Chapter 7
Biogas:
Renewable Natural Gas

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ABSTRACT

Biogas is a renewable natural gas used in production of energy which is generated by breakdown of organic matter by anaerobic digestion. It is a composition of methane, carbon dioxide, and some other gases in small quantities. The most common natural resources for production of biogas are aquatic sediments, animal waste, crop residues, wastewater sludge, and many others. Some other sources are landfills, water lagoons, etc., which are a result of human activity. There are several technologies used for biogas production, mainly biodigesters, wastewater treatment plants, and landfill gas recovery systems. Production of biogas is highly dependent on the feedstock availability and the policy support by the government.

INTRODUCTION

Fossil fuels are among the most highly used sources of non-renewable energy which lead to 80% of the global needs. To attain sustainable economic growth, antagonistic and fast-paced deployment of renewable resources is needed. One of the most common sources of energy is fossil fuels. To sustain the non-renewable sources, we need accelerated and antagonistic deployment of efficient energy sources by the second half of the century (IRENA, 2017a). The use of efficient bioenergy conversion and modern technologies are gaining high importance recently which are used to fulfill the demand of global energy

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needs. Biogas is one of the most cost-effective and ecologically beneficial forms of renewable energy (Deublein & Steinhauser, 2011). It could be a viable option for the world's insatiable energy demand while also reducing waste and greenhouse gas (GHG) emissions. Anaerobic digestion may transform sewage sludge, agricultural and crop leftovers, animal dung and industrial organic wastes, and wastewaters into biogas. The type of the raw materials used for digestion, as well as the pH of the medium, influence the composition of biogas (Muoz et al. 2015). Under anaerobic conditions, bacteria decompose complex organic matter into simpler components, resulting in biogas and fertilizer (Gemmeke, 2009 & Piwowar, 2020). The technique of using anaerobic respiration for the production of biogas has numerous environmental benefits. It helps to treat organic wastes along with introducing green energy, protecting the environment, and also helps to reduce greenhouse gas emissions (Falk, 2011; Theuerl, 2019; Daniel, 2017; Gemmeke, 2009; Stolze, 2017]. There are four phases to the biodegradation of complex organic compounds. Hydrolysis, acidogenesis, acetogenesis, and methanogenesis, are the respective steps (Rohstoffe, 2012). The composition of biogas has a higher concentration of methane which generally makes up to 50% to 75%. This methane content makes the biogas flammable and also generates a blue flame which can be used as an energy source.

The calorific value is fixed on the basis of the concentration of CH_4 as the other substances do not play a major role in the energy content. The calorific value of raw biogas is 21MJ/m^3 considering that the density of 1.22 kg/Nm^3 CH_4 present in the raw biogas is up to 50% which is also similar to that of air (1.29 kg/Nm^3) (Rutz and Janssen 2008). So as to know more about the various applications of biogas, it is a must that the concentration of CH_4 is appreciably higher (i.e. >90%). This also states that the utilization capacity of any biogas is determined by the composition of the gas. Upgrading biogas is a widely used, well-developed, and easily obtainable technique. It is becoming more widely used around the world, although it is still in its infancy when compared to the biogas producing industry. After treatment, biogas can be used for a variety of purposes, including electricity and heat generation, natural gas grid connection, and automotive biofuel (Rosen T, 2019).

BIOLOGICAL REACTIONS

Hydrolysis, acidogenesis, acetogenesis, and methanogenesis, are the procedures followed after then numerous complex biochemical reactions and as a product of these, biogas is formed (Ghodrat et al., 2018). The complete reaction of conversion of food wastes into biogas is as follows (Deublein & Steinhauser, 2011):

$$C_cH_nO_oN_nS_s + wH_2O \text{ ® } mCH_4 + nNH_3 + sH_2S + (c\text{-}m)\ CO_2$$

where, m= ⅛ (4c+h-2o-3n-2s)

w = ¼ (4c-h-2o+3n+3s)

Carbohydrates ($C_6H_{12}O_6$), proteins ($C_{13}H_{25}O_7N_3S$), and lipids ($C_{12}H_{24}O_6$) come under the degradable fraction of the food waste.

Individual stages are controlled by various microorganism consortia, which have syntrophic interactions with the microbial consortia participating in the other stages. On hydrolyzing bacteria excrete

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