Application of Hycura in Municipal Waste Digestion Recovering Biogas

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Abstract

Disposal of municipal waste, a by-product from the sewage treatment process, is resulting in landfilling problems hence need for sustainable methods in managing this municipal waste such as biogas generation via bio catalytic routes. This study focused on anaerobic treatment of municipal waste, co-harnessing biogas as a value added products utilizing Hycura, an engineered enzyme bio-catalyst. Anaerobic digestion of municipal waste was investigated for potential biogas generation at mesophilic temperature of 35 °C and thermophilic temperature of 55 °C. An engineered bio catalyst, Hycura was loaded at 0.5g/L. The biogas quantity produced was measured using the water displacement method. Samples of the biogas were analyzed for bio-methane, carbon dioxide and traces gases composition using a gas analyzer. Optimum biogas production was obtained under mesophilic conditions and Hycura loading of 0.50 g/L with a 78% bio-methane composition. Biogas production from municipal waste does not only provide a waste management initiative but also a renewable energy source.

Keywords: Anaerobic digestion, biogas, bio augmentation, Hycura, municipal waste

1. Introduction

The conversion of bio waste to biogas is increasingly becoming popular as a waste management initiative to generate a source of energy that is renewable and ecofriendly (Savari et al., 2016). Biogas is mainly composed of methane (CH_4), carbon dioxide (CO_2), and other trace gases including hydrogen sulphide (H_2S). Biogas production can be fully described by 4 stages which are hydrolysis, fermentation, anaerobic digestion and methanogenesis. The biogas production stages are given in Figure 1.

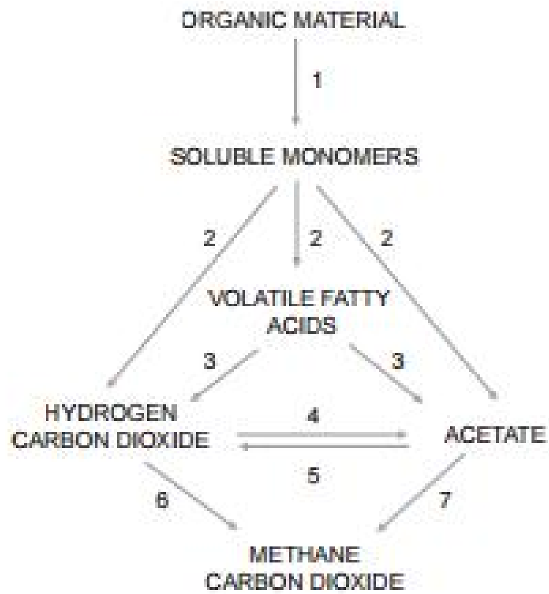

Figure 1. Biogas production processes (Westerholm, 2012)

Although, the production of biogas from bio-waste has been success, there is still need to determine the effect of bio augmentation. Bio augmentation products or catalysts are added to speed up the degradation of fats and the accumulation of these acids in organic matter (Joubert, 2012). Bio augmentation can also be used to hinder the generation of hydrogen sulfide (H_2S), ammonia, and other odor causing organic compounds (Joubert, 2012). These substances are actually contaminants in biogas; bio augmentation will accelerate the degradation of such compounds (Joubert, 2012).

Studies have been done to enhance the degradation of organic waste in biogas processes by inoculation with enzymes or bio catalysts. For example, bio augmentation of *Clostridium cellulolyticum* during batch digestion of wheat straw achieved higher methane potential compared with a non-inoculated control (Peng et al., 2014). In another batch cultivation studies, brewery spent grain was used as substrate and an increase in the methane potential and a change in microbial community was observed by addition of various hydrolytic bacteria (Čater et al., 2015).

Additionally, in a two-phase continuous method digesting maize waste, bio augmentation with a cellulolytic culture dominated by *Clostridium* achieved increasing substrate hydrolysis and methane production (Martin-Ryals et al., 2015). Successful bio augmentation has also been shown using a non-hydrolytic, fermentative bacterium, *Acetobacteroides hydrogenigenes* (Zhang et al., 2015).

Recently, engineered catalysts like Hycura are becoming topical in organic waste management (Hycura, 2016). This study therefore focused on the bio augmentation of municipal waste for potential enhanced biogas production using Hycura.

2. Materials and Methods

2.1 Materials

Hycura was obtained from Australia. Municipal solid waste was obtained from a local landfill.

2.2 Methods

Municipal waste collected from a local landfill and characterized for bio waste composition. Bio augmentation was conducted during the anaerobic digestion stage at temperatures of 35 °C and 55 °C. Anaerobic digestion was conducted in 500 mL digesters and plugged with cotton wool and aluminum foil to ensure anaerobic conditions. A retention time of 30 days and the pH was maintained at 6.5-7. Hycura was loaded at 0-0.5 g/L. The biogas composition was quantified using a Biogas 5000 gas analyzer.

3. Results and Discussion

3.1 Raw material characterization

Only bio waste from the municipal waste was considered for the anaerobic digestion with food and garden waste having the major compositions (Figure 2). The municipal waste had a total of 93% organic waste with food waste having the major composition.

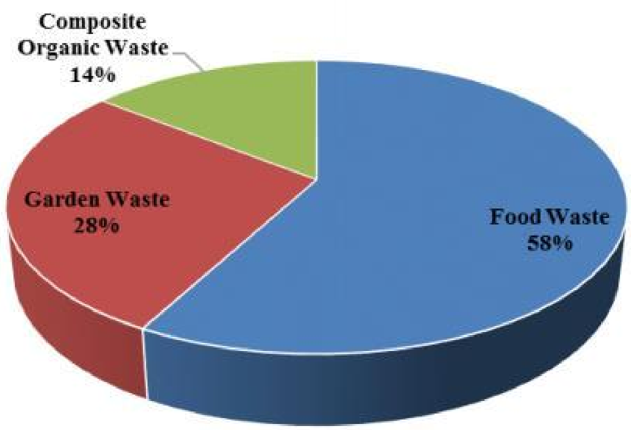

Figure 2. Municipal waste characterization

3.2 Effect of thermophilic and mesophilic digestion of the municipal bio waste

The anaerobic digestion of municipal water under mesophillic temperatures of 35 °C favored more biogas production (Figure 3). The cumulative amount of biogas generated was 3 times higher under mesophillic conditions in comparison to the thermophilic temperatures of 55 °C. Navickas et al. (2013) indicated that at high temperatures of greater than 56 °C, the accumulation of volatile acids increase which result in decreased methane content. The biogas composition during this digestion was an average of 50-59 for mesophilic conditions and 46-48% for thermophilic conditions (Table 1). This can be attributed to the fact that anaerobic digestion of the municipal waste favors mesophillic conditions where the methanogens are highly active hence higher bio methane production.

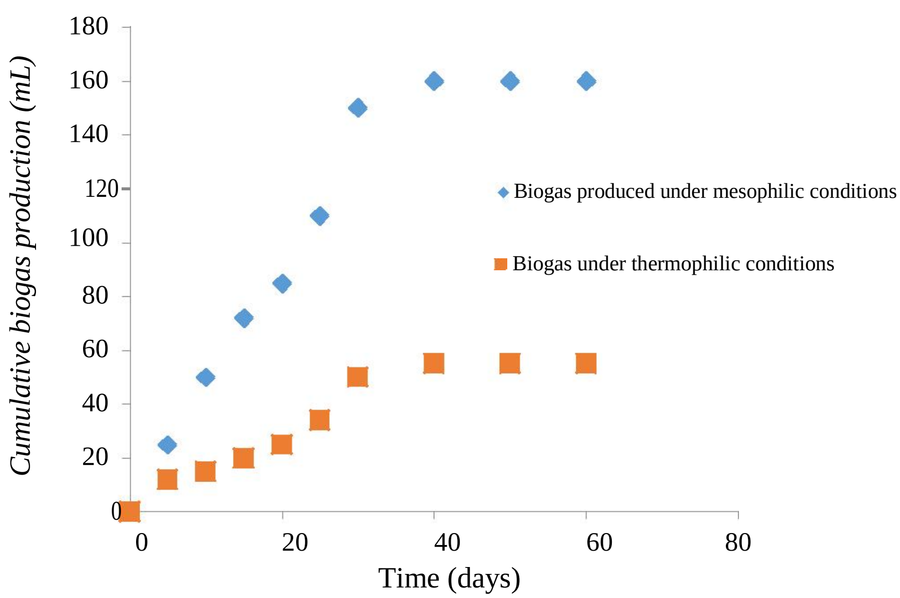

Figure 3. Biogas generation from municipal waste under mesophilic and thermophilic conditions

Table 1. Municipal waste biogas composition under mesophilic and thermophilic conditions

Gas	*Mesophilic conditions*	*Thermophilic conditions*
CH_4	50-59	46-48
CO_2	30-35	38-40
H_2S	<8	<10
Other gases	12	<14

3.3 Effect of bio augmentation of municipal waste on biogas production

The cumulative biogas produced increased with increase in the retention time for conditions with and without Hycura bio augmentation (Figure 4) under mesophillic conditions. The cumulative biogas was 50% more for a system that had Hycura in comparison to a system that had natural digestion. Zhang et al. (2015) also indicated that adding *Acetobacteroides hydrogenigenes* during biogas production from maize straw resulted in a 19-23% increase in methane yield. Duran and Tepe (2006) also reported a 29% increase upon bio augmentation of biosolids under mesophilic conditions using a commercial product containing selected strains of *Bacillus*, *Pseudomonas*, *& Actinomycetes*. In summary, increases of 15-55% in methane composition have been reported in literature upon bio augmentation of various micro-organisms (Angelidaki et al., 2000; Cirne et al., 2006; Weiss et al., 2010 and Costa et al., 2012).

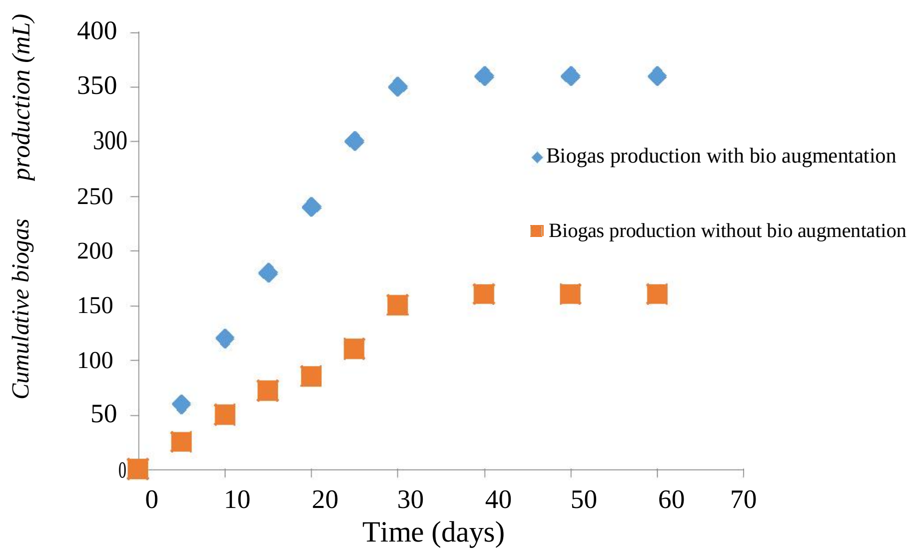

Figure 4: Effect of bio augmentation on municipal biogas generation under mesophillic conditions

The biogas from municipal solid waste that was bio augmented with Hycura was about 30% rich in bio methane as compared to a system without bio augmentation (Table 2). The H_2S in the biogas from the municipal waste that was digested with Hycura was very low and this can be attributed to the effect of the Hycura on the municipal waste. Joubert (2012) indicated that bio augmentation can be used to hinder the generation of H_2S, ammonia, and other odor causing organic compounds.

Table 2: Municipal waste biogas composition for bio augmented systems

Gas	*$*B_1$*	*$*B_O$*
CH_4	50-59	74-78
CO_2	30-35	20-25
H_2S	<8	<1
Other gases	12	<10

*B_1-Biogas with Hycura bio augmentation B_0-Biogas without bio augmentation

4. Conclusion

Bio augmentation of municipal waste to enhance biogas production is critical for improving the quality of the biogas produced especially increasing the methane content. Contaminants like hydrogen sulphide are removed and the bio methane quality enriched. Mesophilic conditions are ideal for bio augmentation with Hycura.

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Biography

Mercy Manyuchi is an Energy Researcher in the BioEnergy Research Group at the University of Johannesburg in South Africa. She holds a Doctorate Degree from Cape Peninsula University of South Africa, a Master of Science Degree from Stellenbosch University and a Bachelor of Engineering Honors Degree from Zimbabwe. Her research interests are in waste to energy technology, value addition of waste biomass and renewable energy technologies.

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