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Sustainability of the anaerobic digestion biogas production system

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Abstract

One of the main environmental problems of today's society is the continuous increase in the amount of organic waste. In many countries, the sustainable management of waste, as well as the prevention of its accumulation and the reduction of its quantity, have become major political priorities. This represents an important contribution to the common efforts to reduce pollution, greenhouse gas emissions and the mitigation of climate change at the global level. The past practices of uncontrolled waste disposal are no longer acceptable today. Even the storage on the garbage platform or the incineration of organic waste are not the best practices, because the protection standards have become much stricter nowadays, and the energy recovery and the recycling of nutrients and organic materials have become a necessary thing.

The production of biogas through anaerobic digestion (AD) is considered to be the optimal treatment in the case of animal waste, as well as in that of a wide variety of organic waste suitable for this purpose, because in this way, the respective substrates are transformed into renewable energy and organic fertilizer for agriculture.

Keywords: biogas, climate policies, organic waste, anaerobic digestion, photosynthesis.

Introduction

The production of biogas through an aerobic digestion (AD) is considered to be the optimal treatment in the case of animal waste, as well as in that of a wide variety of organic waste suitable for this purpose, because in this way the respective substrates are transformed into renewable energy and organic fertilizer for agriculture.

Anaerobic digestion (AD) is a complex biological process through which, in the absence of oxygen, the organic substance is transformed into biogas (or biological gas), consisting mainly of methane and carbondioxide. The percentage of methane in biogas varies depending on the type of organic matter digested and the process conditions, from a minimum of around 50% to 80%.

Currently, the most important application of AD processes is the production of biogas in special installations by processing substrates from agriculture, such as animal manure, vegetable residues, energy crops or organic waste resulting from agro-industrial activities and the food industry. According to the International Energy Agency (IEA), a number of several thousand agricultural factories that use the AD process are functional in Europe and North America. Many of these are represented by technologically advanced installations, built on a large scale, their number having grown considerably in recent years.

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It is estimated that at the European level there is a considerable potential for increasing the current production of biogas, based on the activities in the animal husbandry field. After the enlargement of the EU, the new member states of Eastern Europe must also use these technologies and benefit from their high biogas potential. The implementation of AD technologies in these countries will contribute to the reduction of a large number of environmental pollution problems, along with the intensification of the sustainable development of rural communities and the agricultural sector as a whole.

The biogas produced by the AD process is cheap and constitutes a source of renewable energy, it produces, after combustion, neutral CO2 and offers the possibility of treating and recycling a whole variety of residues and secondary agricultural products, of various bio-residues, of organic waste water from industry, domestic water and sewages ludge, in a sustainableand "friendly" way with the environment. At the same time, bioga sbrings a large number of socio-economic benefits, both for the farmers directly involved in its production, and at the level of the entire society.

The nutrient circuit, through the biogas production process – from the production of raw materials to the application of the digestate as fertilizer - is a closed one. Carbon compounds (C) are reduced through the process of anaerobic digestion, methane (CH4) being used for energy production, while carbon dioxide (CO2) is released into the atmosphere, from where it is taken up by plants during photosynthesis. Some carbon compounds remain in the digestate, improving the carbon content of soils when the digestate is used as fertilizer. Biogas production can be perfectly integrated into the activity of conventional farms or organic farms, where the digestate replaces the usual inorganic fertilizers, products obtained with the consumption of a large amount of fossil energy. (Fig.1).

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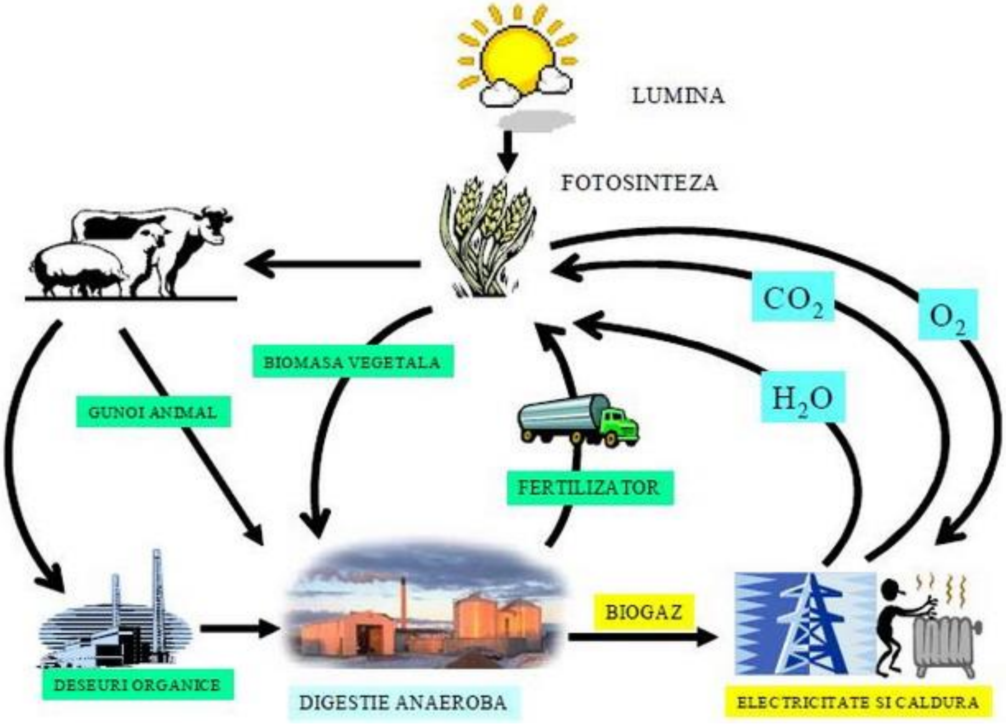

Anaerobic microorganisms show a low speed of development and a low speed of reaction and therefore it is necessary to maintain optimal, as much as possible, the conditions of the reaction environment. The process times are relatively long if compared to those of other biological processes, the advantage of the process is that the complex organic matter is transformed into a cheap fuel gas with a high calorific value. In the reaction environment, usually called a digester (or anaerobic reactor), a compromise must be reached between the demands of all groups of bacteria, to allow the simultaneous development of all the microorganisms involved. the optimal ph is 7 - 7.5. The optimal process temperature is around 35 0C, if mesophilic bacteria are used, or around 55 0C, if thermophilic bacteria are used. The following groups of bacteria participate in the process:

- hydrolytic bacteria, which break down biodegradable macromolecules into simpler substances;

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- acidogenic bacteria, which use as a substrate the simple organic compounds released by the hydrolytic bacteria and produce short-chain organic acids, which in turn represent the substrate for the following groups of bacteria;
- acetogenic bacteria, obligate hydrogen producers (OPHA: Obbligate Hydrogen Producing Acetogens), which use as a substrate the products of acidogenic bacteria, giving rise to acetate, hydrogen and carbonic anhydrides;
- homacetogenic bacteria that synthesize acetate starting from carbonic anhydrides and hydrogen;
- methanogenic bacteria, differentiated into two groups:
- those that produce methane and carbonic anhydrides from acetic acid, called acetoclastics;
- those that produce methane starting from carbon dioxide and hydrogen, called hydrogenotrophic bacteria.

While methane is released almost entirely in a gaseous state, due to its low solubility in water, carbon dioxide participates in the balance of biomass carbonates, according to the reaction. The different species of bacteria have close interactions and the metabolism products of some species can be used by other species as substrate or growth factors.

The general biodegradability of the wastes analyzed at the level of the sewage collection basin, can vary between 60 and 80%, depending on the "age" and the type of food. Table 1.1 shows the estimated amounts of biogas that can be produced by anaerobic fermentation of different types of wastes from livestock farms.

A further classification of the biodegradable fractions allows distinguishing within the soluble fraction a rapidly biodegradable part (about 20% of SSV) and a slower one, and within the suspended part an easily hydrolyzable part and a more difficult one can be distinguished.

Tipul de dejectii	**Continut de substanta uscata(%)**	**Substanta organica (% subst. uscata)**	**Volum biogaz (m^3/ t subst. organica)**
Dejectii lichide bovine	6-11	68-85	200-260
Dejectii solide bovine	11-25	65-85	200-300
Dejectii lichide porcine	2,5-9,7	60-85	260-450
Dejectii solide porcine	20-25	75-90	450
Dejectii lichide pasari	10-29	75-77	200-400
Dejectii solide pasari	32,0-32,5	70-80	400
Dejectii solide ovine	25-30	80	240-500
Dejectii solide cabaline	28	75	200-400

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Data collected from long-term laboratory samples, under normal anaerobic reactor conditions, with limited hydraulic stability times. they reach levels of transformation of the organic substance into biological gas between 70 and 90% of the maximum biodegradability, depending on the state of the wastes. Low levels of transformation can be due to low temperatures, hydraulic retention times that are too short, organic loads that are too high, as well as the presence of inhibiting substances or antibiotics in high concentrations.

The production of biogas and implicitly the cogeneration of electricity, respectively heat, through its burning, also generates other beneficial phenomena such as:

- Elimination of odors and polluting emissions (NH3 and CH4) because the foul-smelling substances that may be formed during the AD process (hydrogen sulfide, mercaptan, ammonia) are burned together with the biogas.
- Stabilization of the droppings by eliminating the organic load due to AD, which gives the droppings sufficient stability in the subsequent periods of storage by slowing down the degrading and fermentative processes, as well as reducing the production of foul-smelling compounds.
- Reduction of the pathogenic load through anaerobic digestion in mesophilia. This can partially reduce the possible pathogenic load present in the liquid wastes. Anaerobic digestion in thermophilia can generate complete sanitation of excreta, with the total destruction of pathogens.

In traditional agricultural practices, mineral fertilizers and animal droppings are applied to the agricultural soil to increase the supply of nutrients and improve the quality of the crop. When this surplus of nutrients infiltrates agricultural land and reaches the environment, there is a risk that they become pollutants, mainly because of nitrates from nitrogenous compounds. Therefore, the spreading of mineral fertilizers and animal droppings must be done carefully, both in terms of quantity and application period, in order to reduce the risk of over-accumulation of nutrients and their infiltration.

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