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CONVERSION OF COW DUNG TO BIOGAS AS RENEWABLE ENERGY THROUGH MESOPHILIC ANAEROBIC DIGESTION BY USING SILICA GEL AS CATALYST

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Abstract- *Conversion of solid waste is a great source of renewable energy. In this research, biogas was produced from cow dung (CD) without and with using silica gel as a catalyst, and compared between them and developed a mathematical correlation. Two laboratory-scale digesters consist of glass conical flask of 1-liter capacity each was constructed, where one set-up was without catalyst and the other was with catalyst. Cow dung was used 265 gm and water was used 435 gm in each experiment. In the slurry, for all the observations total solid content was maintained 8% (wt.). The digesters were operated at ambient temperatures of 27 – 31℃. The total gas yield was obtained about 1.105 L/kg of CD for digestion without catalyst and about 1.23 L/kg of CD for digestion with catalyst. The gas was collected about 14 days for both the digestions. Comparison between the gas yields and mathematical correlation were done.*

Keywords: Cow Dung, Biogas, Solid Waste, Mesophilic Anaerobic Digestion, Simulation

1. INTRODUCTION

Solid waste is one of the major factors to be concerned about that, converting these types of waste to a great source of renewable energy. As, in the current world, the discussion on solid wastes is becoming more distinctive when newer 'emerging' issues are brought up into the surface [1]. Nevertheless, earlier issues that have not been resolved include the problem of getting consistent and reliable data on solid waste, substandard systems and poor service level for storage, collection and disposal and poor accounting or budgeting systems for solids waste services [2]. Energy crisis and waste management are the major issues that the world is facing today. To overcome this problem, an efficient way of technology is needed. The organic fraction of solid waste is required to manage in such a way as to minimize the negative environmental impact, fewer hazards to human health and maintain ecological balance [3]. Conventional ways of processing and disposal of municipal solid waste are Landfill, Composting, Recycling and Recovery, Incineration, and anaerobic digestion process [4]. The landfill is the open dumping method for final disposal of solid waste. But it arises the problems of gases, bacteria, greenhouse effects, toxins, leachate, air pollution, and groundwater pollution. Composting is another method of solid waste disposal mainly due to the high percentage of organic material in the waste composition. Centralized composting plants are not functioning effectively due to high operating and maintenance cost and incomplete separation of materials [5]. Though recycling is generally carried out by the informal sector, faulty collection systems, low quality of scrap and recycling rate is low despite a high number of waste pickers working the process is not economically feasible. Due to the high capital, operation, and maintenance costs involved for the installation of incineration plants, incineration is not popular as a waste disposal system. Anaerobic digestion of solid waste is an effective technology that treats different types of organic waste [6]. It is a biological process that happens naturally in which anaerobic bacteria decompose organic matter in environments with little or no oxygen and produces biogas. Anaerobic digestion is in principle possible between 30^{o}C and approximately 70^{o}C. Differentiation is generally made between three temperature ranges: the psychrophilic temperature range lies below 20^{o}C, the mesophilic temperature range between 20^{o}C and 40^{o}C, and the thermophilic temperature range above 40^{o}C [7]. The main advantages of anaerobic digestion of solid waste are in terms of energy, cost, and ecological balance, which make this technology much better than another conversion process [8].

Concerns about sustainable development and environmentally sound policies have been growing considerably everywhere. Waste disposal problem is also one of the alarming problems in Bangladesh. To diminish this problem proper conversion of solid wastes into renewable energy through biogas technology is one of the most effective and sustainable solutions. Biogas originates from biogenic material and is a type of biofuel

[9]. Cow dung which is the undigested residue of plant matter passed through the animal's gut is one of the most suitable sources of producing biogas. The composition of biogas mainly depends on feed materials and biogas generally composes of 55-65% methane, 35-45% carbon dioxide, 0-3% nitrogen, 0-1% hydrogen, and 0-1% hydrogen sulfide [6]. Biogas technology has advantages which include the following: generation of storable energy sources, production of a stabilized residue that can be used as a fertilizer, an energy-efficient means of manufacturing nitrogen-containing fertilizer, a process having the potential for sterilization which can reduce public health hazards from fecal pathogens, and if applied to agricultural residues, a reduction in the transfer of fungal and plant pathogens from one year’s crop to the next [10].

2. METHODOLOGY

Anaerobic digestion procedure was selected for converting cow dung to biogas without and with silica gel as a catalyst. Two laboratory-scale digesters were constructed and applied for conversion of cow dung to biogas consists of equipment’s were: 1.0L conical flask, Gas jar, Water bath, Rubber cork, Gas pipe, Rod.

2.1 Source of Cow Dung and Slurry Preparation

Cow dung (CD) was collected from different areas in Khulna. The total solid content of cow dung was determined by heating cow dung at 115^{o}C in oven for 42 hours. And the total solid (TS) content was found to be 21.10%. Normally total solid content of fresh cow dung varies between 15 – 19%. For preparing the slurry 8% of total solid content was maintained by adding water. For each experiment 700 gm slurry was prepared from 265 gm of cow dung and 435 gm of water. For anaerobic digestion with silica gel 2.8 gm silica get was added into the slurry.

2.2 Experimental Set-up and Procedure

Four experimental setups of two different type were made to investigate the production of biogas from the anaerobic digestion of cow dung using silica gel as catalyst. Where one type setup was used with silica gel (WSG) as catalyst and the other type was used without silica gel (WOSG). The digesters made of glass conical flask of 1 liter capacity connected with gas collector and water bath. As methanogenic micro-organisms are very sensitive to temperature fluctuation the digesters were kept in a cool place. The gas jar was placed upon the water bath. Plastic pipes were used to connect the digesters and the gas jar.

Fig.1: Without catalyst setup A-1

Fig.2: Without catalyst setup A-2

Fig.3: With catalyst setup B-1

Fig.4: With catalyst setup B-2

Digestion was done at ambient temperature. During the investigation the volume of the produced gas was measured with the help of water displacement method. At the time of experiments, these were ensured that the digesters were fully gas tightened. Figure 1, 2, 3, and 4 show the experimental setup of A-1 (without catalyst), A-2(without catalyst), B-1 (with catalyst) and B-2 (with catalyst) respectively. Figure 5 represents the anaerobic digestion process of cow dung.

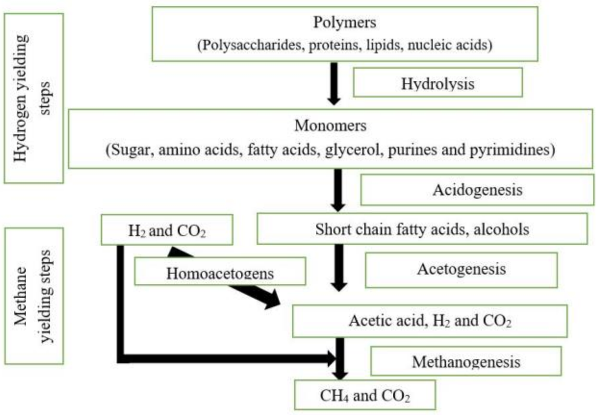

Fig.5: Anaerobic digestion process of biogas production

2.3 Total Solid Content of Cow Dung

Beaker + Cow dung (before oven dry) =83.72 gm
Beaker + Cow dung (after oven dry) =57.40 gm
Beaker wt.=50.36 gm
Cow dung (before oven dry) =83.72-50.36=33.36 gm
Cow dung (after oven dry) =57.40-50.36=7.04gm
Total solid content= (7.04/33.36)*100% = 21.10%

2.4 Regression Analysis

After obtaining all the experimental results, they were plotted in the excel sheet and produced Total gas yield vs Time graph for all the setups. And from that graphs, regression equations were developed. And using those regression equations, any future data of the setups maintaining the same ratio can be predicted.

3. RESULTS AND DISCUSSIONS

3.1 Total Solid Content Result of Cow Dung

Total solid content of the collected sample was 21.10%. So, Cow dung will be used 265 gm, water 435gm of total wt. 700gm.

3.2 Biogas Generation From Without Catalyst Setup

Setup A-1 gas produced 293 ml and Setup 2 gas produced 285 ml. Data were taken for collected gas at room temperature for the digestion set-ups between 28/11/2018 and 12/12/2018. Figure 6 shows the total gas yields for anaerobic digestions of cow dung without silica gel catalyst for A-1 setup. The regression equation is $y = 1.8585x^2 - 4.4074x + 5.8132$ and $R^2=0.9907$.

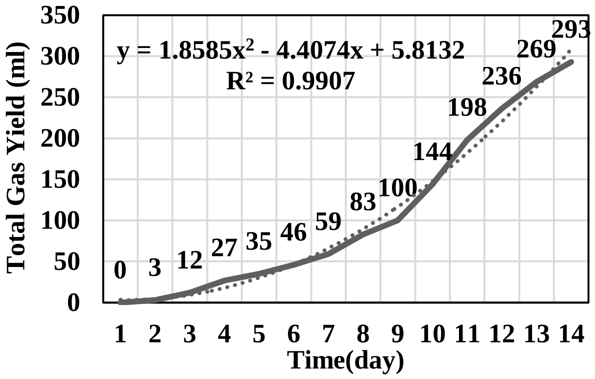

Fig. 6: Time (day) vs Total gas yield (mL) of setup A-1 of without catalyst

Figure 7 shows the total gas yields for anaerobic digestions of cow dung without silica gel (WOSG) catalyst for A-2 set up. The regression equation is $y = 2.4301x^2 - 1.4063x + 16.927$ and $R^2=0.9923$.

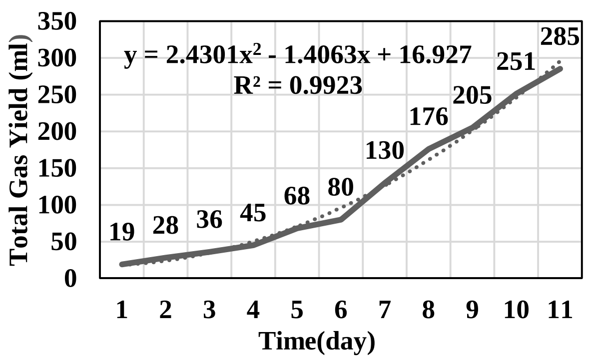

Fig. 7: Time (day) vs Total gas yield (mL) of setup A-2 of without catalyst

3.3 Biogas Generation From With Catalyst Setup

Gas production of Setup B-1 and B-2 were 325 ml and 318 ml respectively. Data were taken for collected gas at room temperature for the digestion set-ups between 20/12/2018 and 03/01/2019. Figure 8 shows the total gas yields for anaerobic digestions of cow dung with silica gel catalyst for B-1 setup. The regression equation is $y = 0.66x^2 + 19.102x - 41.83$ and $R^2=0.9763$.

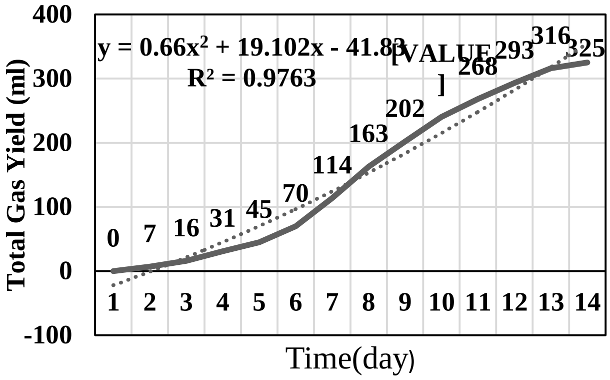

Fig. 8: Time (day) vs Total gas yield (mL) of setup B-1 of with catalyst.

Figure 9 shows the total gas yields for anaerobic digestions of cow dung with silica gel catalyst for B-2 setup. The regression equation for B-2 setup is $y = 0.7308x^2 + 17.551x - 41.681$ and $R^2=0.9744$.

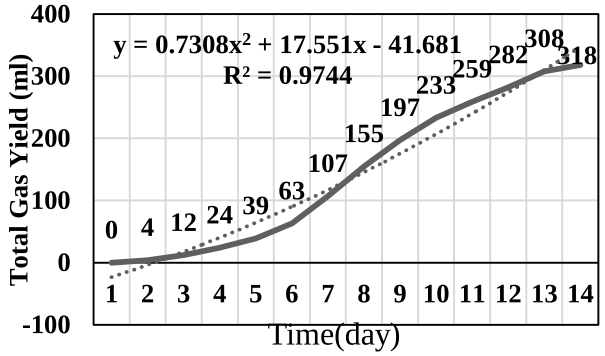

Fig. 9: Time (day) vs Total gas yield (mL) of setup B-2 of with catalyst.

All the curves are upward curvilinear shape. Graph for setup A-1 and A-2 are similar and for setup B-1 and B-2 are similar. Biogas was collected the gas collector for 14 days. Biogas collection in the gas collector was in a cumulative manner so that the direction of the graph is upward. The gas collection was not uniform so that the graphs are in an irregular shape.

Table 1: Combined data table of experimental results.

Set-up type	Setup no.	Volume of produced gas (mL)	Gas generation rate (L/kg)
Without catalyst	A-1	293	1.105
Without catalyst	A-2	285	1.07
With catalyst	B-1	325	1.23
With catalyst	B-2	318	1.20

3.4 Comparison Between The Data's Obtained From Without Catalyst And With Catalyst Setup

Comparison between the rates of biogas generation from the two different setups of without catalyst and with catalyst is shown in figure 10. Among all the set-ups, the rate of gas generation and the yields of gas of B-1 setup is highest.

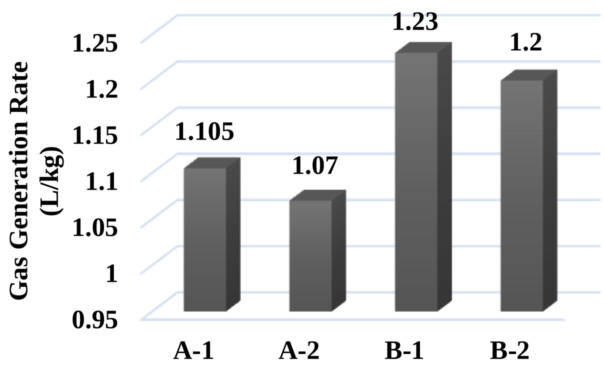

Fig. 10: Comparisons of data's obtained from the four set up of two different type.

4. CONCLUSIONS

The total solid content of cow dung was measured and it was converted into 8% total solid content. After gaining the required total solid content, the setups were made, and silica gel was also used as a catalyst. And all the four set-ups produced biogas mixture of methane, carbon dioxide, and others. The comparison is made after obtaining all the volumes of the produced biogas. From the two setups of without catalyst setups, 293 mL and 285 mL gas were produced. The rate of gas generation was found for the two setups were 1.105 L/kg and 1.07 L/kg. And from the other two setups of with catalyst setups, 325 mL and 318 mL gas were produced. The rate of gas generation was found for the two setups were 1.23L/kg and 1.2L/kg. After investigating all the obtained results, it was found that 12.07% extra gas has been produced for using silica gel as a catalyst.

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