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Anaerobic Digestion of Different Substrate: Comparative studies

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Abstract
Organic waste (agricultural waste, municipality waste, Industrial waste, etc) which are relatively found in abundance due to increased human activities contains mainly of organic content, which decomposes under anaerobic conditions. Different substrates influence on the amount of biogas production. The volume of biogas produced was measured indirectly by the volume displacement method, it was observed that the amount of biogas generated from these substrates with decreasing and increasing the percentage of total solid reduction, total solid which gave the maximum volume of biogas generated for combinations of substrate, cow dung+ water hyacinth, cow dung, Water hyacinth, and kitchen waste+ Water hyacinth at 37°C and at 55°C cow dung, Cow dung+ kitchen waste, Cow dung+ Water hyacinth, kitchen waste+ Water hyacinth, Kitchen waste+ Cow dung+ Water hyacinth respectively.

***Keywords**: Biogas, Anaerobic digester, substrates, methanogens.*

1. INTRODUCTION

Waste management becomes the global problem, the conversation of waste material into fertilizer and biogas helps to protect the environment. Global energy demand is growing rapidly, and about 88% of this demand is met at present time by Fossil fuels [1] Which results in the concentration of greenhouse gases in the atmosphere are rising rapidly with fossil fuel derived carbon dioxide emission being the most important contributor. In order to minimize related global warming and climate change impacts, greenhouse gases emission must be reduced. In this context biogas from waste residues are energy crops will play a vital role in future, biogas is a versatile renewable energy source which can be used for replacement of fossil fuel in power and heat production [2].

The production of biogas is an anaerobic digestion process, it is one of the most energy efficient and environmentally beneficial technology [3] in the formation of biogas involves large group of complex and differently acting microbe species, the whole biogas process can be divided into three steps hydrolysis, acidification, and methane formation, three types of bacteria are involved.

Biogas is a mixture of gases composed of methane (40-70%), carbon dioxide (30-60%), hydrogen (0-1%), hydrogen sulfide (0-3%), however well function biogas system can yield a whole range of benefits for the users the society and the environment[4].

2.MATERIAL AND METHOD

2.1 SUBSTRATE AND INOCULUM PROCESSING

All type of biomass can be used as substrate for biogas production as long as they contain carbohydrates, proteins, fats, cellulose, and hemicelluloses, as main components [5]. Different types of substrates are used for the experiment such as (cow dung, fruits, vegetables, and other agricultural waste). The total quantity of substrate so collected was thoroughly mixed and subjected to shredding to a size as small as 2-5mm in pieces. The substrate should be per-treated by pasteurization process which would reduce the role of native flora and will be later streamlined to the inoculum flora and also helps in splitting of organic polymers by hydrolysis into short chain biological good available compounds which increases the biogas yield while the retention time in the digester can be reduced drastically [6]. The inoculum collection should be done under strict anaerobic conditions from an active biogas plant. Cow dung based biogas slurry was collected in one liter plastic jars filled to the maximum and capped loosely after filling.

2.2 DIGESTER AND OPARATING CONDITIONS

Batch digestion of the experiment was conducted in laboratory scale glass reactors, containing 30% dry weight of substrate. About 10% of the slurry from an active anaerobic digester was added as inoculum to the reactors. One set of reactors was incubated at 37°C (mesophilic temperature), and another set at 55°C (thermophilic temperature). Duplicates were maintained for 3 weeks of anaerobic digestion.

2.3 TECHNICAL ANALYSIS

The analysis of sample taken from the effluent were carried out when the steady state was established, the biogas produced from each reactor was collected and measured on daily basis by volume displacement method. Change in the pH with time were monitored by removing a small drop of the slurry from sealed bottles with a needle and syringe, the solution was spotted onto pH paper specific for a various pH ranges, the accuracy of this method was checked occasionally by determining slurry pH with a pH meter. The biogas samples were analyzed for total solid (TS), volatile solid (VS), and chemical oxygen demand (COD), Are determined according to the standard methods [7].

3. RESULT AND DISCUSSION

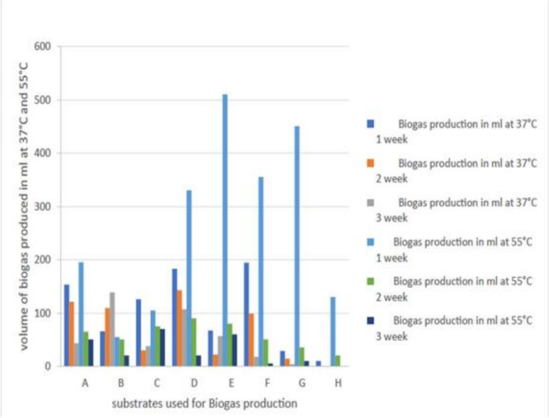

Fig. 1 Biogas production for a period of 4 weeks

The biogas produced was continuously monitored in all bioreactors. The experimental results concerning daily biogas production are shown in Figure 1 there are four parameters which are taken under consideration for biogas production by using different types of substrates.

The substrate rich in organic matters are collected and combinations of substrate are used for biogas production and from table 1 and 2 it has estimated that combination of substrate: Cow dung and Water hyacinth , kitchen waste and water hyacinth, Water hyacinth, and cow dung has given maximum volume of biogas at 37°C and for 55°C cow dung, Cow dung and kitchen waste, Cow dung and water hyacinth and kitchen waste, Cow dung and water hyacinth, kitchen waste and water hyacinth, has given maximum volume of biogas.

Temperature choice and control are critical to the development of anaerobic digestion process, having a strong influence over the quality and quantity of biogas production. The microorganisms participating in the process of anaerobic digestion (especially methanogenic ones), are divided into three large categories:

• Cryophiles (Psychrophiles), operating at temperatures from 12 to 24, digestion characteristic area under cryophilic regime;

• Mesophiles, operating at temperatures between 22-40°C, characteristic area for mesophilic regime digestion;

• Thermophiles, operating at temperatures between 50 – 60°C, characteristic area for thermophilic regime digestion [8].

In experiment, two temperature conditions are maintained one is mesophilic at 37°C and another one is thermophilic at 55°C from the figure 1 is has found that the biogas production is more in thermophilic condition than mesophilic.

In the thermophilic range, high temperature causes higher rates of biochemical reactions and implicitly an increase in the yield in biogas production, higher solubility and lower viscosity [9].

The high energy consumption of the thermophilic process is offset by the higher productivity of biogas. It was found that thermophilic methanogenic bacteria are much more sensitive to temperature fluctuations (+/- 10 C), requiring a longer period to adapt to the new temperature to achieve maximum productivity in biogas, while the bacteria mesophilic endure temperature fluctuations of +/- 30 C, without a significant influence of biogas production.

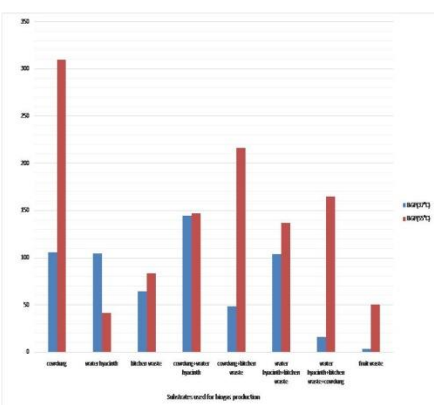

Fig. 2: Relationship between total solids (mg/l) and Biogas production at 37°C and 55°C

From the experiment conducted as shown in figure 2 it has been found that at 37°C percentage of total solid reduction is increased with increasing biogas production where has at 55°C percentage of total solid reduction is does not change with decrease or increase in biogas production.

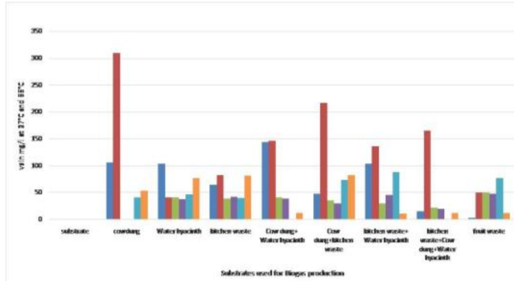

Fig. 3- Relation between volatile solids and biogas production

Volatile solids are residue from total solid determination is ignited to constant weight. The remaining solids represent the fixed total, dissolved, or suspended solids while the weight lost on ignition is the volatile solids. It is useful in the control of biological treatment plant operation because it offers a rough approximation of the amount of organic matter present in the solid fraction of wastes, figure 3 has shown that the volume of biogas production was decreased with increasing percentage of volatile solids.

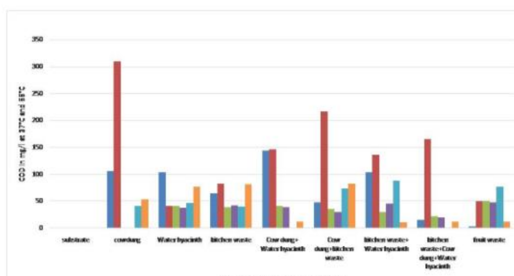

Fig. 4: Relationship between COD (mg/l) and Biogas production at 37°C and 55°C

Chemical oxygen demand (COD)is another important criteria under biogas production from figure 4 it has estimated that volume of biogas production is increasing with

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increasing COD. It is observed that the maximum yield of biogas is observed wherever there is cowdung used as a substrate at 55°C and combination with other substrates with cowdung

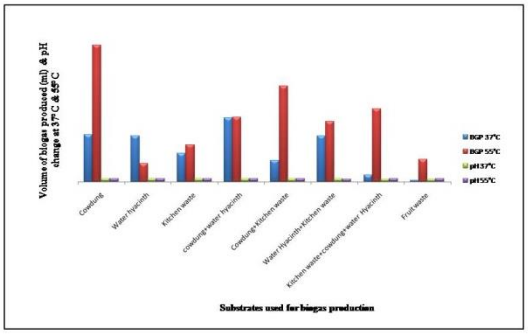

Fig. 5- Relation between pH and biogas production

In anaerobic digestion all life processes are carried out at well-defined values of pH. The pH of the optimal hydrolitic stage is between 5- 6 [10]. For methane production stage, the optimal pH value varies between 6.5 – 8 [11].If the pH value decreases below 6, methane production is strongly inhibited.

The temperature of the reaction medium influences the pH value. While the temperature is increasing, the carbon dioxide solubility decrease; this is why in the case of thermophilic digesters the pH value is higher than in the mesophilic ones where the carbon dioxide will dissolve easier and will produce carbonic acid in reaction with the water, increasing the acidity.

During the digestion process, the pH value may increase because of the ammonia presence resulted either by the protein degradation or by its presence in the charging flux; also it can decrease if VFA(Volatile Fatty Acids) will accumulate in the reaction medium. It is essential that the reaction medium provide sufficient buffering capacity to neutralize VFA accumulation [12].

All the digestors had maintained a neutral pH throughout the experiment. It was observed from the figure 5 that the digestors with pH 7 and substrate as cowdung with 55° C showed the maximum production of biogas. Hence every reactor had been maintained a neural pH by adding sodium chloride and sulfuric acid to facilitate the maximum biogas production.

CONCLUSION

For achieving successful anaerobic digestion several physical and chemical parameters must be considered. Such as temperature, percentage of total solid reduction, percentage of volatile solids, COD and pH. The most important physical factor is temperature. In anaerobic digestion there are generally two temperature ranges. Anaerobic sludge digestion can occur in the mesophilic rang (37°C), and in the thermophilic range (55°C),It is important that the temperature remains constant throughout the process because it may become a lagging factor for maximum biogas production. The temperature of the reaction medium influences the pH value. While the temperature is increasing, the carbon dioxide solubility decrease; this is why in the case of thermophilic digesters the pH value is higher than in the mesophilic ones where the carbon dioxide will dissolve easier and will produce carbonic acid in reaction with the water, increasing the acidity [12].

pH has to be monitored and maintained properly by adjusting pH by adding sodium chloride or sulfuric acid, for proper functioning of a digester. And also maximum biogas yield was obtained by the substrates such as cow dung and water hyacinth at both the temperature 37°C as well as 55°C because the slurry which was used has an inoculum was obtained from an active gobar gas plant.

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