Biogas can be a solution to South Africa energy needs especially to rural areas of Eastern Cape Province that have plenty of biogas substrates from cattle, donkeys, goats, sheep and chicken. The effectiveness of cow dung for biogas production was investigated using a field batch biogas digester. The cow dung was collected from University of Fort Hare Dairy farm and was analyzed for total solids, volatile solids, total alkalinity, calorific value, total alkalinity, pH, Chemical Oxygen Demand and Ammonium Nitrogen. The biogas composition was analysed using a Gas Analyzer. In the experiment, it was observed that the biogas production from the cow dung increased exponentially with time and ceased after certain days of degradation. The alkalinity values were within the normal range, above the threshold alkalinity of 500 mg/L for anaerobic digestion and stable ammonium-nitrogen levels in cow dung improved anaerobic digestion process. The study revealed that cow dung produced biogas yield with an average methane yield of 50%. In addition, the study revealed further that cow dung as an animal waste has great potentials for generation of biogas and its use should be encouraged due to its early retention time and high volume of biogas yields.

**Keywords:** Anaerobic digestion, Digester, Cow dung, Biogas, Methane yield

# INTRODUCTION

South Africa has a warm climate and in most locations ambient temperature is sufficient to maintain the biogas fermentation process and no artificial heating is required in biogas digesters and the biogas installations are generally based on psychrophilic and mesophilic anaerobic digestion process. The Anaerobic Digestion (AD) of organic raw materials converts organic matter into biogas and digestate (Tani et al., 2006; Zhang et al., 2007). Biogas generally consists of a mixture of methane, carbon dioxide, nitrogen, oxygen, hydrogen sulphide and traces of other gases (Ward et al., 2008).

The following are some of the factors affecting the biogas fermentation process of organic substances under anaerobic conditions; the quantity and nature of organic matter, the

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temperature, acidity and alkalinity of substrate and the flow and dilution of material.

The use of biogas from biomass for energy production is considered to be one of the most promising alternative, sustainable and renewable energy sources (Cherubini and Strømman, 2011). The anaerobic digestion process consists of a series of metabolic reactions that include hydrolysis, acidogenesis, acetogenesis and methanogenesis performed by a wide range of microorganisms and producing a biogas containing mainly methane and a digested substratum (digestate), that can be used as organic fertiliser or raw material for biofertilisers (Themelis and Ulloa, 2007). Unlike fossil fuels, biogas from AD is permanently renewable, as it is produced from biomass, which is a living form of storage of solar energy through photosynthesis (Al Seadi et al., 2008).

Biogas has proved to be one of the reliable sources of energy because it is cheap and reduces greenhouse gas emissions. In addition, it reduces the smell of manure by turning its volatile organic compounds into odourless methane and carbon dioxide. Biogas is one of the most untapped sources of natural and sustainable energy available. Although biogas is used all over the world, however this technology in South Africa is still premature.

Biogas technology has the following advantages (Brown, 1987, Silayo, 1992 and Lekule, 1996); It provides an alternative source of energy thus reducing the rate of deforestation, relatively cheap source of energy, improves crop-livestock-tree system through nutrient cycling, reduces time and workload of collecting fuel wood, reduces kitchen smoke-pollution thereby promoting human health, promotes good health through safe treatment of manures, as a renewable source of energy, it provides a reliable power supply that is environmentally friendly and is a rich source of nitrogen, phosphorus (P), potassium (K) and other macro- and micronutrients.

The biogas digesters available in South Africa are of three main types namely; Balloon (tube) digester, Floating drum digester and Fixed dome digester. In this research a cylindrical biogas digester was designed, constructed and fed with cow dung and monitored to see its performance characteristics.

**MATERIALS AND METHODS**

**Source of Substrate**

Fresh cow dung was collected from University of Fort Hare Dairy farm. Prior to loading the cow dung into the batch biogas digester, stones, leaves, sticks, waste feed and other foreign substances were picked from the cow dung waste. Furthermore, water was added to the substrates, Total Solids (TS) of for the prepared sample was determined to find out the amount of water to be added to the substrates before feeding into the batch digester. The most favourable TS value desired for better biogas production is 8% (Ituen et al., 2007).

Figure 1 shows the designed and constructed...
biogas digester that was fed with fresh dung after it was insulated with sawdust. In addition, Figure 2 shows the plastered second wall of the batch biogas digester that was constructed to keep sawdust, an insulating material for the batch biogas digester.

Substrate Parameters

The following parameters for the substrates were determined, pH, Total Solids (TS), Volatile Solids (VS), ammonia-nitrogen (NH₄-N), Total Alkalinity (TA), temperature (T) and Caloric Value (CV). All the analytical determinations were performed according to the standard methods for examination of water and waste water (ALPHA, 2005). The temperature of slurry was measured by type-K thermocouple, while the digital pH meter measured the influent and effluent pH.

Biogas Analysis

The biogas composition was analysed by the biogas analyser. The biogas analyser consisted of Non-Dispersive Infrared sensor for sensing methane and carbon dioxide and Palladium/Nickel sensor for sensing hydrogen and hydrogen sulphide. Figure 3 shows the biogas data acquisition system that includes a biogas analyser.

RESULTS AND DISCUSSION

The daily biogas yield of cow dung when the digester was insulated is shown in Figure 4. It was observed that the biogas production from the cow dung increased exponentially with time and ceased after a retention time of 31 days.

Biogas Data...

Figure 4: Biogas yield for cow dung

The experiment was carried out under a biogas temperature range of 29 to 32°C and for a retention period of 31 days. From Figure 4 it was observed that the biogas production started to increase from day 11 and kept increasing until reaching the peak value of 0.5 m³ on day 19 and then declined to 0.03 m³ on day 25. The results...
obtained were indicative of strong microbial activities in the biogas digester. From day 11 to day 18 the gas yield \((Y)\) is approximated by the equation:

\[
Y = 0.052t - 0.462 \quad \text{for} \quad 11 \leq t \leq 18 \quad \ldots(1)
\]

While from day 19 to day 23, the gas yield is approximated by:

\[
Y = -0.165t + 3.121 \quad \text{for} \quad 19 \leq t \leq 23 \quad \ldots(2)
\]

The rapid biogas production between day 11 and 19 was attributed to readily biodegradable organic matter in the substrate and the presence of high content of the methanogens. The total volume of biogas produced was 2.55 m\(^3\). The total biogas yield of 70\% (1.71 m\(^3\)) was attained in the first 19 days before the biogas yield declined. However, the biogas yield from day 19 to day 31 was 30\% (0.54 m\(^3\)) of the total biogas production. It was observed that after day 23 of the experiment the biogas digester produced less than 0.03 m\(^3\) biogas. Figure 5 shows that pH range decreased with time attaining a minimum value of 7.1, on day 16 as cow dung was converted to fatty acids.

As from day 16 the pH started to increase gradually as the fatty acids were consumed by the methanogens. The optimum biogas yield of 0.48 m\(^3\) was achieved at pH 7.1 as shown in Figure 5. The best fit for the pH \((R)\) is approximated by the equation:

\[
R = 0.007t^2 - 0.2182t + 8.8047 \quad \ldots(3)
\]

Figure 6 shows a COD graph for the cow dung. The initial COD entering the digester was 38456 mg/L and decreased gradually to final value of 27543 mg/L. This gives a total COD destruction of 10913 mg/L.

The optimum biogas of 0.48 m\(^3\) (Figure 5) was produced at a COD of 30987 mg/L. The maximum biogas production was produced from day 14 to day 17 because COD removal efficiency was highest. The COD \((S)\) best fit can be approximated by the equation:

\[
S = 2.6026t^3 - 111.11t^2 + 746.51t + 37213 \quad \ldots(4)
\]

Table 1 shows the biogas yield for cow dung after the digester was insulated. The biogas produced had methane content of 50\% at an average temperature of 31°C.

From Table 1 it was observed that the biogas from cow dung had an average yield of 50\%. This suggests that the performance of the digester improved by using sawdust as an insulating material for the biogas digester. Figure 7 shows the relationship between biogas yield and NH\(_4\)-N.
for cow dung. The NH$_4$–N concentrations for cow dung are ranged from 920 mg/L to 1090 mg/L. The highest biogas yield of 0.48 m$^3$ was produced at NH$_4$–N concentrations of 925 mg/L. The inhibiting concentrations of NH$_4$–N are reported to be above 1500 mg/L (Calli et al., 2005, Chen et al., 2008, Fricke et al., 2007). Therefore, stable NH$_4$–N levels in cow dung improved anaerobic digestion process.

### CONCLUSION

These results on the production of biogas from cow dung showed cow dung is a suitable substrate for biogas. In addition, the study revealed further that cow dung as an animal waste has great potentials for generation of biogas and its use should be encouraged due to its early retention time and high volume of biogas yields. In the experiment, it was observed that the biogas production from the cow dung increased exponentially with time and ceased after certain days of degradation. Results indicated that average biogas yield for the cattle manure is 50% methane. Furthermore, the study has found that total alkalinity, ammonium-nitrogen, temperature variation, total solids concentration, chemical oxygen demand, pH and agitation are the factors that affect quality and quantity of methane.

### REFERENCES


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