The Use of Solid Fuel for Biogas Production in a Biodigester

G.A Soliu 1*, C. Onunka2

1 Mechanical Engineering Department, University of KwaZulu-Natal, Durban, South Africa.
2 Department of Mechanical Engineering, Mangosuthu University of Technology, Durban, South Africa
*Corresponding Author: ganiatsoliu@gmail.com

Abstract-
Biogas production technology is a technology with great potential and has the potential to influence the type of energy mix available within a given community. Biogas was produced by the microbial digestion of organic matter in the absence of air in a biodigester. Cow dung was used as the solid fuel necessary for biogas production. Approximately 40kg of cow dung was collected for the purpose of this study. The cow dung collected were sun dried and crushed manually to ensure homogeneity before mixing with water to produce biogas by anaerobic decomposition. Cow dung and water were mixed in the ratio 2:1. The mixture was homogenized with manual stirrer. A digester of 400 liters’ capacity was designed and the inner part of the digester was covered with nylon to ensure proper cow dung fermentation. A plastic pipe situated at the top was connected to the digester to serve as gas outlet of the digester and the other end of the plastic pipe was connected to an inflatable tube for gas storage. The digester was stirred three times a day to avoid scum formation in the digester. There was less biogas produced at the initial days. The minimal production of biogas at the initial three days was mainly due to the slow microbial growth. There was a substantial increase in biogas production from the 9th day. The increase in biogas production was due to the exponential growth of microbial activity in the digester. Sudden decreases in biogas production was due to unregulated pH in the digester. The unregulated pH in the digester increased the concentration of ammonia nitrate. Ammonia nitrate can inhibit the process of biogas production.

Key words: Cow dung, Biodigester, Biogas, Solid fuel

1. Introduction
Due to the increase in the price of fossil fuels and taxes on energy sources, finding an alternative clean and economical source of energy has become a major concern for households and small to medium businesses. In addition to the acquisition of economic assets, good quality of life is needed in developing economies. In most developing countries, energy consumption is a great determinant and indicator of economic development [1] [2]. Biogas is a renewable source of energy which can be used as an alternative for liquifed natural gas or liquefied petroleum gas [3]. Biogas is a clean, efficient and a renewable source of energy that can be used as an alternative to other fuel sources especially in rural communities [4]. Biogas is a colorless gas. Biogas produces blue flame and can be suitable for cooking, heating of ovens or crucible and lighting. It has a heating value of 22mJ/m³. Biogas is an odorless gas which can be obtained from various feedstocks such as piggery, cattle dung, poultry waste and cabbage from kitchen wastes.
Typically, a kilogram of cattle dung yields about 0.09m³ of biogas per day. Biogas has been used for cooking and heating in various countries like India, China and Nepal [5] [6]. Biogas technology materials is available wherever there is waste. However, the technology adoption rate is low despite its numerous advantages. As a cheap source of energy whose material is common, biogas is suitable for rural, urban and industrial application and as a substitute for other source of energy like charcoal, firewood, kerosene and etc. [7] [8]. The factors influencing the use of biogas as a combustible gas are the biogas to air mixing rate, flame speed, ignition temperature and biogas pressure. Biogas requires less air per cubic meter for combustion in comparison to liquefied petroleum gas or liquefied natural gas [9]. There are quite a good number of biogas plants that have been built around the world in order to propagate the use of renewable energy. The use of renewable energy creates the platform for solving environment pollution problems caused by organic wastes and to generate degradable fertilizer.

Biogas digester can be constructed using various materials from steel, rubber, zinc, plastics, mild steel, aluminum or concrete. The body of biogas digester can be fabricated through casting process [10]. Traditionally, concrete has been widely used to build a biogas digester. Concrete is cast in order to build the wall of the digester. With recent advancements in material development, different materials can be used to fabricate a digester in order to make it more efficient and durable in the production of biogas [5]. Biogas digester is commonly used across the world because it generates methane gas which can be used in generating electricity and for heating living space. It can also be used to replace cooking gas [11]. For example, in India, the biogas digester is widely used at home to generate electricity and use as cooking gas [12].

According to [13], two arguments were proposed to effectively promote the use of biogas digester. The first argument emphasized on mutual benefits among individuals. In [13], it was proposed that all the benefits from biogas technology must be enjoyed equally and at the same time. The second argument was on the awareness on how biogas can be generated. The awareness should be amplified among the government and various stakeholders which will benefit the community. Government should encourage and stimulate the use of biogas which can slow down deforestation from the use of firewood. Biogas can supply energy which serves as a cooking fuel. This ability to supply energy replaces various cooking fuels, which can be generally used in rural households in most developing countries. The increasing scarcity of fossil fuel has led to a growing effort to store fossil fuels and increase their value through hoarding. However, local fuel supply is extremely complex. Access to biogas as a fuel substitute for some social groups does not necessarily alleviate but can even create technological challenges which the social groups may be lacking.

Organic matter such as cow dung can serve as solid fuel in a biodigester. In this study, cow dung was used as the solid fuel in the production of biogas. The objective of the study was to produce biogas from cow dung.

2. Methodology
The research was carried out in four parts consisting of sample collection, design and fabrication of biodigester tank, experimental procedure and characterization.
2.1 Materials
The materials used in the design of the bio digester include:

- 40kg Cow dung,
- Mild steel plate of 2 mm thickness is used for the digester tank.
- 1 length of angle bar is used as digester stand.
- 7mm diameter of galvanize pipe was used as slurry outlet for the digester
- On cylinder was used as gas holder
- 5yards of rubber hose is used to connect gas from digester tank to the gas collector
- Stirrer connected to a motor was used as stirring mechanism
- Nylon is used for lining to avoid leakage
- Valves were used as a switch for slurry outlet and gas burner.

2.2 Sample collection
Cow dung was obtained from the cattle ranch. Approximately 40kg of cow dung was collected for the purpose of this project. The cow dung collected were sun dried and crushed manually to ensure homogeneity before mixing with water to produce biogas by anaerobic decomposition.

2.3 Design of the biodigester tank
The components of biogas plant include: digester tank, an inlet for feeding cow dung, an outlet for the digester slurry and the gas delivery system for taking out and utilizing the produced gas. Figure 1 shows the design set for the biogas production.

![Figure 1: Biogas production setup](image)

2.4 Fabrication process
The digester was fabricated using the following process

- Cutting of mild steel metal according to design fabrication
- Cutting of angle bar into dimension required
- Rolling of sheet metal into shape
- Welding of sheet metal
- Making indentation of the substrate inlet cover
- Drilling holes for inlet and outlet port
- Painting of the digester.
2.5 Characterization of the waste
The total volume of digester used for the experiment was 400 liters. The total wastes used comprised of cow dung and water mixed in the ratio of 1:2. This is an indication that total waste of 40kg was used along with 80kg of water making the overall substrate quantity in the digester 120kg which represent 66.8% of the digester volume.

3. Results and discussion
The cow dung was digested anaerobically using the composition as indicated in table 1. The 30-day biogas production is shown in figure 2.

| Specification                        | Value |
|--------------------------------------|-------|
| Mass of cow dung used (kg)           | 40    |
| Mass water used (kg)                 | 80    |
| Average pH                           | 7.12  |
| Mass of slurry (kg)                  | 120   |
| Average ambient temperature(°C)      | 33    |

The production of biogas was slow at the initial stage. The slow rate in biogas production was due lack of adequate bacterial growth in the digester at the initial stage. There was substantial production of biogas from day 9 to the 30th day of the study. The increase in the biogas production rate was due to healthy microbial community within the biodigester. The cow dung produced a maximum of 79ml volume of biogas on day 30. There was a decrease in the production of biogas after the 30th day. The decrease in the volume of biogas produced was due the presence of ammonia nitrate in the slurry. Ammonia nitrate creates an imbalance between the microbial load and the cow dung. The efficiency the biodigester is reduced due to inadequate microbial activity and the presence of ammonia nitrate.

4. Conclusion
A biogas digester that is air – proof was constructed in order to ensure the breaking down of cow dung by bacteria anaerobically. Biogas can be produced by using cow dung as solid fuel in a biodigester. The performance of the biodigester was dependent on the balance between the
moisture content, microbial load and the quantity of cow dung in the digester. Biogas production technology can be used to assist rural communities in providing energy for cooking and heating. The retention period for the production of biogas in this study was six weeks starting from the microbial digestion of the cow dung in an anaerobic condition to the production of biogas in the digester.

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