



An Investigation on the Potential of Biogas Production from Elephant Grass and Guinea Grass

Sindra L. Summoogum-Utchanah^{*1} and Doolar Poorneema¹

¹Department of Chemical and Environmental Engineering
University of Mauritius
Reduit, Moka, Mauritius

Abstract: Anaerobic digestion of Elephant grass (EG) and Guinea grass (GG) as well as the co-digestion of EG and GG were studied in a single phase digester at ambient temperature. Six different treatments were set up based on mixture proportions in digesters labelled A-F. The compositions of the digesters were as follows: Digester A contained 2 % total solids (TS) EG, B 2 % TS GG, C 2 % TS mixture of EG and GG, D 6 % TS EG, E 6 % TS GG and F 6 % TS mixture of EG and GG. It was observed that the 6 % TS EG digester produced 3455 ml of biogas compared to only 1725 ml collected for 6 % GG. A mixture of these two grasses is not recommended for anaerobic digestion as the biogas production is lowest compared to the systems using only one grass type. The results for pH, chemical oxygen demand (COD) and soluble chemical oxygen demand (SCOD) tests revealed that the degradation process was taking place well in all digesters.

Keywords: Anaerobic; digestion; co-digestion; elephant grass; guinea grass; total solids

I. Introduction

The world is facing a major crisis, namely an energy crisis, due to a worldwide increase in energy demand caused by a rise in population growth, industrialisation and an increasing rate of consumption of fossil fuels. Consequently, the focus is on renewable sources of energy such as biogas which is obtained from anaerobic digestion (AD). AD is the treatment of several organic wastes by a series of biological process and recovery of bio-energy in the form of biogas, which consists mainly of CH₄ and CO₂ [1]. Biogas production from agricultural biomass is of growing importance as it offers extensive environmental benefits such as energy savings, recycling of nutrients within agriculture and reduced CO₂ emissions [2]. In AD, co-digestion is also possible where a major amount of a main basic substrate is mixed and digested together with minor amount of a single, or a diversity of supplementary substrate [3].

Grass can be used as a feedstock for biogas production as it is readily available, it does not require any pre-treatment and its digestate can be used as fertilizer, thus helping farmers to reduce their energy cost. Even environmental concerns such as deforestation and ecological damage will not be an issue as the grass which will be cut will grow in a short span of time. Moreover, the use of fertilizer produced from the digestate which is of a good quality will not cause significant greenhouse gas (GHG) emissions. During the process of AD, especially that of grass, the use of inoculum is very important. The most essential role of inoculum is a source of microorganisms. This slurry increases the rate of degradation significantly. According to Mshandete et al. (2004), the co-digestion of different substrates may upgrade the AD process because of the presence of better carbon and nitrogen balance [4]. Moreover, the digestion of more than substrate can give rise to positive synergism and the excess nutrients can boost microbial growth [5]. As such, cow-dung which is a rich source of bacteria is chosen as inoculum. Hence, a mixture of grass and cow-dung would lead to a synergetic effect and as a result the biogas yield would be high.

There are many types of grass which can be used for biogas production namely Elephant grass (*Pennisetum Purpureum*) and Guinea grass (*Panicum maximum*). Both types of grass are very common in sugarcane fields and they may be regarded as a source of nuisance. Therefore, AD can be proposed as a solution especially for farmers. Because of this consideration, in this study, we aim to investigate the potential of biogas production from Elephant grass (EG) and Guinea grass (GG), as well the effect of co-digestion of EG and GG.

II. Material and Methods

Twelve laboratory scale digesters bottles were constructed for the AD process. Six of them were used as digesters for biogas monitoring while the remaining ones were used as duplicates for collection of substrate samples.

A. Characterization of Grass Sample

Substrate in the form of fresh grass was obtained from fields and gardens for characterization purposes. The latter was carried out to estimate the amount of substrate, water and inoculum to be added in each digester to vary the percentage total solids. The first one was the moisture content test wherein samples of the grass were weighed and dried in an oven at a temperature of 60 °C for around 24 hours. The difference between the initial and final weight determined the moisture content. The determination of the percentage volatile solids was the next step which was done using the dried grass samples placed in a furnace at a temperature of around 550 °C for 3 hours. The same experiment was carried out for the inoculum to be used.

B. Experimental Setup

The sample was first cut into small pieces of around 20 mm which was then crushed mechanically thus increasing its contact surface area. A mixture was then prepared with the crushed grass, inoculum and water which was fed in the digesters and the duplicate bottles. The system was checked for any possible air leakages and the inverted tube cylinder method was used for biogas collection. The experiment was monitored for a period of 30 days.

C. Tests on Substrate Sample

The pH meter was used to measure the pH of the substrate sample from the duplicate digester bottles. The probe was inserted into the sample until stabilization. On the other hand, the COD value was obtained from the following formula:

$$\text{COD mg/l} = \frac{(B-S)}{T} \times D \times 1000$$

Where D: dilution factor; S: titre value for digested tube containing diluted sample (ml); B: titre value for digested tube containing distilled water (ml) and T: titre value for undigested distilled water (ml). Moreover, the procedure for the soluble COD test is similar to the COD test but the only difference is that the sample to be used is first passed through a centrifuge and filtered and then it is diluted. Lastly, the biogas collected in each airtight plastic bag was passed through a gas analyzer to determine the content of the biogas produced.

III. Results and Discussions

The pH value of the substrate is an indication of the bacterial activity in an anaerobic digestion system. The pH of 6 % TS EG was higher than the remaining % TS EG, GG and mixes as shown in fig. 1. Moreover, there was a considerable fall in pH value for the 2 % TS EG and GG from days 4 to 14. It was also noted that for both the 6 % TS EG and GG, the pH values were more stable due to the higher substrate and inoculum content.

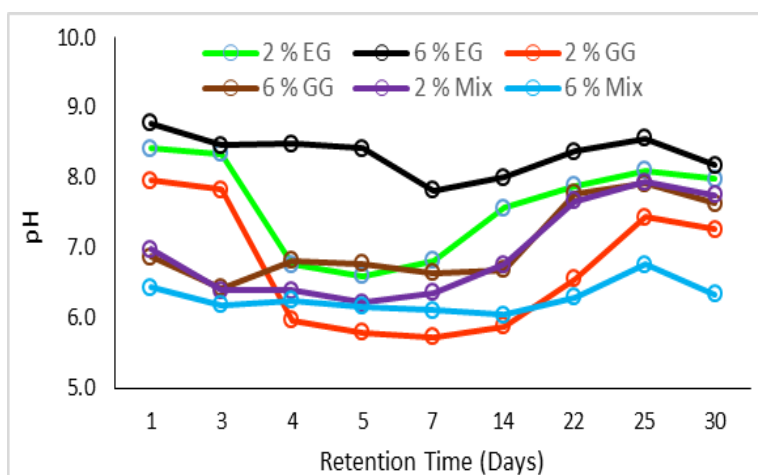


Fig. 1: Variation of pH against retention time

Fig. 2 illustrates the biogas production for the different % TS against retention time. While the 2 % and 6 % TS EG digester yielded the highest yield, the 2 % TS mix gave the lowest amount of biogas. This was due to the fact that the methane bacteria took more time to adapt to the environment in the latter case compared to the others.

The graph of COD against retention time is plotted in fig. 3. At first, the COD value in the digesters were high as the substrates were fresh. Also, the highest values of COD were recorded for both 6 % TS EG and GG. Gradually, a decrease in COD values were noted up to day 11 as the degradation process took place.

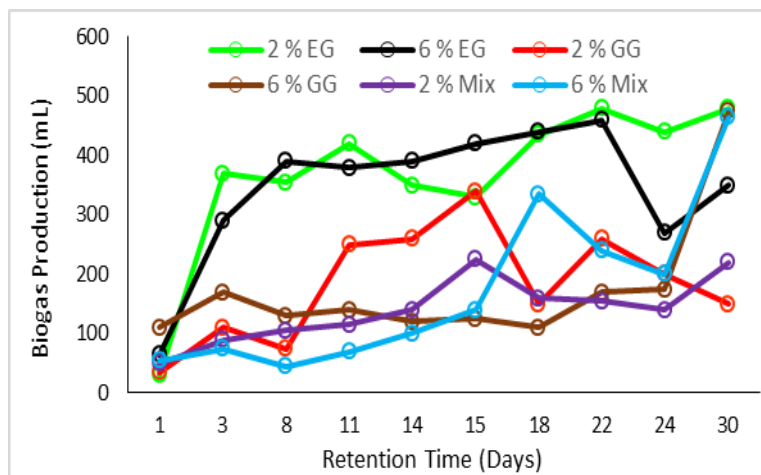


Fig. 2: Variation of biogas production against retention time

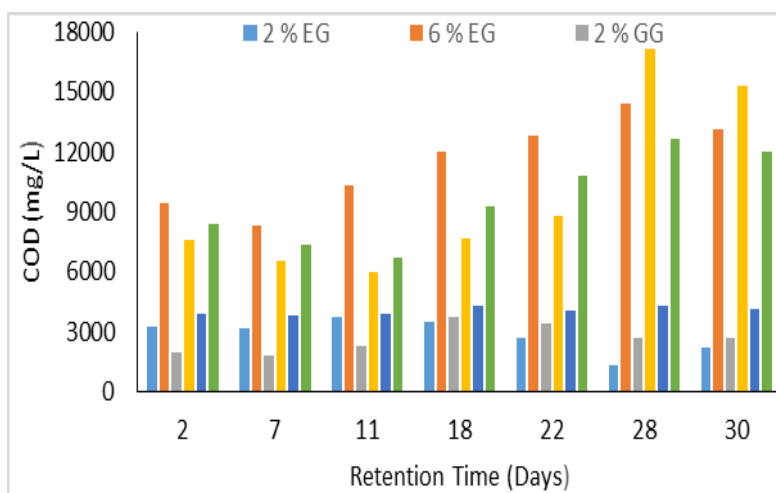


Fig. 3: Variation of COD against retention time

Fig. 4 below illustrates the change in SCOD as the anaerobic digestion progresses. As seen, all the curves exhibited a decrease in SCOD values up to day 15 and 21 for 2 % TS EG and 2 % TS GG, 2 % TS mix, 6 % TS EG and 2 % TS mix respectively.

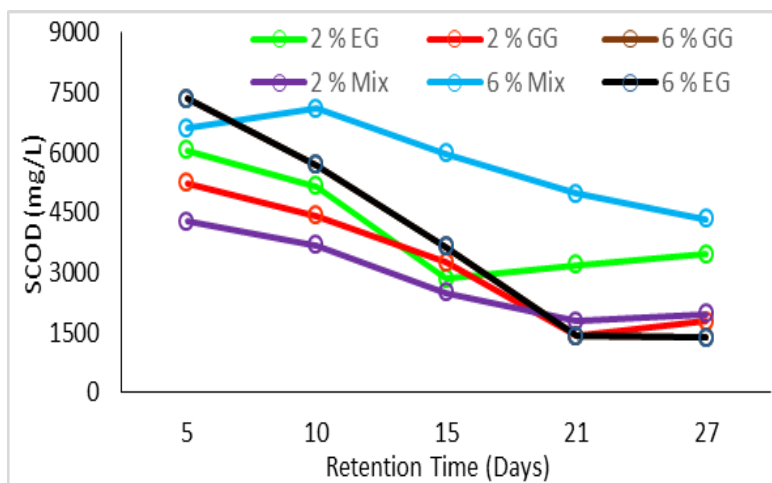


Fig. 4: Variation of SCOD against retention time

Table 1 below shows the variation in composition of biogas in each digester. The digester containing 6 % TS EG produces the highest amount of methane. On the other hand, the digester containing 2 % TS mixture of both

grasses produces the least amount of methane gas. These results indicate that EG has a higher potential to produce methane gas compared to the GG alone or when used as a mixture of both grass.

Table 1. Variation in % composition in each digester

Digester	% Composition			
	Methane (CH ₄)	Carbon dioxide (CO ₂)	Oxygen (O ₂)	Balance
2 % EG	47.2	10.3	8.4	34.1
2 % GG	40.6	11.9	9.1	38.4
2 % Mix	37.2	12.6	9.5	38.7
6 % EG	52.8	13.9	8.9	24.4
6 % GG	43.4	9.6	10.7	36.3
6 % Mix	39.3	11.4	8.8	40.5

IV. Conclusions

In this project, the feasibility of production of biogas from each type of grass was determined by experimentation. Hence, the AD of EG and GG as well as the co-digestion of EG and GG were studied at ambient temperature. It was found that EG was a better option than GG in terms of biogas production. Also, when a mixture of both grass was used the biogas yield was less compared to the individual ones. Following the monitoring of the experiment, it was shown that there was a considerable and gradual decrease in the pH value of each digester indicating that there was a healthy anaerobic environment in the digesters. The results for the COD and SCOD tests concluded that the degradation process was taking place well in all digesters.

V. References

- [1] J.Clemens, M. Trimborn, P. Weiland and B. Amon, 'Mitigation of greenhouse gas emissions by anaerobic digestion of cattle slurry,' Agriculture, Ecosystems and Environment, vol 112, pp. 171-177, doi:10.1016/j.agee.2005.08.016
- [2] A. Kacprzak, L. Krzystek and S. Ledakowicz, 'Co-digestion of agricultural and industrial wastes,' Chemistry and Material Science, vol 64 (2), pp. 127-131
- [3] R. Braun and A. Wellinger, 'Potential of Co-digestion,' <http://www.iea-biogas.net/files/daten-redaktion/download/publi-task37/Potential%20of%20Codigestion%20short%20Brosch221203.pdf> Accessed on 15th March 2014
- [4] A. Mshandete, A. Kivaisi, M. Rubindamayugi and B. Mattiasson, 'Anaerobic batch co-digestion of sisal pulp and fish wastes,' Bioresource Technology, vol 95, pp. 19-24, doi: 10.1016/j.biortech.2004.01.011
- [5] J. Mata-Alvarez, S. Mace and P. Llabres, 'Anaerobic digestion of organic solid wastes: an overview of research achievements and perspectives,' Bioresource Technology, vol 74, pp. 3-16, doi: 10.1016/S0960-8524(00)00023-7