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Study of Biogas Production from Organic Waste through the Implementation of Biodigestors

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A B S T R A C T

Biogas is considered as a gaseous tributary of the anaerobic digestion of agro-industrial waste, a boiler, it can be burned in combustion engines to generate electricity and heat through cogeneration. Biodigesters responsible for producing energy with a content of 1 m3 of biogas (60% CH4 and 40% CO2) equivalent to 6 kWh / m3. It undergoes a purification its composition will depend not only on the technology used for the process but also on the treated substrate. Its methane composition varies between 50 and 70% and present between 30 and 40% CO2 and less than 5% hydrogen (H2) and other gases. The calorific value of biogas is associated with the composition of the methane it has. Biogas is a very versatile source of energy, it can be transformed into thermal energy through the use of process eliminating hydrogen sulfide and other contaminants from the membranes, it can be used as fuel, purifying and adding the necessary additives, it can be transformed into biomethane, a compound with characteristics very similar to natural gas. Biogas can be used as an electricity generator or as a heat producer if both sources of energy are generated, we speak of a cogeneration process, the electricity produced by generation can be injected into the electricity grid or consumed by the industry that generates the waste.

Keywords

Anaerobic digestion, methane, biodigesters, Energy

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Introduction

As population growth increases; get environmental problems, caused by incorrect waste management and it is also increase consequences such as climate change, have forced a search for a correct management of the organic fraction of waste (López *et al.*, 2015). One of the problems due to the mismanagement of waste is the emission of greenhouse gases, causing global warming.

According to Ávila *et al.*, (2018), Organic solid waste can be transformed, through the action of micro-organisms, into a mixture of gases called biogas. This mixture of different gases is produced by the anaerobic decomposition of organic matter, mainly made up of methane (CH_4). Where, organic waste is transformed by the action of microorganisms into a mixture.

Anaerobic digestion enables the degradation of the biodegradable organic fraction present in urban solid waste, transforming it into biogas, with a high content of methane and therefore susceptible to energy use and into a final stabilized waste, with a high rate of destruction of pathogenic microorganisms, which meets the conditions to be used as a soil improver (Reyes, 2017).

Development of the Topic

Currently, large amounts of money and time are invested worldwide focused on the study and development of alternative forms of energy, especially clean and low-cost. Being the challenge of the future which is based on several premises that must be taken into account to justify the use in its entirety (Martínez, 2015).

The composition of the biogas depends on the digested material and the operation of the process. When the biogas has a methane content higher than 45% it is flammable (FAO, 2011).

Renewable energies offer us three advantages if we compare them with fossil fuels. The first one is that they are virtually inexhaustible (oil is limited like the sun). The second is that they are not polluting (if we are talking about clean renewable energies, excluding then the incineration of biomass as renewable energy). The third advantage is its ease of relocation (Bautista, 2010). In general, the types of renewable energies are directly related to the use of waste caused by humans, companies, social groups, etc. Obtaining energy at low cost and sustainable with the environment.

At present almost all the energy Germany command the application of this type of energy with 48% of its totality is(Venegas, 2019).

Biodegradable organic waste

It includes organic waste such as waste or residues of animal and vegetable origin, which have the ability to rapidly degrade, transforming into another type of organic matter.

They are substances that can decompose into the chemical elements that make it up, due to the action of biological agents, microorganisms and fungi under natural environmental conditions. Organic compounds can be converted into gases and (Bustamante, 2014).

When these wastes are not controlled, they have a strong impact on the environment, due to their content in organic matter and mineral elements and sometimes the presence of heavy metals, phytotoxins, among others, being highly polluting.

Anaerobic digestion

For Núñez (2017), anaerobic digestion is a set of interconnected biological reactions, through which organic matter is converted into biogas by the degradative action of a consortium of oxygen-sensitive microorganisms. More than 90% of the energy available by direct oxidation in organic matter is transformed into methane where microorganisms consume only 10% for their growth.

It is also called biomethanization or biogas production, in a biological process in the absence of oxygen, a complex process in which different groups of microorganisms intervene, where organic matter is decomposed into simpler compounds that are subsequently decomposed into volatile fatty acids.

Stages of anaerobic digestion

Hydrolysis

The first stage develops, there is a degradation of complex organic compounds such as lipids, proteins, carbohydrates and inorganic compounds. These are depolymerized by the action of hydrolytic enzymes on soluble and easily degradable molecules such as fatty acids, amino acids, monosaccharides and inorganic compounds.

These new molecules, being simpler, are more easily solubilized in the medium. The microorganisms responsible for this are hydrolytic-acidogenic bacteria (Parra, 2015).

The reaction molecules can be direct or indirect nucleophilic substances, since the hydrolysis is catalyzed by specific acids and bases, where the hydronium ion and the hydroxide ion provide an alternate way to change the pH and the dissociation constants of compounds of interest.

Acidogénesis

The soluble compounds resulting from the hydrolytic stage will be transformed by the action of microorganisms and fermentative bacteria through a fermentation process, resulting in acetic acid (CH_3-COOH), hydrogen (H_2) and carbon dioxide (CO_2) mainly, and to a lesser extent, intermediate products: alcohols, volatile fatty acids (other short-chain fatty acids in addition to acetic acid) and organic acids. As previously indicated, acidogenic bacteria are involved, the most commonly identified being *Butyvibrio*, *Propionbacterium*, *Clostridium*, *Bacteroides*, *Ruminococci*, *Bifidobacterium*, *Lactobacillus*, *Streptococci* and *Enterobacteria* (Acosta, 2005).

In this stage the concentration of hydrogen formed by intermediate product influences the type of final product formed during the fermentation process.

Acetogenesis

Acidogenesis generates acetic acid, hydrogen, carbon dioxide, VFA, ethanol, and aromatic compounds. The first three can be directly converted to methane by methanogenic microorganisms. However, ethanol, VFA and aromatic compounds need a previous stage: acetogenesis (Núñez, 2017).

The importance of this stage is based on its consumption as a substrate for other microorganisms, the products that are not directly converted to methane by methanogenic bacteria are converted into methanogenic substrates.

Metanogénesis

Methanogenesis is the final stage of anaerobic digestion. The formation of grow mainly in its substrate (acetate) and the second, is the hydrogenotrophic where the microorganisms grow on substrates such as methane occurs from two main routes, the first, is the acetoclastic in which the hydrogen microorganisms (H) and carbon dioxide (CO_2).

Their metabolism is characterized by integrating the biosynthetic and bioenergetic pathways for the production of ATP, and in the absence of hydrogen, they oxidize compounds to obtain electrons (Corrales, Romero, Bohórquez, & Corredero, 2015). This is developed by the decarboxylation of acetate and the mechanization of carbon dioxide and hydrogen by bacteria into ketogenesis.

Biodigesters

According to Galarza (2020), they are systems designed to optimize biogas production from agricultural waste, manure or industrial effluents, among others, which allow obtaining clean and low-cost energy.

While Corona (2007) affirms that inside this organic waste mixed with water is stored that when decomposed in the absence of air generates biogas and cylindrical, rectangular, spherical or hemispherical tanks can be used, or this will depend on the user and will not affect the process or to the final product.

For Rivas *et al.,* (2010), states that they are systems designed to optimize the production of biogas from agricultural waste, manure or industrial effluents, among others, which allow obtaining clean and low-cost energy. The use of this technology is not new, but in recent years it has gained importance.

History of biodigesters

The first manifestations of biogas date back to 1600 AD, identified by several scientists as a gas from the decomposition of organic matter.

In the year 1890 the construction of the first full-scale Biodigester in India is reported and already in 1896 in Exeter, England, the public lighting lamps were powered by the gas collected from the digesters that fermented the sewage sludge of the city (Pachón & García, 2017).

Biodigester function

Generation of biofertilizers, provide nutrients, organic matter and the recovery of the soil, maintaining its fertility avoiding the degradation process.

Clean energy, renewable energy, where biogas has lower greenhouse gas emissions.

Low-cost heat energy from waste.

Effluent treatments, the biodigestion process itself builds; with advantages over traditional aerobic treatments.

Types of biodigesters

Fixed lid or Chinese type biodigester

It consists of a closed system, usually built of masonry and below ground level. They have a fixed dome-shaped lid that contains the biogas inside, an inlet to feed the substrate and an outlet for the digestate that usually acts as a compensation tank. The space that contains the gas must be hermetic, for which synthetic or other paints are applied that guarantee the required tightness (Barrera, Odales, Carabeo, & Alba, 2020).

Table.1 Chemical composition of biogas

Components	Formula	Percentage
Methane	CH_4	40-70
Carbon dioxide	CO_2	30-60
Hydrogen	H_2	0,1
Nitrogen	N_2	0,5
Carbon monoxide	CO	0,1
Oxygen	About $_2$	0,1
Sulfide Hydrogen	H_2S	0,1

Source: (Blanco, Cepero, Suárez, & Giraldo , 2012) .

Table.2 Nutritive composition of manure in fresh matter

Origin of manure	m.s. (%)	N Kg/t	P_2O_5 Kg/t	K_2O Kg/t	MgO Kg/t	S Kg/t
Bovine	32	7	6	8	4	-
Equine	35	14	5	12	3	0,9
Porcine	25	5	3	5	1,3	-
Ovine	28	15	16	9	4,5	-
Birds	8	2	0,5	3	0,4	-

Source: (Reyes, 2017) .

Fig.1 General diagram of anaerobic digestion

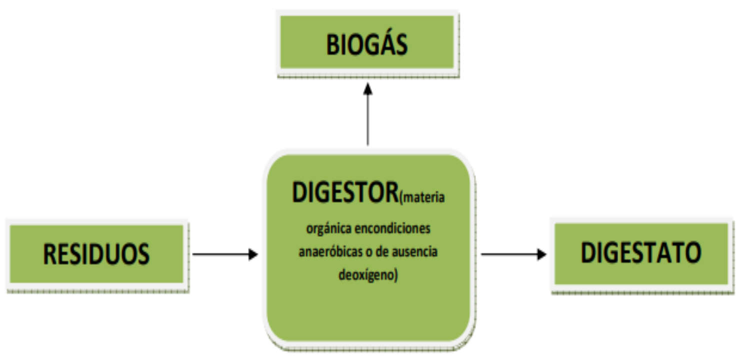


Fig.2 Basic design of a biodigester

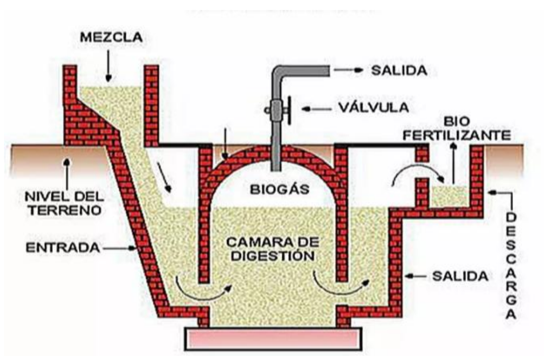


Fig.3 General diagram of a Chinese type or fixed lid biodigester.

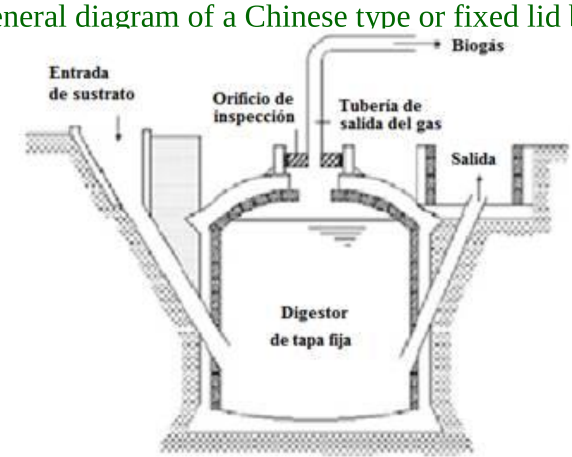


Fig.4 General diagram of a floating bell or Hindu-type biodigester.

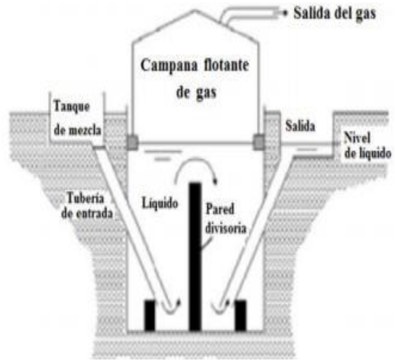
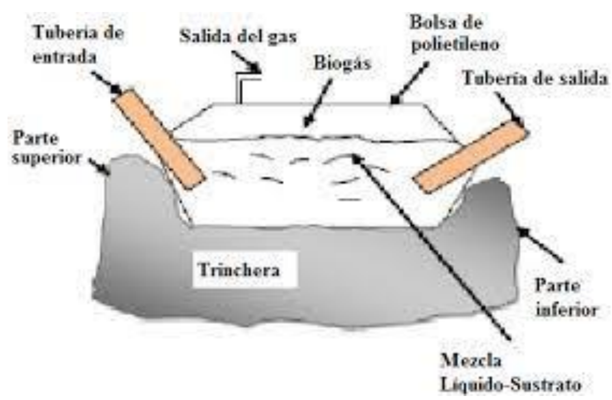


Fig.5 General diagram of a tubular or polyethylene bag Biodigester



Hindu-type or floating bell biodigester

The model has a drum that can be made of brick, concrete or reinforced plastic and the gas is housed in the upper part of it when the floating dome is full rises while when the gas is consumed its level decreases. The single digester fully discharged when required align repair (Chorus, 2015)

Tubular or polyethylene bag biodigester

Tubular or polyethylene bag biodigesters are made up of a bag "resistant to environmental conditions". The bag is considered fragile and susceptible to mechanical damage and changes in environmental temperature, so its useful life is considered between 2 and 5 years. Extreme exposure to low temperatures can considerably reduce biogas production due to its insufficient insulation from the outside environment, while high ambient temperatures can catalyze the production of other volatile compounds other than methane (Barrera *et al.,* 2020).

Biogas formation

The development through methane fermentation methane production or anaerobic digestion is defined as the biological decomposition of organic matter under anaerobic conditions The complete biogas process can be divided into three steps: hydrolysis, acidification and methane formation which involve three fermentation bacteria, acetogenic bacteria and methanogenic bacteria (D. López, Jiménez, &

Romero, 2012). Currently, biogas is essential to optimally convert biogas into biomethane or also known as green gas. The use of this type of energy has been seen in the use of boilers, vehicle fuel, engines or turbines to generate electricity

This type of process is carried out centuries ago, where the production of biogas is carried out through anaerobic fermentation, being a biological process used more frequently by nature, the bacteria that intervene form microbiological groups in which each group formed will find the right conditions for your needs such as light intensity, exposure to ultraviolet radiation, among others. This type of process was developed with the aim of decomposing organic materials, reducing the carbon footprint and obtaining energy that is friendly to the environment and at low cost.

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