Impact of variables affecting biogas production from biomass

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Abstract. As a substitution of fossil fuels and a resource of Renewable Energy, Biogas is of vital important in this era of abated energy resources. Production of biogas from anaerobic digestion by utilization of waste and organic matter provides an excellent solution for waste management. In this review, it is shown that what are the main factors which affect the biogas production, how they are affecting and at what condition optimal results are produced. Temperature is the important factor which affects the biogas production. At higher temperature, maximum biogas is produced. There are other factors like the C/N ratio, pH value, compression ratio, and the total solid concentration which are affecting the biogas production. In this paper, concentration of all these factors at various conditions has been noted and the optimal condition is specified. It is also specified at what condition the higher gas yield will be produced.

Key Words: Renewable Energy; Biogas; biogas from

1. Introduction

Accomplishing the demand of energy there are many resources but some fuels like fossil fuels are depleting day by day and also these fuels are harmful to the environment so to save our environment and for the replacement of these fuels Biogas is the best option. Biogas can be produced from various wastes like animal manure and slurry, sewage, sludge, municipal solid waste, and food waste so it can reduce waste and also some fertilizers suitable for the agricultural purpose are also produced during biogas production process. In India total waste generation is 531.53 lakh MT/Annum referred to in reply o part (a) of the LokSabha Unstarred Question No. 2974 for 04/01/2018 regarding “Generation of Solid waste”.

Anaerobic digestion is the process to produce biogas from biomass. Biogas composition is mainly of methane(CH4) two-thirds by volume and CO2. This process includes four phases to produce biogas Hydrolysis, Acidification, Acetogenesis, and Methanogenesis. Hydrolysis is the process in which disintegration of water into H+ and OH- ions occurs. By hydrolysis breakdown of various organic polymers like protein, fats and carbohydrates occur. Acidogenesis is the next step of anaerobic digestion which includes the breakdown of organic matter by acidogenic bacteria which produce H2, CO2, H2S, Volatile fatty acids and other products. In the third step which is acetogenesis, acetate generates which is a derivative of acetic acid. In the final step, methane is produced from the products of the last step. There are various factors which affect the digestion process and these factors will also affect the biogas production, so biogas production depends on various factors like temperature, pH value, C/N ratio, HRT. In this review paper, it is shown that how this factor will affect the biogas production.
1.1 Effect of Temperature
Temperature is an important factor which affects biogas production. On increasing the temperature biogas production increases. Season temperature affects the biogas production. So during winter, less biogas is produced as compared to the summer season. There are many bacteria’s which develops and helps in producing the biogas. These bacteria also develop at various temperatures. According to Barik (2012) anaerobic bacteria develop well at temperature of about 309.9K (mesophilic) and 327.6K (thermophilic). Biodeg (2013) had done research on biogas generation from cow dung at different temperature condition. He had taken the volume of slurry as 3g dung with 10cm3 water at different temperature and observes in different time duration. The following table 1 shows the results:

Table 1: Physio-chemical properties of biomass

| Properties                | Flask        |
|---------------------------|--------------|
|                           | A            | B            | C            | D            |
| Volume of slurry          | 3g dung 10cm3 water | 3g dung 10cm3 water | 3g dung 10cm3 water | 3g dung 10cm3 water |
| Temperature               | Ambient 25±20C | Ambient 25±20C | Sunlight outdoors | 400C         |
| Gas collection over water | water        | Lime water   | ----          | ----         |
| Gas yield production      | Highest (15.60cm3) | ----        | ----          | ----         |
| Highest percentage gas    | Week 3 (41.30%) | Week 4 (53.85%) | ----          | Week 2 (39.29%) |
| yield week                |              |              |              |              |

According to Biodeg (2013) highest gas yield produced was 15.60cm3 at ambient temperature which is collected over lime water in week 4.

1.2 Effect of C/N Ratio
Carbon mass to nitrogen mass ratio is called as C/N ratio. C/N ratio affects the volume of the biogas produced. During acidification process bacteria’s develop under acidic conditions so to produce acetic acid carbon and oxygen is required. When anaerobic environment is deficient with oxygen then nitrogen is required for the growth of micro-organisms. During hydrolysis ammonia is produced as by-product from nitrogenous compound. Proper hydrolysis is important for the production of ammonia otherwise this will lead to a condition termed as ammonia toxicity. Ammonia is important factor causing methanogenesis inhibition. Excess ammonia is also dangerous as it may lead to digester failure.

Microorganisms generally utilize 25-30 times carbon than nitrogen during anaerobic digestion. Greatest suitable C/N ratio in methane generation is considered as 20-30. If C/N ratio is high, then nitrogen will consume initially which will make process to slow down. Amount of nitrogen will be high in digester and carbon will be low if C/N ratio would be too low [18-19].

1.3 Effect of pH
pH value is main factor in anaerobic digestion. Development of microbes during anaerobic fermentation affected by pH. pH of digester content depends on carbon dioxide and volatile fatty acids. This is also affected by the temperature of reaction medium. Yadvi (2004) state that if pH is greater than 5 then production of CH4 would be greater than 75%. Shiva Subramaniam(2014) investigated different pH (5, 6, 7, 8, 9, & 10) on biogas production from food waste with a retention time of 30
days. Better yield of biogas and bacteria growth was found at pH 7. Edison Muzenda conducted an experiment in which he took 3 different pH values and for each value the rate of biogas production was different. The highest biogas production was at a pH of 6.5.

1.4 Total Solid Concentration
Total solids concentration is a measurement that includes the combination of total dissolved solids and total suspended solids. M. Kannan (2017) conducted an experiment in which total solids concentration of 5%, 10%, 15% and 20% were taken and the effect on biogas production was investigated in the reactors with mesophilic temperature condition and hydraulic retention time of 30d. The volume of biogas produced was measured at regular intervals (24hr) using water displacement method. The results show that the reactor with 10% of total solid concentration had greater biogas production as compared with other reactors. Budiyono (2010) conducted an experiment in which the effect of Total Solid concentration on biogas production was studied by varying TS from 2.64% - 18.40% for a period of 90 days.

1.5 Hydraulic Retention Time
It is average duration of time holding slurry in digester. Shorter Hydraulic Retention time means less active bacteria and larger HRT needs larger digester which means more cost and low efficiency. Types of bacteria’s or micro-organisms and temperature affect the HRT. Shorter HRT in thermophilic temperature system while greater HRT in mesophilic temperature system. At high temperature, reaction occurs fast and so the degradation will also be faster and HRT will be less. As HRT is affected by some factors and it also affects some factors so it is not easy to find suitable HRT as shown in table 2.

Table 2: Effect of HRT

| Effects of HRT      | Hydraulic Retention Time |
|---------------------|--------------------------|
|                     | 20days       | 40days       | 60days       |
| Methane Content     | 22.4%        | 36.9%        | 42.4%        |
| pH value            | 5.8-7.1      | 6.6-7.4      | 6.3-7.3      |
| Biogas production   | 48.8ml/g TS  | 79.9 ml/g TS | 89.1 ml/g TS|
|                     | 55.2 ml/g volatile solids | 94.3 ml/g volatile solids | 105.2 ml/g volatile solids |
| Degradation of cellulose | 43.8%     | 52.1%        | 55.4%        |
| Degradation of hemicellulose | 47.1%     | 71.4%        | 76.8%        |

2. Conclusion
According to all the factors that are mentioned the suitable condition for the production of biogas can be. The temperature for the biogas production ranges from the 310K-330K. C/N Ratio for the generation of the biogas is 20-30. pH for the suitable anaerobic digestion of the Biogas is 6-7. Total solid concentration required ranges from 5%-9%. Hydraulic Retention Time should be higher for more micro-organisms to develop in Biomass.
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