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BIOREACTOR SYSTEMS FOR WASTE TREATMENT USED IN ORDER TO ACHIEVE BIOGAZ BY DRY DIGESTION

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Abstract: The paper presents a synthesis regarding bioreactors systems used at waste treatment in order to obtain bioenergy (biogas) by dry digestion. Biogas production is a good way of satisfying national and European regulations becoming more stringent in relation to the use of organic waste for energy production, followed by recycling as fertilizer. Biogas technologies contribute to reducing the volume of waste and of costs for their disposal.
Keywords: dry digestion, digesters, waste, bioenergy

1. INTRODUCTION

The essential element of a biogas company is digester, a sealed reaction tank at the entry of air, in which the raw material is subjected to an anaerobic digestion process, thus, producing biogas. Common characteristics of all digesters, apart from being air proof, are: existence of raw materials feeding, exhaust systems and existence of biogas and digestate systems. In terms European climates anaerobic digesters must be insulated and heated [5].

Worldwide, there is a diverse building range of biogas digesters types. Thus, are used concrete, steel, brick or plastic digesters, shaped as silos, troughs or basins, located underground or on the surface.

The size of a biogas plant are determined by digesters size, ranging from a few cubic meters in the case of small household installations up to large commercial plants, possessing several digesters, each with volumes of thousands of cubic meters. Choosing the digester construction type is determined, primarily, by water content, respective, by the dry substance of the digested substrate.

As mentioned above, the technology of anaerobic digestion operates in two basic systems: wet digestion, when the average content of dry matter (DM) of the substrate is lower than 15% and dry digestion, when the content of dry substance of the substrate is above this value, usually between 20–40% [1,2].

In agriculture, the majority of anaerobic digestion and biogas processing systems are liquid fermentation systems, or submerged fermentation systems, as they are called in industry. This is because most garbage disposal systems from West farms lead to liquid manure obtaining.

Even in cases where the solid manure is obtained, in order to ferment and to produce biogas, companies specializing in this field aim to liquid fermentation systems.

Thus, the solid matter is mixed with large volumes of water. There are used very large capacity fermenters, and after fermentation, the solids must be separated again from the liquid phase.

At Hohenheim University in Stuttgart, the researchers developed a fermentation system for solid biomass with biogas obtaining, transferring the applied system to biodegradation of the urban solid waste, dejections and of biomass farms.

Because in farms are obtaining much smaller quantities of manure or solid residues than waste from human settlements cannot be taking over the continuous system, automated applied in the latter case, and it is necessary to apply the fermentation system used in this industry domain [7].

2. MATERIAL AND METHOD

The method consists in filling the fermenter one time, this closes, fermentation takes several weeks, after which opens fermented biomass to download and fill up again with another fermentation batch.

There is no mixing system; only portions of the fermented material remain in the fermenter as inoculants (leaven) to initiate the next fermentation. Because biogas production fluctuates during fermentation and is 0 at the beginning, then increase reaching maximum production and then begin to fall as the organic matter is consumed, it requires the construction of several fermenters for liquid fermentation. Most fermentation systems in solid substrate use fermenters, garage type (figure 1).

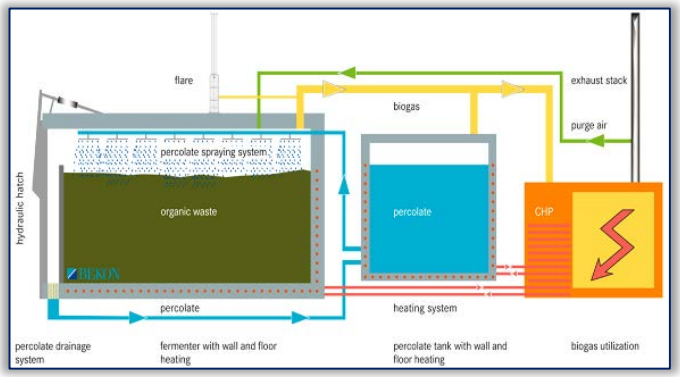

Figure 1 - Fermentation in solid substrate with percolation [10]

Basically, rooms are made by concrete, hermetically sealed, into which the solid substrate is introduced. At the upper side is disposed a system of perforated pipes in which the solid substrate is sprayed with liquid.

The liquid is percolated through the entire solid mass and is accumulated at the bottom size in a tank where it is pumped back into the perforated pipes in order to be disperses all over the solid mass. This washing of the solid substrate is usually done twice a day, for 15 minutes. The used substrate should be of a structure that allows the movement of fluid throughout the solid mass.

Therefore, there are not used materials with high compaction degree (such as cows excrements), or if used, they should be thoroughly mixed with material to give them texture and aeration for liquid circulation (chopped straw, substrate plant, etc.). Best results are obtained with horse excrements, which have better structure and loose fibre [3, 10].

Instead of the main phase of composting, organic waste is introduced into the fermenter (figure 2) at a volume of about 58 m^3 and then producing biogas by means of a three–phase process.

Figure 2 – MobiGas technological tank, [10]

The first stage is an anaerobic one, in which the material is ventilated into the fermenter. In the second stage the ventilation is stopped and begins anaerobic phase.

A percolators substance is sprayed over material and fermenting container is heated by underfloor. Generation of biogas begins and lasts approx. 2–6 weeks. When the material is analysed in the last phase

of the fermentation container is ventilated again and thus the process is stopped. The biogas is used directly, on the spot, via cogeneration unit in the form of electricity and heat. The remaining material is then processed and turned into compost through secondary composting process, [8].

Bioferm dry fermentation technology to produce biogas (bioenergy) manufactured by Bioferm company, differs from traditional systems of wet fermentation "digesters wet", which use a container that is loaded with raw material liquid, especially organic household waste containing the minimum solids to 25% mass of material, the materials mixed and stirred by means of mobile parts. Bioferm technology for dry fermentation (high solid content) uses a batch type of approach, in which the material remains stationary during the anaerobic digestion, internal moving parts are not necessary. These attributes allow dry fermentation digester to recover energy from almost any type of organic waste. Bioferm technology (figure 3) uses non–continuous type digesters, where organic waste is loaded and remains in digester until material exhaustion, without internal mixing systems, [9].

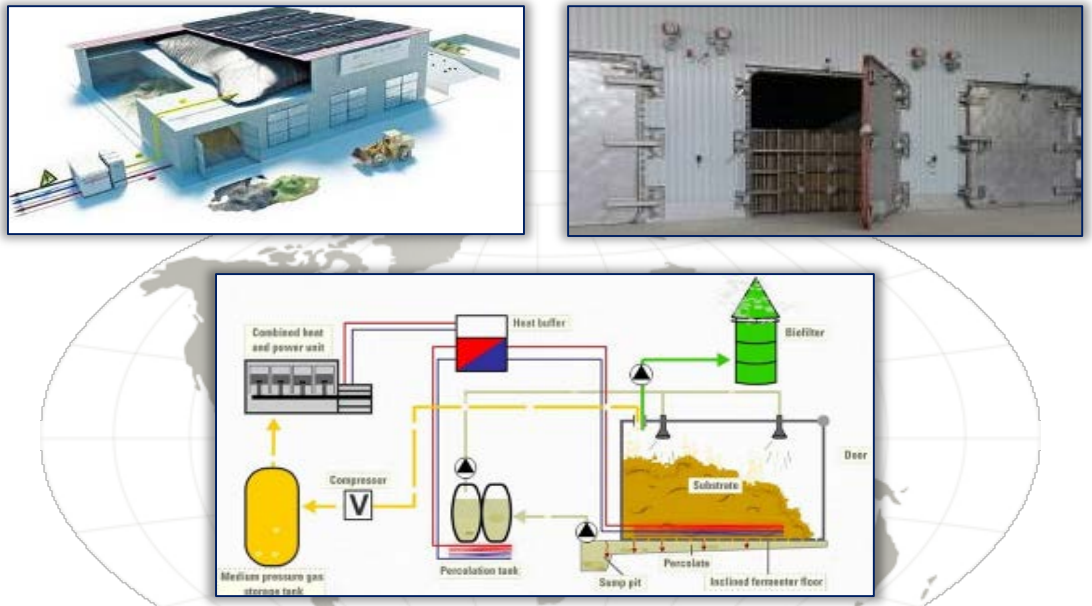

Figure 3. BIOFerm – dry fermentation technology, [11]

The digestion system (dry anaerobic fermentation) is composed of rectangular fermentation rooms, with dimensions of 114 x 23 x 17 m, in which the household organic waste and agricultural waste remain in methanogenesis process for about 28 days. Modular design of the digestion system enables rapid adaptability of the system and a flow of organic waste annually about 8000–8500 tons.

Multitech SP–the German company (Figure 4) – performs neutralization of organic agriculture and municipal waste through anaerobic digestion process –DFAD dry.

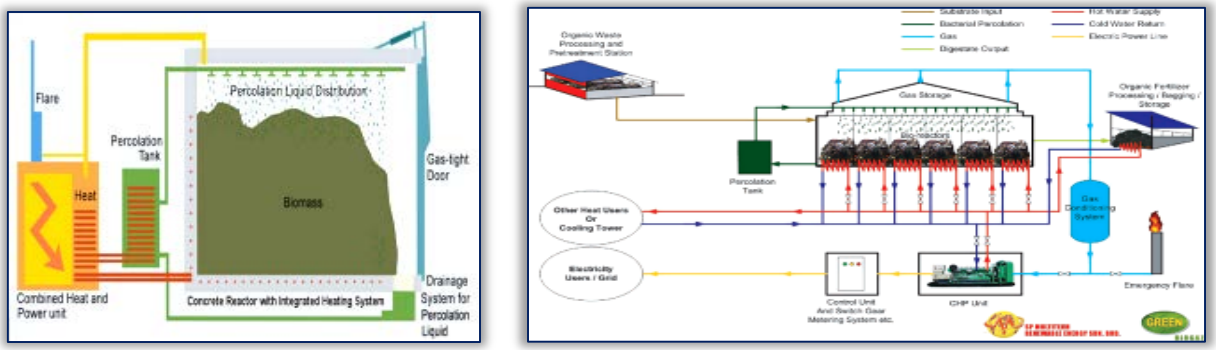

Figure 4. – Digester and technological scheme by DFAD system [12]

The process takes place in gastight premises, suitably divided; the variation is given by the amount of material available as feedstock. The system is made up of chamber slides having more anaerobic digesters; the digestion process is continuous, the material is finished, being passed from a digester to another. Unlike the anaerobic wet fermentation process, dry fermentation system, the substrate does not have to be stirred. Being a perfect gastight system, dry fermentation process does not emanate unpleasant odours and thermophilic environment in which the process is driven to determine final digestate that can be used as fertilizer.

3. RESULTS

By implementing the dry anaerobic digestion technologies, have been achieved good results with the poultry manure, which uses permanent litter.

When are used solid materials with high compaction degree, they form zones within the fluid is leaking and zones where the liquid never comes, and where the material remains undegraded.

The liquid has a crucial role in the fermentation of solid material, because it is the carrier of microorganisms to pass through the substrate and scatter them throughout the substrate table top.

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By flowing liquid and other areas of the substrate, it will methanogenic microorganisms in areas where they are lacking.

This percolation is done because in fermentation system, in solid substrate fermentation system, there are no blenders as in closed system in order to obtain a homogenous substrate and methanogene microorganisms [5].

Table 1. Comparing the solid substrate fermentation system with liquid substrate system, [4]

Criterion	Solid substrate fermentation	Submerged fermentation system (liquid)
Substrate	Solid, wed (max. 50% total solids)	Liquid, pumpable (max 13% total solids)
Technology	Pre mixing, liquid flow through percolation flooding	Homogenization
Potential problems	Percolation system (clogged sieves, injectors)	Foaming, deposits, float, blocked pumps, agitators damaged
Equipment	Modules, fermenters in battery	Complex, continuous operating, multiphase
Malfunctions	It affects one or a batch mode	It affects the whole system
Energy consumption in the process	Low (only for pumps leaching, low power)	Low (only for pumps leaching, low power)
Energetic density of the substrate	High	Low
Emissions	Low	High
Necessary substrate	Solid manure	Liquid dejections

Dry fermentation system, achieved through technology and bioreactors (digesters) Bioferm®™ system is most suited for operations which process organic waste with a higher total solids content of 25%, including:

- food waste,
- grooming the courts,
- dried animal manure bedding,
- other large quantities of solid waste

The anaerobic digestion substrates are classified with regard to their origin, dry substance content (DM) and methane production. In table 2 there are brief presented the characteristics of material type used in obtaining biogas. The substrates with dry substance content smaller than 20% are used for wet anaerobic digestion; manure and other wet organic waste coming from food industry are included here. `When dry substance content is higher than 35%, the digestion type is called dry digestion. Dry digestion is specific for energetic cultures and silo materials.

Table 2. Characteristics of the digestible raw materials types [1]

Raw materials type	Organic content	Ratio C:N	DM %	VS% from DM	Biogas production $m^3 \times kg^{-1}$
Pig manure	Carbohydrates, proteins, lipids	3–10	3–8	70–80	0.25–0.50
Ovine manure	Carbohydrates, proteins, lipids	6–20	5–12	80	0.20–0.30
Poultry manure	Carbohydrates, proteins, lipids	3–10	10–30	80	0.35–0.60
Straw	Carbohydrates, lipids	80–100	70–90	80–90	0.15–0.35
Grass	–	12–25	15–25	90	0.55
Fruit waste	–	35	15–20	75	0.25–0.50

The produced biogas is collected in a special sack for storage and is then continuously fed by using biogas source.

Biogas can be used either in combined units of heat and power (CCP) for the generation of electricity and heat, or it can be improved and turned into natural gas sources (GNR) for injection into the gas grid and use as fuel vehicles as compressed natural gas (CNG). Biogas can be used either in units combined heat and power (CCP) for the generation of electricity and heat, or it can be improved and turned into

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4. CONCLUSIONS

According the new Frame Directive in 2009 proposed for RES, Romania should provide until 2020: a distribution of energy of 24% from total electric energy consumption and 10% from to total energy used in transport by biofuels.

The set of target indicators for electricity from RES set out in European Directives 2001 provide for Romania to reach by 2010 the distribution of 33% of energy from RES in electricity consumption Gross and compliance with European Directive for biofuels in 2003 to achieve in 2010 consumption of 5.75% from total bio–fuels in transport fuels.

Bioenergy obtaining (biogas) by dry methanogenesis processes by the help of technologies and digesters systems (bioreactors) presented within article is seen like a key solution for encourage sustainable development of the rural zones, which can support the production of non–food and energy crop cultivation and afforestation abandoned.

Thus the projects integration for establishment / development of plants / biogas installations in local / regional sustainable development, especially in rural areas, are a viable alternative and also suitable which can solve both energy issues and waste management and chemicalization decrease in agriculture by using digestate as fertilizer.

As long as the potential of urban and rural waste is very high it is expected that both the interest and investment in biogas to increase, especially in rural areas, biogas plants based on raw materials from agriculture (both from primary and the secondary production).

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