improve the dynamics of fermentation.

Brewers Brewing, represent about 77% of waste organic matter in the production of beer. Their recovery as a result of drainage or compaction is expensive. They can, however, be used in biogas plants as rich in nutrients, such as fiber, protein and fatty Bevelled, can be used for fodder purposes, and are characterized by a high yield of methane [Kasprzak 2012].

Distillers due to the short suitability for storage and a low dry matter content make it difficult to dispose. Dried decoction process of feed utilization requires the use of energy intensive processes, such as: filtration, drying, evaporation, phase separation). Distillers can replace manure biogas plants in the process because of its nutritional value (rich in minerals, fats and vitamins) and high hydration [Hanczakowska 2005].

Whey represents about 80–90% of the volume of waste from the production of milk and cheese. It is necessary to fractionation solid and liquid components, for example by the use of membrane filtration for industrial development. High hydration whey, rich in proteins, fats and lactose and the ability to produce high-biogas makes it a suitable substrate for use in a biogas plant [Jodłowski 2008].

Fruit and vegetable waste generated mainly such as bagasse, primarily grapes, apples, carrots, potato pulp and beet pulp. They are impermanent and unstable material, requiring immediate processing. This poses a threat to the rapid growth of microbiological contaminants. Therefore, storage requires fixation (ensiling or drying). Up to 80% of organic matter from bagasse can be converted into biogas which is rich in nutrients: fiber, carbon and nitrogen compounds, pectins and polysaccharides [Tarko et al. 2012, Misiura 2013, Kuczyńska at al. 2011].

CONCLUSIONS

1. Waste that cause difficulties in rendering can be used successfully in agricultural biogas plants.
2. The use of biomass is the best way to produce energy from renewable sources.
3. The development of biogas enables the structural reconstruction of power based on the sustainable development of agriculture energy, the flow of private capital to rural areas, as well as the stabilization of energy supply.
4. Disposal of waste in agricultural production and food processing helps preserve ecological safety.
5. A reduction in CO_2 emissions in the production of electricity and heat.
6. The development of biogas plants, not only in agriculture, is in line with the implementation of the commitments to the European Union.

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