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# Effect of Additives Biogas Generation Using Anaerobic digestion

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## Abstract

*As the conventional sources of energy dying out sharply, the trends to find out alternative as well as ecofriendly sources of energy getting much more importance. Among the renewable energy sources, biogas is the distinct one that is produced from different wastes and at the same time generates energy with divergent applications. In this study, cow dung is used to produce biogas through anaerobic digestion considering their relative low cost, easy availability and heating values. In order to enhance the biogas generation rate, an inorganic additive, namely ($Cu (NO_3)_2$) is used. Later on, a comprehensive study has been carried out in terms of chemical composition of the generated biogas, which demonstrates that the use of additive increasing the degradation rate of the charge and increasing the biogas generation.*

Keywords: Biogas, Anaerobic Digestion, Additive

### 1. Introduction

With the rapid advancement of industrialization and modernization, the demand of the fossil fuels hikes up in a significant manner. The deficiency of the conventional fuel resources insists the scientists and researchers at different corners of the world to find out sustainable and clean energy sources.to meet up this demand. In this very sense, renewable energy sources are an important branch of energy consortium with respect to the present energy crisis and financial realities. Renewable sources of energy mainly comprised of the solar energy, wind energy, different thermal and hydro energy, and biomasses. Almost 70% of total populations in Bangladesh rely on biomass energy directly or in- directly for cooking as well as heating [1]. At present, about 47% of the total population has access to electricity and only 6% have access to natural gas through the national pipeline grid [2]; moreover, these services remain largely unreliable. From the very beginning the rural community of Bangladesh largely depends on the naturally derived wood, animal excreta, agricultural waste fuel which accounts for 62% of energy consumption [3]. Every year about 44 million tons of fuel wood has been used for cooking and heating purposes throughout the country whereas the average efficiency for a traditional cooking stoves has been found about 5-15% [4]. However, this uneconomical burning of these biomass not only causes gradual running down of the forest resources but also causes serious environmental pollution due to the emission of unburned hydrocarbons and the traces of $NO_x$, $CO_x$, $SO_x$ etc. [5].

In this very way, upgradation of the existing biomass resources (i.e., animal manure, crop residues, kitchen waste and green wastes) to biogas shows a promising steps towards overcoming the energy crisis. Biogas is an alternative and renewable energy source produced through the anaerobic (oxygen free) digestion of organic matter whereby the organic matter is converted into a combustible biogas rich in methane.

In Bangladesh, biogas is mainly produced from cattle dung and poultry excreta along with a minimal focus on Municipal Solid Waste (MSW) and water hyacinth. It has been estimated that almost 41,830$m^3$ per day of biogas can be produced from organic municipal solid waste available only in Dhaka alike to 83.66MW of electricity which is approximately 3.8% of the city's daily demand [6]. The main advantage in using anaerobic digestion is the biogas production, which can be used for steam heating; cooking and generation of electricity. On the other hand, anaerobic digestion of cow dung, poultry waste and water hyacinth in batch type fixed dome biogas plant produced be obtained from the livestock residues of the country, equivalent to 1.5 million tons of kerosene fuel (which is currently used as the principal fuel for lighting in rural areas) [7].

In this study, the authors would like to focus on the biogas generation from the cow dung using additives. Usually additives are classified into organic and inorganic additives. One is inorganic additive and other one is organic additives. Inorganic additives include iron salts, magnesium and calcium salts, commercial charcoal Darco G-60, Nickel ions, Eosin blue etc. The organic additives include Powdered leaves of some plants such as gulmohar, leucacenaleucocephala, acacia auriculiformis, dalbergiasisoo and eucalyptus tereticonius, plant waste like rice straw, corn stalks, cotton stalks and wheat straw etc.
The proceeding sections deals with the materials and methods for the generation of biogas from cow dung with without using additives at section two. The effect of additives on biogas generation and a mere comparison of chemical composition

of the biogas generation with and without using additives has been discussed in the result and discussion chapter at section three. The conclusion presents at section four.

## 2. Materials and Methods

### 2.1 System component

A physical structure designed to carry out anaerobic digestion of organic materials is called "Biogas plant". Figure 1 shows the components of biogas plants.

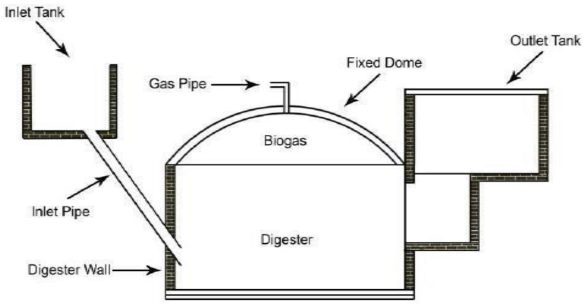



*Figure 1: Components of biogas plant*

### 2.2 Feed stocks

Substrates for feed stock should contain organic materials that should be free from toxic compounds and inorganic materials. Methane biogas production is proportional to microbial activity where the organic substrate converts into biogas. Co-digestion means adding two or more organic matters which gives higher rate of biogas production compared to single. In this work cow dung and kitchen waste is used as feed stocks.

### 2.3 Methodology

Anaerobic digestion mainly comprises of hydrolysis, acidogenesis, acetogenesis and methanogenesis phase as shown in Figure 2. In spite of longer processing time, it is considered as a feasible technology for renewable energy production. The AD process consists of the four steps, the first step being hydrolysis occurs at the beginning of the process where extracellular enzymes, decompose complex organic polymers to simple soluble monomers. Proteins, lipids, and carbohydrates are hydrolyzed to amino acids, long-chain fatty acids, and sugars, respectively. Further fermentative bacteria (acidogens) converts these small molecules to a mixture of volatile fatty acids (VFAs) and other minor products such as alcohol. Then, Acetogenic bacteria further convert the VFAs to acetate, carbon dioxide, and or hydrogen, using these direct substrates where produced Acetogenisis state produced methane by Methanogenic bacteria, the last step of the AD process [38].

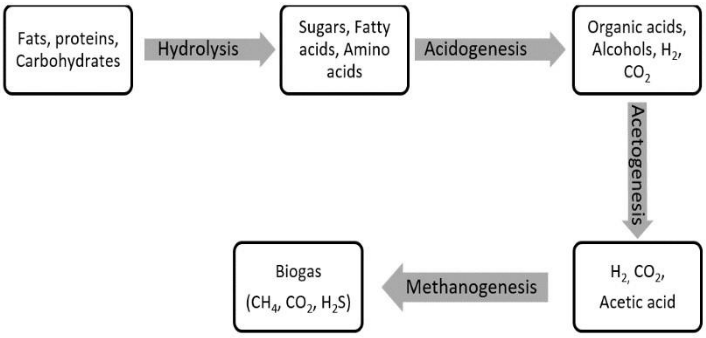



*Figure 2: Sequence of biodegradation processes in anaerobic digestion*

### 2.4 Working principle

At first cow dung was collected from the local area of Rajshahi. Then pretreatment was done to the feed material. Pretreatment refers to the separation of plastics, metals, papers etc. from the collected feed material. Then the cow dung was mixed with water in the mixing tank. After that the mixture was poured into the digestion tank and settled down to take place anaerobic digestion. As the digestion process continued, sludge was formed at the end which in turn can be used as fertilizer. During the charging step, about 2000kg cow dung mixed with water at a ratio of 1:1 and feed to the digester. Then the mixture was allowed to digest in the digester for seven days. And when biogas production was started, cow dung was feed in daily basis after 15 days of charging. About 30 kg of cow dung was mixed with water and feed daily. To observe the effect of additives on the biogas generation and chemical composition, additive was added with the daily feed after 25 days of charging. Cow dung was mixed with water and 1gm/kg $Cu(NO_3)_2$ was poured into the mixing tank and then mixed thoroughly. The mixing of additives with the daily feed has a significant effect on the biogas generation and its chemical properties.

## 3. Present Energy Scenario and Potential of Bio-resources

### 3.1 Energy Scenario of Bangladesh

Bangladesh is situated in the north-eastern part of south Asia with a population of 159.9 million in 2016 [8]. The future development of Bangladesh is likely to result in a rapid growth in the demand for energy with accompanying shortages and problems. The country has been facing a severe power crisis for about a decade due to large population growth [9]. Figure 3 shows year wise population in Bangladesh. At present, 56% of total electricity generation of Bangladesh is from the power plants under public sector and 44% of the net-generation of the country is from private sector [10].
Even though many extra units both from public and private sector have been added to the national grid, power crisis

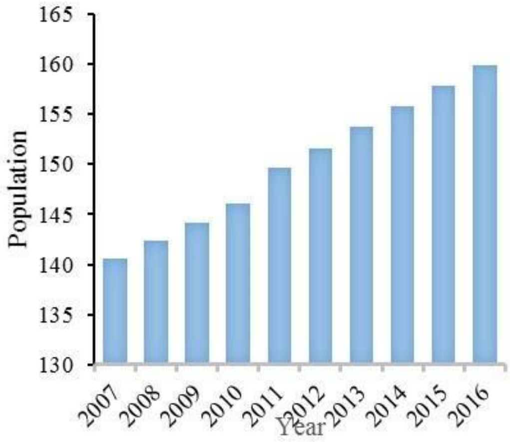



Figure 3: Population in million

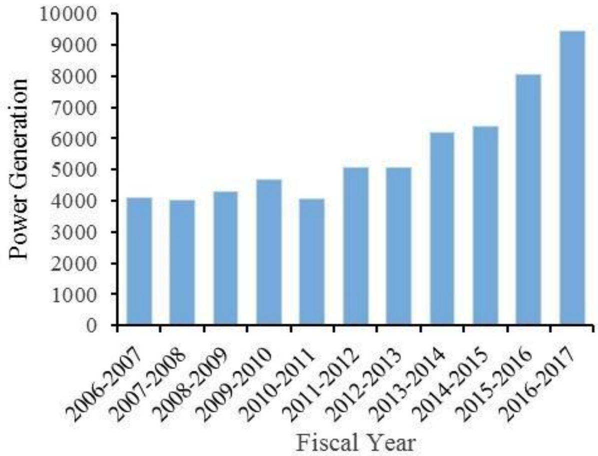



Figure 4: Maximum power generation in MW

is still a big issue in our country. Figure 4 shows the maximum generation of electricity from the year 2006 to 2017. So, due to high demand, maximum generation could not remove power crisis in the country. In public sector, most of the power stations of the country have become very old and they are operating lower than their rated capacity with derated machineries. According to Bangladesh Power Development Board, maximum demand of power in fiscal year 2016-2017 was 14126MW against the installed capacity of 13, 261 MW which is lower than the maximum generation. The demand of electricity cannot be met due to insufficient production of electricity around the country and as most of our power stations depend primarily on natural gas as fuel, because of shortage of gas supply some power plants are unable to produce power of their rated generation capacity. Biogas can come in handy in case of power generation.

### 3.2 Potential of bio-resources

Bangladesh has enormous potential of renewable energy. Animal dung from cattle, buffalo, goat, sheep, horse and chicken is the most widely utilized feed stock for biogas production in Bangladesh. Total livestock production in Bangladesh has grown at 3.7 percent annually from 2000–2015 [7]. It is calculated that more than five billion m3/year of biogas could be achieved from the livestock wastes of the country.

**Table 1:** Annual yields of agricultural crops and biogas potential in Bangladesh in 2013 [11]–[15]

| Crops | Production rate kton/year | Biogas production potential, $m^3$/kg dry matter | Total biogas production potential ($10^6$ $m^3$/yr) |
|---|---|---|---|
| Rice | 51500 | 0.50-0.62 | 8994 |
| Wheat | 1255 | 0.65-0.75 | 89.64 |
| Vegetables | 13221 | 0.3-0.9 | 115 |
| Sugarcane | 7300 | 0.4-0.7 | 127 |
| Jute | 1657 | 0.3-0.4 | 750 |
| Pulse | 767 | 0.4-0.5 | 5.7 |
| Cotton | 473 | 0.3-0.35 | 46.8 |
| Maize | 2042 | 0.4-1.0 | 381.2 |
| Groundnut | 126 | 0.4 | 239.6 |

Table 1 summaries the potential local feed stocks for digesters in Bangladesh on the basis of number of livestock. The total biogas production potential was calculated using average values for specific biogas production by animal type (Table 2) [16].

**Table 2:** Major livestock and biogas production potential in Bangladesh in 2014-2015

| Animals | Heads in million | Biogas production rate in $m^3$/kg dry matter | Total biogas ($10^6$ potential $m^3$/year) |
|---|---|---|---|
| Cattle | 23.64 | 0.30-0.33 | 4510 |
| Buffalo | 1.46 | 0.31-0.33 | 0.87 |
| Goat | 25.60 | 0.32-0.34 | 4.51 |
| Sheep | 3.27 | 0.4-0.42 | 0.32 |
| Poultry | 261.77 | 0.31-0.32 | 0.92 |

### 4. Result and discussion

In this study biogas production was started from the 4th day after charging the digester. The amount was very small at the

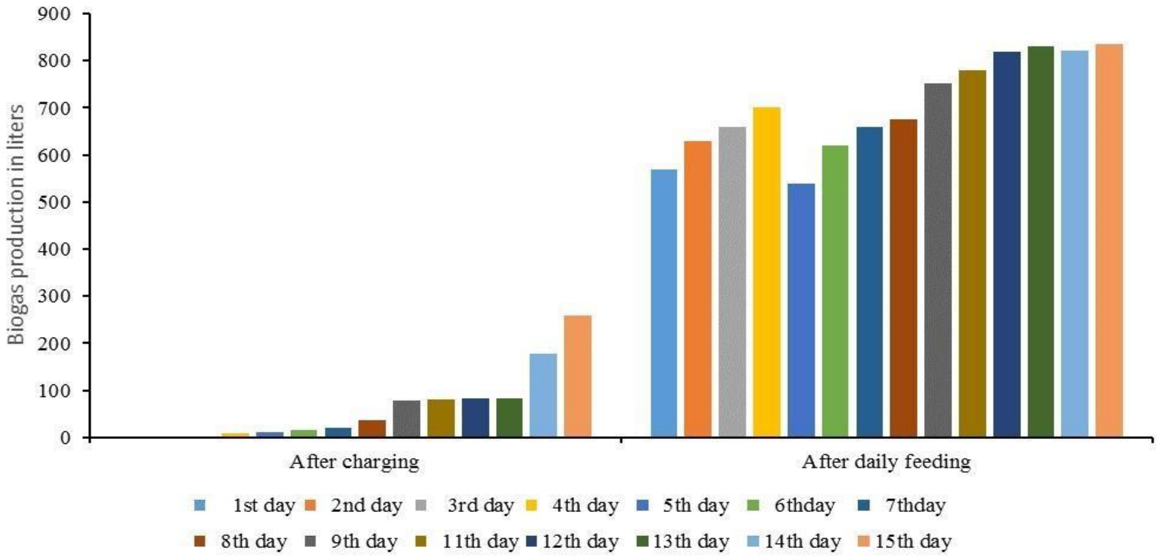
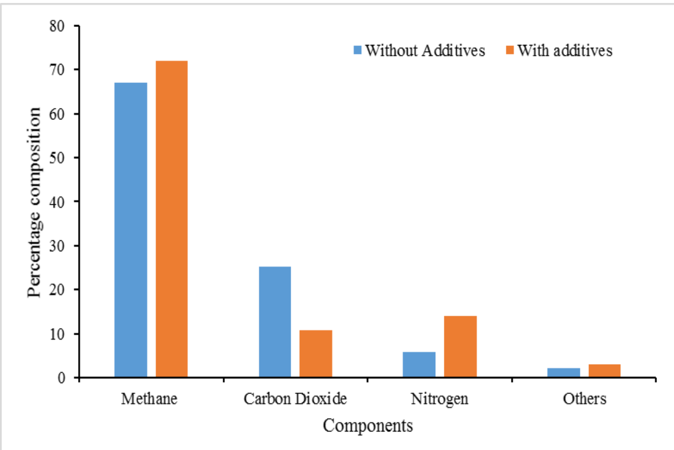



*Figure 5: Data for biogas production in liters*

beginning but the amount increased significantly after 13th day. In this experiment, biogas generation started earlier due to the fact that cow dung was collected from the local household. As the data was taken in the rainy season the cow dung came into contact with the rain water which initiate the hydrolysis phase of anaerobic digestion. For this reason, biogas generation started earlier than expected. As soon as the biogas production started at a very handsome amount the daily feeding was started. A total of 20 day's data is shown in the Figure.




From the Figure 5 it is seen that biogas generation is increased after daily feeding of cow dung. At the 5th day of daily feeding biogas production was decreased. But after that biogas production is increased again. Then sample was collected periodically and their percent composition analyzed by gas chromatography. The comparison between their percentage compositions has been shown in the following Figure 6.

From the Figure 6 it is evident that after adding additives in the digester the percentage of methane is increased and the percentage of carbon dioxide is decreased significantly.

*Figure 6: Percentage composition of biogas using additives and without using additives*

The amount of methane in biogas, without using additives, was found 67.04% and after adding additives it was increased to 72.06% which indicates a marked a change in the heating value with an increase in methane concentration. Whereas carbon dioxide ($CO_2$) is a colorless, heavy and odorless gas, its increasing concentration in biogas causes other components to decrease. Mainly methane concentration decreases, which in turn decreases the heating power of biogas. $CO_2$ emission is also harmful for environment. After adding additives into the digester the concentration of $CO_2$ is decreased significantly from 25.22% to 10.86% which is very remarkable as well as ecofriendly. Before introducing additives in the digester the amount of nitrogen was found 5.82 % and after adding the additives the concentration was found 14.45%. The amount of nitrogen gets increased due to the addition of cupric nitrate. Other components ($H_2$, $H_2S$, $O_2$ etc.) were found 2.04% in the sample before using additives and after adding additives they were 3.08%.

We know pH of the slurry have a significant effect on biogas production. In neutral pH microorganisms grow faster. It aids the methanogenic bacteria to increase methane yield. More VFA is produced during the first three stages of AD, and removed via the last step of $CH_4$ production [17]. VFA accumulation decreases the pH level. Decrease in pH level aid inhibition of anaerobic digestion. N contents in the substrate increase ammonia concentration which in turn reduces VFA accumulation. As a result, the value of pH increased towards the neutral pH level of a little bit higher [18].

According to the study by Calli et al., ammonia inhibition occurs when the pH value is over 7.4 [19]. In our study pH of the cow dung slurry was about 6.5 and VFA accumulation was initially higher. That's why adding N contents ($Cu(NO_3)_2$) increases ammonia concentration which in turn increases pH, slightly higher. Thus methane content is increased as well as biogas production.

**Table 3:** Effect of various Additives

| Additive | Amount | Increased biogas production |
|---|---|---|
| Urine | Urine : Cow dung : Water= 50:35:15 | 30% |
| Biochar | 5% | 5% |
| Charcoal Darco G-60 | | 17% |
| Nickel ions | 2.5-5 ppm | 54% |
| Eosin blue dye | 0.1 µM | 25-35% |
| 1% NaOH | Pant residues : 1% NaOH= 1:1 | 100% |
| Powdered leaves of some plans ( like Gulmohar) and legumes | | 18-40% |

Table 3 summarizes the effect of some additives on biogas production. Kumar et al. (1987) experimented on commercial charcoal Darco G-60 resulted in 17% and 34.7% increase in biogas generation in batch and semi continuous digesters, respectively. Nickel ions increase the methane production by 54%. Nickel was found to enhance the production up to 5 ppm [21]. Eosin blue dye at a concentration of 0.1 µM increased the biogas by 25-35% when mixed to manure slurry. Powdered leaves of some plants such as gulmohar, leucacenaleucocephala, acacia auriculiformis, dalbergiasisoo and eucalyptus tereticonius have found to improve biogas yield by 18-40% [20]. Plant residues treated with 1% NaOH for 7 days combined with slurry manure at a weight ratio of 1:1 showed a twice increase in biogas production. [22]. Plant waste like rice straw, corn stalks, cotton stalks and wheat straw when mixed with cattle manure increased gas production by 1080%.

## 5. Conclusion

In this study, biogas was generated from cow dung using additives and without additives. In both cases sample of biogas was analyzed through the gas chromatography and the composition of different constituents has been sort out. From the experimental results, it has been seen that addition of $Cu(NO_3)_2$ increases methane content from 67.04% to 72.06% and decreases the amount of carbon dioxide from 25.22% to 10.86%. As the heating value of the biogas solely depends on the amount of methane present in the biogas composition, thus the addition of $Cu(NO_3)_2$ has promising contribution towards generating methane enriched biogas as well as decreasing subsequent $CO_2$ production.

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