Potential of Grass for Biomethane Production in Anaerobic Digestion using Bioprocess Control AMPTS II

Ireen Maile[1], Habtom Tesfagiorgis[2], and Edison Muzenda[1, 3]

***Abstract*—** In this study, grass was digested through anaerobic digestion using Bioprocess Control AMPTS II to determine the biomethane potential of grass. Cellulosic biomass is abundantly available to be used as feedstock for anaerobic digestion. The substrate was prepared and fed into the digester, and purged with nitrogen to create an anaerobic condition, which was connected to a scrubbing unit filled with 3M NaOH solution. The gas exiting the CO_2 fixing unit was sent to the flow cell where the volume of biomethane is determined. It was observed that 1L of gas within a period of 15 days can be obtained from a 500ml digester.

***Keywords*—** Biomethane, CO_2 fixing, flow cell, inoculum.

I. Introduction

There are two sources of energy, namely renewable and non-renewable energy. The latter refers to energy sources that cannot be replaced upon consumption. These are the energy sources that are currently at threat of depletion. These forms of energy mainly comprise of coal, oil and natural gas, otherwise generally referred to, in consolidation, as fossil fuels. Nuclear energy may be considered as a non-renewable form of energy. A renewable form of energy refers to energy derived from solar, water, wind, biomass and geothermal sources [1]. Oil and gas are the two main feed stocks for petrochemical plants. The end products of these processes are industrial materials such as plastics, dyes, polymers, insecticides, synthetic fertilizers and pharmaceuticals [2]. According to the Energy Information Administration (EIA), the world energy consumption in 2007 was 38% oil, 23% gas, 26% coal, 6% nuclear and 7% for other renewable resources. This indicates that fossil fuels provide over 85% of the world energy consumption [3]. This is a cause for concern as these resources are slowly depleting and causing serious negative impact to the environment and the earth at large.

Action upon the above mentioned issue has been taken by many countries. Renewable sources of energy have been and are being studied throughout the globe. This technology mainly includes sustainable resources such as biogas production by anaerobic digestion (AD). Although other renewable energy sources, such as wind, solar and water, have been tried; none of these seemed to have the potential to fully meet the high demand on a national grid scale [4]. Developing countries have abundant available cellulosic biomass, in the form of grass, which can be used as the feedstock for anaerobic digestion. Thus, has potential to cater for the energy needs [5].

Biomethane has become the most preferred alternative fuel to replace fossil derived fuels for vehicular use. The market price of upgraded biogas is nearly 20-30% lower than that of petrol. However, its use is limited since it requires vehicles to be dual-fuel which is expensive when compared to the conventional ones. In addition, benefits of reducing the tax exists when using dual-fuel cars compared to conventional passenger cars [6].

There are four major steps in the production of biogas namely: hydrolysis, acidogenesis, acetogenesis and methanogenesis. These are interdependent, complex chronological and corresponding biological reactions in which the products from one group of microorganisms serve as the substrates for the next, resulting in transformation of organic matter mainly to methane and carbon dioxide [7].

Temperature affects the chemical properties of the components in the substrates and the growth rate and metabolic activities of the micro-organisms in the digester. pH affects the production of biogas because each group of the micro-organisms have their specific pH range for optimal activities. Methanogenic bacteria have an optimum pH between 6.5 and 7.2 and are extremely sensitive to pH fluctuations [8]. The type of organic substrate used for anaerobic digestion has a direct impact on the biogas production rate and its composition. Particle sizes of the substrate also have a significant influence on the gas production rate [9, 10]. It is, therefore, necessary that the particle size of the substrate be not too large as it may result in the digester clogging and difficulty experienced by the microbes in breaking down the substrate [9].

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Grass is one of the feedstock used for biomethane production and a lot of research has been done on it. However, biomethane production from biogas using Bioprocess Control AMPTS II has not being fully exploited. The objective of this study was to evaluate the potential of grass for biomethane production using Bioprocess Control APMTS II.

II. Methods and Materials

Biomethane potential tests were carried out using bioprocess control AMPTS II. The machine has 3 sections (i) digester, (ii) CO_2 fixing unit, and (iii) gas collecting unit. Batch system was used for the investigation. Grass cuttings collected from the University of Johannesburg parks were used as substrate. A 500 mL digester, with effective volume of 400 mL, was used for biogas production which had head space of 150 mL. The study was run with a retention time of 15 days.

Sodium hydroxide, obtained from Sigma-Aldrich (South Africa), was used for CO_2 removal. A 3M NaOH solution was prepared to be used as the scrubbing solution to absorb the impurities. A pH indicator solution was added to determine the saturation point for the cleaning solution to be replaced. The substrate was prepared and fed into the digester, and purged with nitrogen to remove the oxygen and create an anaerobic condition. The digester was connected to a 100mL bottled (used as scrubber) filled with 80mL of the 3M NaOH solution. The gas exiting the CO_2 fixing unit was sent to the flow cell (gas collection) where the volume of biomethane is determined as shown in Fig. 1.

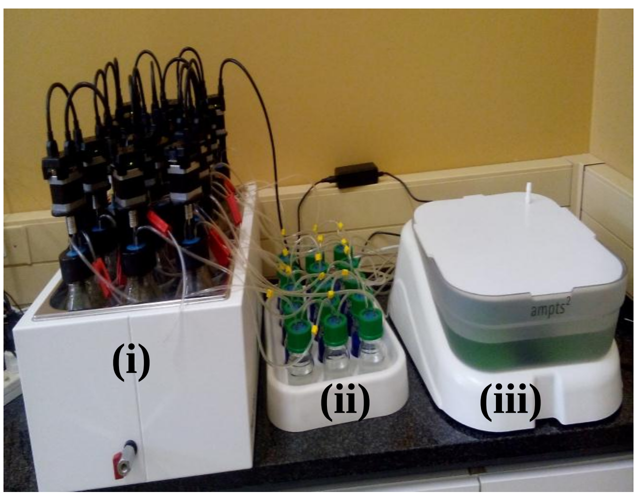

Fig. 1 Schematic diagram of for the bioprocess control AMPTS II setup.

III. Results and Discussions

A. *Biomethane potential from grass*

The results from the BMP machine showing the methane potential were collected and summarized below. Fig 2, shows the cumulative biomethane yield for a period of 15 days. It was observed that biomethane potential of grass is 1L of gas in a period of 15 days using a 500ml digester. It can be observed from the graph that the methane yield is increasing on a steady rate as represented with is a straight line. There was consistency in the yield from all the digesters which can be used to make a prediction based on the substrate used under the same conditions. From the graph, it was also observed that anaerobic digestion was still continuing as the substrate was not fully, degraded, albeit at a slower rate. Thus, hydraulic retention time needs to be studied and established in order to run the tests on full scale and complete degradation of substrate.

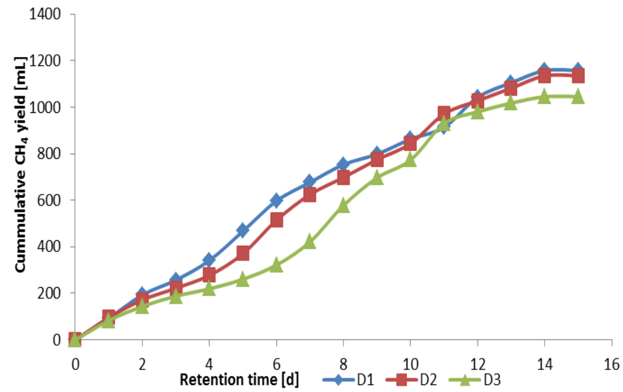

Fig. 2 Cumulative methane yield from three different digesters

Hourly methane yield was also recorded and the result is presented in Fig. 3. Similar trends were observed for Digester 2 (D2) and Digester 3 (D3). Their hourly yield was at a steady rate and near constant. However, Digester 1 (D1) showed different pattern as it overshoots at certain hours of the day. It also has the lowest hourly production at certain hours.

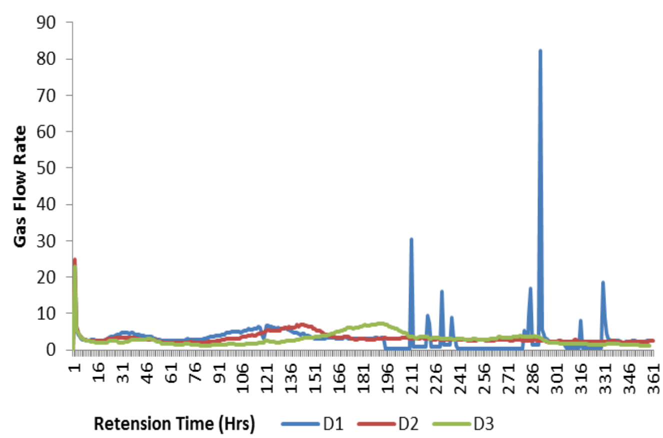

Fig. 3 Hourly gas production by Digesters 1, 2 and 3.

Data for daily methane production was also obtained and computed in Fig. 4. From the graph, it can be seen that there fluctuation in daily gas production by all the digesters. A comparison was made based on minimum, maximum and average daily gas production. Accordingly, Digester 1 had the highest cumulative yield but the lowest gas production as compared to Digesters 2 and 3, with a minimum and maximum daily production of 4.4 and 130 Nml, respectively. However, it had the highest gas production average. Digester 2 had the highest minimum gas production, meaning that at least it produced 50.5 Nml gas. In contrast, Digester 3 had the highest

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maximum gas production but lowest cumulative yield and average than the other digesters.

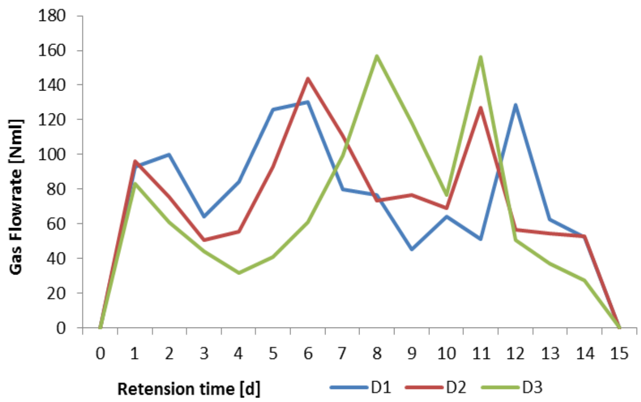

Fig. 4 Comparative daily gas production in Digesters 1, 2 and 3.

B. Comparative biomethane potential from grass and cow dung

The cow dung that's used as an inoculum was used as a control to determine the effect it might have on the substrate biodegradation. The results are presented in Fig. 5. There was a fluctuation in the daily gas production for all the digesters that might be due to microbial activity in operational conditions at the respective days. Strikingly, D1 and D2 produced the same amount of gas on day 15 while D3 had the lowest. All the digesters with cow dung had the highest gas which is comparable to observations made by [11] in a study comparing different substrates.

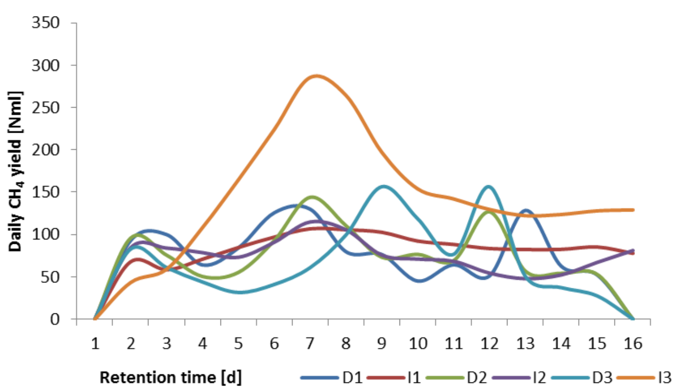

Fig. 5 Daily methane production for digesters with substrate and inoculum

IV. Conclusion

Grass is a suitable substrate for biomethane production because the type of organic substrate used for anaerobic digestion influence the composition of biogas produced. 1L of biomethane can be obtained from digesting grass in a 500 ml for a period of 15 days.

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