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Anaerobic Digestion Process for Biogas Production

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ABSTRACT: The growing addition of greenhouse gases to the environment, as well as the depletion of petroleum supplies, pique the academics' interest in developing innovative techniques for generating clean, long-term power from natural sources Many of these resources exist in reality and are ready to assist mankind at any time. Among the several renewable energy sources accessible, windy, solar, and biomass power are the most common. The emphasis of this study is on biogas technology, which is a highly appealing technique to use biomass sources to meet partial energy needs. This paper discusses the overview of anaerobic digestion, Stages of anaerobic digestion, Factor affecting anaerobic digestion and types of anaerobic digestion Biogas systems may benefit consumers in a variety of ways while also helping to safeguard the environment. Biogas is produced by the anaerobic digestion of organic materials in biogas systems. Biodegradable biomass materials may be fed into biomass digesters in any quantity. Typical biomasses include agriculture waste, crop remnants, livestock wastes, forest residues, and other wastes.

KEYWORDS: Acetogenesis, Anaerobic digestion, Biogas, Environment, Proteins

1. INTRODUCTION

Researchers have been pushed to discover innovative strategies to acquire clean and sustainable energy via the use of renewable energy sources due to the scarcity of traditional fuel supplies, rising fuel costs, and growing awareness about environmental concerns(Scarlat et al., 2018). Biogas technology presents a highly appealing method of

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using biomass sources to meet partial energy needs. Biogas systems may benefit consumers in a variety of ways while also protecting the environment. Through anaerobic digestion of organic materials, Biogas is a combination of biogas and carbon dioxide with a tiny quantity of other gases produced by this system. Inorganic material is digested by a large number of bacteria operating simultaneously in the absence of oxygen in anaerobic digestion (Winquist et al., 2019). A complex series of events changes a wide variety of polymeric materials having carbon atoms in various oxidized and/or reductions stages, like polysaccharides, protein, and lipid, to one molecule in their most oxidation and reduction nations (CO_2), respectively (CH_4)(Winquist et al., 2019). A complex series of events changes a wide variety of polymeric materials having carbon atoms in various oxidized and/or reductions stages, like polysaccharides, protein, and lipid, to one-carbon compounds in their most oxidized and reduced states (CO_2), respectively (CH_4).

1.1 Stages of anaerobic digestion:

- *Hydrolysis:*

The first stage in the aerobic digesting procedure is hydrolyzed. At this point, the complex organic macromolecules are broken down into their simple watery constituents. During this step, lipids (fats) are transformed to fatty, polysaccharides (polysaccharides) are changed to basic sugars (monosaccharides), and protein are transformed to amino acids. Different kinds of facultative or obligatory fermentative bacteria carry out the hydrolysis step by excreting extracellular enzymes(Angelidaki et al., 2018). *Lipases transform lipid to long-chain fatty acids, proteases convert proteins to amino acids, and cellulases, amylases, and pectinases hydrolyze polysaccharides including monosaccharides from cellulose, starch, and pectin.*

- *Acidogenesis:*

The soluble molecules created by In the final stage, degradation produces unstable lipid acid, water, carbon monoxide, ethanol, and some organic carbon and sulfur molecules. The acids produced in this stage are acetic acid, propionic acid, butyric

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acid, and valeric acid. The residual compounds are delivered to the next phase to be destroyed by acetogens, whereas the acetic acid generated in this step is transported directly to the final stage (Nsair et al., 2020).

- *Acetogenesis:*

Acetogenesis is the third step of the anaerobic digestion process. Containing the aid of acetogens, Greater than two carbon molecules in volatile fatty acids (from the acidogenesis stage) are converted to acetic acids, water, and carbon dioxide.(Kapoor et al., 2020).

- *Methanogenesis:*

In the last step, methanogenic bacteria (methogens) consume acetic acid, hydrogen, and a little amount of carbon dioxide to generate methane. Acetate decarboxylation produces about % of biogas, with the rest coming from other sources 34 percent produced via carbon dioxide reduction (Zheng et al., 2020).

1.2 Factor affecting anaerobic digestion:

- *Temperature:*

In anaerobic digestion, temperature is the most crucial characteristic to consider. Different methogen species perform best in three temperatures varies: thermophilic (45–60°C), mesophilic (20–45°C), and psychrotrophic (below 20°C). The degree of biogas generation increases as the temperature rises. Because anaerobic digestion response largely ceases below 10°C, In the biogas digestion process, only microbial and psychrophilic temperatures categories are considered beneficial. Because the microorganisms involved in the digestion process are warmth dependent, it is vital to keep the temperature constant (Fu et al., 2021). In terms of holding duration, loading rate, and gas production, thermophilic bacteria are more effective than mesophilic bacteria, but they need more heat and are more susceptible to temperature variations and environmental factors.

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- *Solid to water content:*

To make a slurry with the desired consistency, combine water and raw material. If the slurry is too thin or too thin, biogas production is inefficient. The optimal solid percentage might vary from 7 to 25% dependent on the type of raw materials used. Because sewage waste has a low solid content, an optimal level may be attained by adding solid matter such as agricultural residues, weed plants, and so on (Abdeen et al., 2016).

- *PH level:*

The pH level of the anaerobic digester should be between 6.7 and 7.5. Throughout the procedure, the pH level will fluctuate (Dahlgren, 2020). Because methanogens are particularly sensitive to acid environments, The rate of formation of volatility fatty acids is much faster than that of formaldehyde, resulting in pH values that are below the optimum range and suppressing methanogens. Chemicals such as na2co3, sodium bicarb, gasses nitrogen, nitrate hydroxide, lime, potassium, and sodium hydroxide may be used to manage pH reduction.

- *Retaining period:*

The preservation time is the length of time that natural products are kept on the market material stays within the digester for biogas production. The amount of time the feedstock is retained varies depending on the kind of feedstock and the temperature utilized. The two important retention periods in the anaerobic digestion process are solids holding time and hydraulic holding time. The time bacteria (solids) stay within the digester is referred to as SRT. The abbreviation HRT stands for "substrate retention time." It is the amount of time the input slurry spends within the digester from the moment it enters to the time it exits (Kohlheb et al., 2021).

- *Rate of organic loading:*

The organic loading rate (OLR) is a critical parameter that influences biogas generation in anaerobic digestion, especially when the digestion is done in continuous flow mod.

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The biological conversion capability of the anaerobic digestion system is measured by OLR (Macor & Benato, 2020). It may be calculated as the amount of raw physical (kg of volatile solids) supplied per unit volume each day. Due to the buildup of acids, overeating has a negative impact on digestion. The ideal loading rate for per day total aromatic particles per litre amount of digester is between 0.5 kg and 2 kg, depending on the kind of raw material, retention duration, and process temperature.

- *Carbon to Noise ratio (C/N):*

The C/N ratio15 represents the connection between the quantity of carbon and nitrogen contained in the raw materials. The carbon-nitrogen (C/N) ratio is one of the most important factors in biogas production. The two most essential resources for aerobic microbes are oxygen (in the type of carbohydrate) and ammonia. Microbes devour biomass at a rate that is 30 times faster than nitrogen. As a consequence, carbon accessibility in the substrates would be 20-30 times higher than nitrogen available. (i.e. C/N ratio between 20 and 30) 23-26 for optimal rate. When the C/N ratio is high, methogens use nitrogen quickly, resulting in reduced biogas output. Lower C/N ratios result in ammonia buildup and pH levels over 8.5, which are hazardous to methogens. To maintain the ideal C/N ratio in the digester, high C/N ratio substrate might be co-digested with reduced C/N ratio substrate. When comparing the effects of various feed C/N ratios on biogas production, it was discovered that a C/N ratio of 26:1 produced the most biogas (Qyyum et al., 2020).

1.3 Classification of anaerobic digestion system:

- Continuous and batch processes:

The substrates is fed into the digestion just once in a batch operation, and then the digestion is sealed for the length of the retention time. After the retention period, the processed material is removed from the digester, and a fresh substrate is supplied to restart the process. The generation of gas in this kind is not continuous. The gas output is low at the start and conclusion of the operation, but it is high in the middle (Macor & Benato, 2020). As a result, numerous batch type digesters may be run in parallel to

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ensure a consistent gas supply from batch systems. The digester is continually fed substrate and an equivalent quantity of digested substrate is withdrawn in a continuous operation, resulting in constant and continuous methane generation. The contents of the digester are continually mixed using a mechanical agitator or biogas recirculating in this sort of system.

- Wet and dry systems:

Depending on the total solid content of the input substrate, the process may be classified as wet or dry. The substrates are processed using a dry digesting method with a solid concentration of 20-40%. The substrates processed in the wet system have a solid content of less than 15%. 10 and 16 because a Thick substrate and sludge are handled by the dry system, which takes more power to produce and convey. Substrates may be readily moved in wet systems using ordinary pushes with reduced vigor effort. Furthermore, Materials movement is simpler in wet systems, and bacteria-food interactions is improved, leading in a greater gas generation ratio (Rodero et al., 2019).

- Single-stage and multi-stage systems:

A solitary-phase system encapsulates all phases in a solitary, closed vessel, anaerobic digestion takes place. The foremost issue with a solitary-phase method is that during the acid production stage, acidogenic bacteria lower the pH of the digester, affecting methane generation owing to differences in the development of acidogenic and methanogenic bacterial populations. Both acidity and biogas digestion vessels are utilized separately. Creation in two-stage and multi-stage systems to provide optimal management over organisms during acid and methane formation10, 88. Hydrolysis, acidogenesis, and acetogenesis occur in the first digester vessel, and the product is conveyance to a secondary ship for gas production The temperatures of the secondary digestion vessel may be mesophilic or thermophilic, dependent on the scenario. One stage methods are suggested for dry batching or wet continuously equipment, while two stage systems are preferred for continuously and wet operations.

- *Mesophilic and thermophilic systems:*

The temperature of the digester in mesophilic schemes is kept below 45°C, while the temperature of the digester in thermophilic systems is kept amongst 45°C and 60°C. 16. Mesophilic schemes are more stable than thermophilic systems because they are more tolerant of changes in environmental circumstances. When compared to the mesophilic system, the greater process temperature accelerates the reaction and reduces the substrate retention period in the thermophilic system. In thermophilic systems, achieving a higher temperature demands greater energy input.

2. DISCUSSION

Biogas is made from agriculture wastes, dung, municipal rubbish, plant materials, wastewater, environmental waste, and culinary waste, which is a combination of gases mostly made up of methane and carbon dioxide. It is a source of renewable energy. Anaerobic digestion using anaerobic organisms or methanogen in an anaerobic digester, biodigester, or bioreactor produces biogas.

Biogas is mostly methane (CH_4) and carbon dioxide (CO_2), with some hydrogen sulfide (H_2S), moisture, and siloxanes thrown in for good measure. Methane, hydrogen, and carbon monoxide (CO) are all combustible gases that may be oxidized with oxygen. Biogas may be utilized as a fuel because of this energy release; It may be utilized in energy cells and for any kind of heating, including cooking. It may also be utilized to transform converting gas energy into power and warmth in a gas engine.

Biogas may be compressed once carbon dioxide is removed, just as natural gas can be beaten into compressed natural gas (CNG), and used to power cars. Biogas, for example, In the United States, it is estimated that it has the ability to substitute around 17% of automotive fuel. In several parts of the world, it is eligible for renewable energy subsidies. When biogas is converted to bio-methane, it may be cleaned and improved to the requirements of natural gas Bioenergy is an alternative to fossil fuels. since it has a continual production-and-use cycle and produces no net carbon dioxide. The organic material is transformed and utilised as it grows. It then regrows in a never-ending cycle. In terms of carbon monoxide, as much is collected from the surroundings

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throughout the growth of the primary bio-resource as is finally released when the substance is converted to power.

2.1 Kinds of anaerobic digesters:

- Floating drum type digester:

A circular or shaped biogas, a metal hovering drum or gas-holder, an intake tanks, an outputs tank, an inlet pipeline, an output tubing, and a partition wall comprise a floating-drum type digester. By raising the gas holders up and down with the help of a central guide pipe between the collection and discharging of gas, the gas in the gas holders is kept at a constant pressure. Models such as the KVIC (Khadi and Villages Industrial Council), Pragathi, and Ganesh, and others are examples of floating drum type biogas plants. These plants offer a number of benefits, including the ability to keep biogas at a constant pressure, an integrated setup for scum removal, and the ability to monitor gas volume by detecting the drum position.

- *Fixed dome digester:*

The Chinese were the first to create fixed dome plants. A closed, dome-shaped digestion with an immobile stationary gas makes up a fixed-dome plant. The gas is captured among the sludge and the ceiling of the facility. The gas pressure within the facility isn't consistent here. Fixing dome planters include China fixed-dome plants such as the Janata Model, Deenbandhu Prototype, and CAMARTEC Model. Plants with fixed domes are less costly than those with floating domes.

3. CONCLUSION

This work evaluated and presented the literature on biogas technology and anaerobic digestion in order to fully comprehend the principles and overview. The phases of anaerobic digestion, feedstock, digester types, and anaerobic digestion products were also reviewed and discussed in this paper. This study discusses the factors that influence biogas production as well as the factors that are taken into account while designing an anaerobic digester.

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