ISSN 2229-5518

Factors Affecting the Production of Biogas

Adem YILMAZ, Sinan ÜNVAR, Abdülkadir KOÇER, Bünyamin AYGÜN

Abstract— Biogas is environmentally friendly, relatively cheap and a renewable energy source which occurs as a result of anaerobic fermentation of wastes and organic wastes. Temperature has a very large impact on biological systems. The metabolic activities of methane bacteria changes in regard to carbon / nitrogen so this ratio is important in producing biogas. The C / N ratio should be less than 10/1 or more than 23/1. In the process of producing biogas is essential to mix slurry and wastes to react with each other. In this study, factors affecting biogas, loading rate, retention time, the C / N ratio of the ambient operating temperature, pH, mixing are discussed. The proportion of these factors, speed and operating conditions have been examined and advantages and disadvantages of biogas production have also been demonstrated. Most of the data are shown in tables and graphs. In this work, emphasize on the importance of biogas and the biogas production factors, is intended to contribute public awareness about biogas.

Key words: biogas, biogas production, biogas systems, biogas temperature, biogas use, energy, factors affecting the production of biogas.

1 INTRODUCTION

Energy; produced from renewable and non-renewable sources and an indispensable necessity that people enjoy at every stage of their lives. Mechanization and unconscious use together with industrialization have brought renewable energy sources (oil, natural gas, coal) into extinction point. Scientific studies indicate that non-renewable energy sources will be extinct in the near future. The desire for down the use of non-renewable energy sources leads the world to renewable (solar, wind, geothermal, biomass) energy sources. Biogas, as one of the renewable energy sources, draws attention for its environmentally friendly character and emitting methane gas during the process. In the production of biogas as one of the renewable energy sources have drawn attention for emitting environmentally friendly methane gas during the production process. In addition, the use of anaerobic biotechnology is increasing in many countries the world its lower operating and investment costs compared to other systems. Biogas technology is used in the industrial field in developed countries in contrary to undeveloped countries where primitive production attempts made with local facilities. Biogas production is an essential biological process. For this reason, it is necessary to ensure that all conditions are met. To produce a good biogas, the C / N ratio, pH, ambient temperature, hold time, loading rate, mixing conditions must be completed. An efficient gas production will not take place if all the conditions are not met completely. It is known that some of the biogas plants, that have been established today, are now out of use . If all conditions are met, it is possible to obtain an efficient biogas [1].

- *Adem YILMAZ, Department of Energy Systems Engineering,*
- *Tecnology Faculty Batman University, Batman, Turkey,*
- *Sinan ÜNVAR, Department of Electrıch and Energy, Vocational School, İbrahim Çeçen University, Agrı, Turkey,*
- *Abdülkadir KOÇER, Department of Computer Technology, Vocational School, Akdeniz University,Antalya, Turkey,*
- *Bünyamin AYGÜN, Department of Electronics and Automation,*
- *Vocational School, İbrahim Çeçen University, Agrı, Turkey.*

2 Significance of The Research

Biogas is a gas that released result of fermentation of organic waste and residual materials. It is environmentally friendly energy and fertilizer source which consists of 40-70% methane, 30-60% carbon dioxide, 0-3% hydrogen sulfide and very little nitrogen and hydrogen. Furthermore, it provides recovery of waste. In the biogas production process the scent of animal manure is reduced to such an extent that cannot be smelt. In addition to this, the ill effect of animal fertilizers upon on human health and groundwater also comes to end thanks to the biogas. Moreover, it has also provided a valuable organic fertilizer by converting waste into good use. The components of the biogas are shown in Table 1.

TABLE 1
BIOGAS COMPONENTS [2]

Components	Symbols	Amount
Methane	CH_4	40-70 %
Carbon dioxide	CO_2	30-60%
Hydrogen	H_2	5-10%
Nitrogen	N_2	1-2%
Water vapour	H_2O	0.3%
Hydrogen sulfide	H_2S	A small amount

The factors that affect microbiological bacteria also affect biogas production. Bacteria need a certain pH and temperature to

ISSN 2229-5518

survive their vital activities. C/N ratio is important for its effects on the bactericidal decomposition rate [3].

2.1 Biogas Production

The production of biogas has three stages. In the first stage, long-chain organic molecules are fermented and broken down by acedogenic bacteria, converted into organic acids, and hydrogen and carbon dioxide gases are released during the process. The vast majority of organic wastes become soluble in water during this initial stage. In the second step, organic acids are converted by acedogenic bacteria into acetate (CH_3COOH), hydrogen (H_2) and carbon dioxide (CO_2). However, in order for the reaction hydrogen must be removed from the environment. This is done with methane bacteria that use hydrogen in their metabolism. In other words, while the methane bacteria take the hydrogen they need, they also remove a harmful substance from the environment that adversely affects acedogenic bacteria. The third stage is mainly carried out by methanogenic microorganisms which are archaebacterial. These microorganisms, thanks to their special cell structures, are able to survive at temperatures above 70 ^{0}C that many other organisms cannot. The second component required for biogas formation is bacteria. Bacteria first convert proteins, carbohydrates and oils in organic matter into simple acids such as acetic and propionic acids, then convert these simple acids to methane and carbon dioxide. Some methane-forming bacteria produce CH_4 and H_2O by using CO_2 and H_2, while methane bacteria form acetic acid (CH_3COOH), to produce CH_4 and CO_2 [4,5,6].

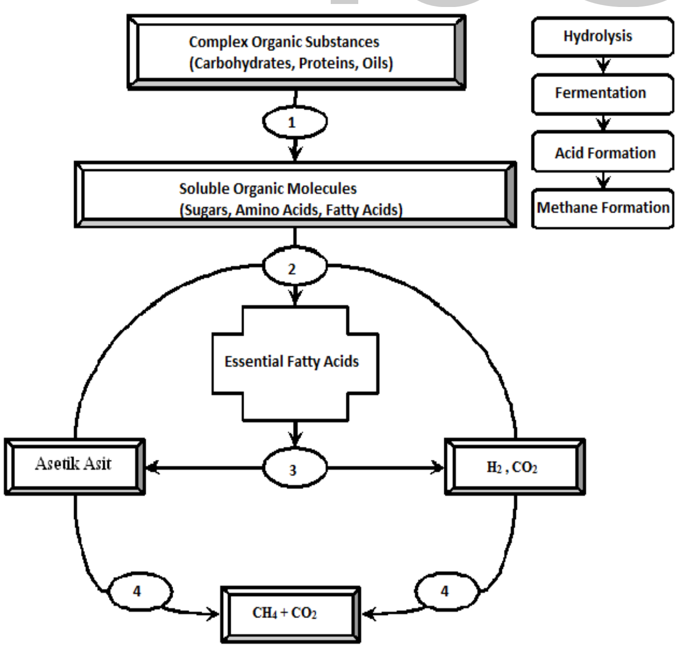

Figure 1. Biogas Formation with Anaerobic Digestion of Organic Matter [7]

2.2 Effect of Temperature on Biogas Production

Methanogenic bacteria are not active at very high and very low temperature values. Therefore, the reactor temperature at which biogas production will take place affects biogas production or speed. The temperature in the reactor also determines the waiting time and the reactor Generally, desirable temperature is 30-35 ^{0}C Production can be stopped in winter when the winter conditions are ignored and the heating process is not performed and the temperature drops below 10 ^{0}C. During anaerobic fermentation, there are three different temperature zones depending on the type of wastewater and waste materials, the pH of the wastewater, and the microorganisms that are formed by them.

1- Psychrophilic fermentation (3-20 °C): In these systems the rate of decay is very slow and the average waiting time is between 100 and 300 days.

2- Mesophilic fermentation (20-40 °C): It is the most applied temperature region in anaerobic fermentation. Hold times range from 20 to 40 days.

3- Thermophilic fermentation (40-70 °C): The retention rate is higher the retention times are shorter (Beijing, 1983; Anon, 1999b). The growth rates of methane bacteria according to temperature ranges are shown in table 2 [8, 9, 10, 11].

Studies in the psychrophilic temperature region are relatively small. However, successful results were obtained at low loading speeds. For example, the loading rate for the mesophilic site is 1-3 kgVS / m^3-reactor-day while it is 0.01-0.04 kgUK/m^3-reactor-day for psychrophilic [7].

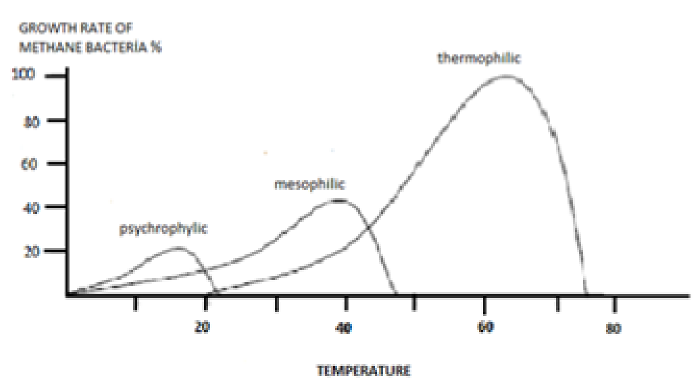

Figure 2. Psychrophilic, Mesophilic and Thermophilic bacteria growth rate of methane [7]

ISSN 2229-5518

2.3 Effect of Carbon and Nitrogen Ratio Biogas Production

Carbon is necessary for formation of biogas and nitrogen is required for the growth and development of aerobic bacteria. C/N ratio should be less than 10/1 and more than 23/1 level. If the C / N ratio is too high, nitrogen will rapidly be consumed in order to meet the protein requirement and will not react with the carbon compound of the raw material and as a result of this gas production will not happen. The optimum C / N ratio for biogas production should be 25-30 / 1. The C / N ratios of the materials commonly used in biogas production are shown in the table below [12].

TABLE 2. SOME SUBSTANCE C / N RATIO [12]

Raw materials	C / N ratio
Duck	8
Human	8
Chicken	10
Goat	12
Pig	18
Sheep	19
Beef	24
Elephant	43
Straw (rice)	70
Straw (wheat)	90
Sawdust	200

2.4 Effect of Mixing Biogas Production

To distribute the organic charge entering the system uniformly with the bacteria, it is necessary to carry out the mixing process in order to ensure the uniform distribution of the solids and the solids collected above and to facilitate the discharge of the produced gas. Mixing allows gas to pass through the foam or over the surface of the liquid, prevent the materials in the liquid from falling to the bottom and allow the bacteria to contact the organic materials homogeneously. As a result, gas production increases by 10-15%. Mixing and shaking does not only have these advantages, but also has other advantages like equalizing the temperature change of the waste in the fermenter, organizing the population density of the bacteria in the slurry and accelerating the reaction by providing a mixture of the bacterial population and fresh waste [12].

2.5. Effect of pH value in biogas production

Best biogas production in the anaerobic environment is the optimum pH range of 6.6-7.6. It causes toxic effects on methane bacteria when this value falls below 6.2. The equilibrium profile reached the plant. The pH of the fermentation system varies depending on the fatty acids produced, the bicarbonate alkalinity and the carbon dioxide. The gas production efficiency is considerably adversely affected when the pH value falls below 5.0. In general, the pH level of the plant is not used to determine the organic acid biogas potential which emitted as the results of buffering effect between carbon dioxide-bicarbonate (CO_2-HCO_3) and ammonia-ammonium (NH_3-NH_4) [12].

2.6. Effect of Waiting Time on Biogas Production

Waiting time refers to the time the wastes stay in the generator. The reproductive rates of bacteria, which break down organic materials and allow the gas to rise, depend on the duration of retention (retention). The breeder varies depending on the species and the type of waste used. The hydraulic retention time and the solid retention time are divided into two. The temperature in gas production from organic wastes has a very important role. The temperature in the reactor also affects the waiting time and reactor volume. There are 3 different temperature zones according to the structure of microorganisms. The most suitable temperature zone for biogas production is the mesophilic fermentation zone.

3 CONCLUSION AND RECOMMENDATIONS

If consideration will run out of fossil-based energy sources in the world clean, reliable, renewable energy sources by prominent local characteristics should be used and disseminated. And also countries increasing industrial investments and population growth are also increasing the need for energy. The consumption of non-renewable energy sources pushes the world countries to invest and work on renewable energy sources. Countries consume non-renewable energy resources (oil, natural gas) reserves and this consumption brings external dependency. Countries needs to turn to renewable energy sources in order to minimize its outsourced energy policy. Countries has an unimportant level of vegetable, urban and organic fertilizer potential. This potential is not adequately assessed. Animal pigments are often used as fuel to meet the need for warming. As a result, the organic matter needed for the soil is disappearing potentially and biogas production and its use must be encouraged to save energy and contribute to energy production. Biogas energy has many advantages and there are no disadvantages. The parameters such as temperature, C / N ratio, mixing, and pH affect the efficiency of the produced energy. Biogas will contribute to the reduction of environmental pollution as it is obtained by conversion of animal, vegetable and industrial wastes which cause the emission of harmful gases.

REFERENCES

[1] Canka Kılıç, F.,(2011), Biyogaz önemi, genel durumu ve Türkiye'deki yeri. Mühendis Ve Makina Cilt:52 Sayı:617

[2] Gül, E., (2011), Biyolojik proseslerde üretim yapan biyogaz tesisinin ve proses sonucu elde edilen biyogaz ile çalışan süt soğutma ünitesi tasarımı optimizasyonu, Ege Üniversitesi. Mühendislik Fakültesi. Makina Mühendisliği. Bitirme Tezi

[3] Biyogaz Çalıştayı Sonuç Raporu (2014), Adıyaman Üniversitesi

[4] Gülen, J., Arslan,H., (2005), Journal Of Engineering And Natural Sciences.

[5] Persson, M.,& Jönsson,A.,& & Wellinger, A.,(2007), .Biogas upgrading to vehicle fuel standarts and grid injection, International Energy Agency (IEA) Publications. Bioenergy. Task 37: Energy throughout the whole world, Berlin 7-11

[6] Madeley,J.(1981), Problems of Biogas Production, Energy Policy, Volume 9, 4, December, Page 328

[7] http://www.cevreorman.gov.tr/belgeler1/biogaz.doc

[8] Eryaşar, A.(2007),. Kırsal kesime yönelik bir biyogaz sisteminin tasarımı, kurulması, testi ve performansına etki eden parametrelerin araştırılması, Ege Üniversitesi, Fen Bilimleri Enstitüsü, Güne Enerjisi Anabilim Dalı, Doktora Tezi

[9] Ilkiliç,C., Deviren,H. (2011), 6th İnternational Advanced Technologies Symposium (IATS'11), Elazığ Turkey

[10] Anon., 2002f, Generating Biogas from Source Separated Organic Waste for Energy Production, http://www.toronto.ca/eia/pdf/anaerobic_ fulldoc.pdf

[11] Pekin, B., 1983, Biyokimya Mühendisliği (Biyoteknoloji), Ege Üniversitesi Kimya Fakültesi Yayınları, No:3, İzmir,

[12] Bahtiyar,Ö.,& Emin O., (2008), Membran yöntemiyle biyogazdan karbondioksitin ayrıştırılması ve metan saflaştırma projesi, PROJE NO: 105Y084

[13] Eryaşar,A., (2007), Kırsal kesime yönelik bir biyogaz sisteminin tasarımı, kurulması, testi ve performansına etki eden parametrelerin araştırılması, Ege Üniversitesi, Fen Bilimleri Enstitüsü, Güneş Enerjisi Anabilim Dalı , Doktora Tezi