International Journal of Waste Resources

Hamouda, Int J Waste Resour 2016, 6:2
DOI: 10.4172/2252-5211.1000218

Research Article Open Access

Engineering and Environmental Parameters for Biogas Production

Ramy M Hamouda*

Agricultural Engineering Department, Benha University 13736, Egypt

***Corresponding author:** Ramy M Hamouda, Agricultural Engineering Department, Benha University 13736, Egypt, Tel: +20132467034; E-mail: ramy.mohamed@hu.edu.eg

Received date: April 04, 2016; **Accepted date:** May 11, 2016; **Published date:** May 18, 2016

Abstract

The cumulative biogas production, methane yield, carbon dioxide and degradation efficiency (De) from dairy manure anaerobic fermentation as affected by studied treatments were studied. The most important results indicated that biogas production increased with a higher values of all treatments under study (FT and AS). The average cumulative biogas production increased from 96.91 to 214.48 m^3/ton T.S manure. The methane yield production increased with a higher all treatments under study (FT and AS). The average methane yield production increased from 58.15 to 128.69 m^3/ton T.S manure. The CO_2 production increased high transaction values under study (FT and AS). The average CO_2 production increased from 38.77 to 85.79 m^3/ton T.S manure. The degradation efficiency (De) increased with increasing both agitation speed and time, where it increased from 0.65 to 1 as the time increased from 3 to 7days, while it increased from 0.65 to 0.78, 0.71 to 0.88 and from 0.92 – 0.97 as the agitation speed increased from 200-500 rpm at 30, 35 and 50°C, respectively.

Keywords: Dairy manure; Biogas; Fermentation; Agitation; Methane; Degradation efficiency

Introduction

In recent years, the liquid manure is one of the popular topics in agriculture. A great number of studies, discussions and consultations have been devoted to it worldwide and in Egypt. Its popularization has been caused by fait development of cattle-breeding and building of cattle with liquid manure removal. The liquid manure is a liquid organic fertilizer, a mixture of urine and faces without litter. In most cases it also contains small or greater quantities of water coming from different sources. The liquid manures differ depending on the extent of thinning with water. The more thinned, the liquid manure is the less dry matter and nutrients it contains. Dairy cattle typically produce between 42 kg and 64 kg (depending on body weight) of manure per day, so if they are housed for 50% of the year that corresponds to 7.6-11.6 tones per cow. In many developing nations, animal faeces have been composted and used to fertilize farm field [1,2]. Anaerobic digestion is a multi-faceted and complex process. No one organism is capable of completely reducing carbonaceous matter to methane. A four step process is required to complete this transformation [3]. Li et al. [4] reported that the dry continuous anaerobic digestion reactor stabilizing source-sorted organic fraction of municipal solid wastes (OFMSW) showed stable performance with highest biogas yield (278.4 lCH_4/kgVS) and (VS) reduction of around 59.21% during loading rate 2.5 kg volatile solid VS/m^3.d in thermophilic condition among the three different organic loading rates (OLRs) of 2.5, 3.3 and 3.9 VS/m^3.d for constant retention time of 25 days. This happened due to more accumulation of Volatile fatty acids (VFAs) and decrease in pH during the loading rates 3.3 and 3.9 VS/m^3.d. The rate at which organic material is supplied to the anaerobic digester is referred to as the organic loading rate [5]. Anaerobic digestion produces CH_4 which is a sparingly soluble gas, and most is degassed from solution and can be recovered easily for subsequent use. Stoichiometry of methane oxidation shows the chemical oxygen demand (COD) equivalent of methane is 4 g COD (g CH_4)-1. At standard temperature and pressure (0°C and 1 atm), it corresponds to 0. 35 L of CH_4 produced per gram of COD converted to CH_4. This directly relates CH4 production and COD removal and provides a way to estimate CH_4 production by knowing how much COD has been removed in anaerobic digester. The production of CO_2 does not contribute to COD reduction because the carbon in CO_2 is in the maximum oxidation state. The CH_4 and CO_2 content of biogas varies depending on the nature of the substrate with CH_4 content in biogas between 50 to 70% [6].

The main objective of this work was to Investigating the effect of fermentation temperature and agitation speed on cumulative biogas production, and its content of methane, carbon dioxide and degradation efficiency. To achieve this goal, the fermentation temperature, and agitation speed and biogas rate as the most important factors affecting the physical, chemical properties the cumulative biogas production were studied.

Materials and Methods

Dairy manure

This waste was obtained from animal farms at Sharkia Governorate, Egypt. The main components of this waste was: Total nitrogen (TN) of 1.42%; Phosphorus (P), of 0.012%; Potassium (K), of 0.015%; Organic Matter (OM), of 34.2% and C/N, of 13.97; Moisture, of 78.8% pH, of 8.13 and Electrical Conductivity (EC), 11.6 dSm-1 (9280 ppm).

Measurements and instrumentation

Scanning thermometer was used to measure temperature (model, Digi-Sense 69202-30 measuring range from-250 to 1800°C+/- 0.1%, USA).

Citation: Hamouda RM (2016) Engineering and Environmental Parameters for Biogas Production . Int J Waste Resour 6: 218. doi: 10.4172/2252-5211.1000218

Bioflo 110 fermentor

A 20 L batch fermentor was used for the production of biogas from dairy manure. The experimental set–up (Figure 1) consisted of the fermenter, the air supply and the computer based data acquisition and control system. The fermenter and all accessories were chemically sterilized using 2% potassium metabisulfite solution and then washed with hot water several times before starting the experiment in order to remove any chemical traces. The reactor was then filled with 20 L of dairy manure. The reactor was operated by speed of 200, 300 and 500 rpm. The dissolved oxygen and temperature of the reactor were monitored continuously.

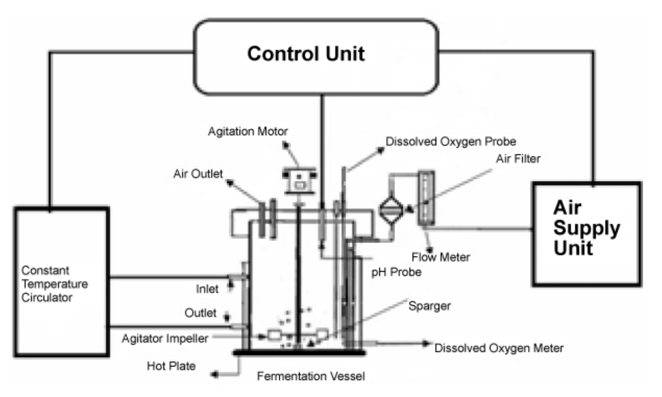

Figure 1: The experimental-setup.

The experiment was devoted to study the effect of fermentation temperature (FT) and agitation speed(AS) on cumulative biogas production from dairy manure anaerobic fermentation as affected by temperature with (30, 35 and 50°C) and agitation rotation speed (200, 300, and 500 rpm). A total of 27 runs including 3 replicates were conducted.

Result and Discussion

Biogas production

Effect of fermentation temperature and agitation speed on cumulative biogas production: Figure 2 show the effect of (FT) and (AS) on cumulative biogas production from dairy manure anaerobic fermentation. It could be seen that the Biogas production increased with increasing all treatments under study (FT and AS). The average Cumulative Biogas production increased from 96.91 to 214.48 m^3/ton T.S manure as the fermentation temperature increased from 30 to 50°C, on the other hand, The average Cumulative Biogas production increased from 96.91 to 113.58 m^3/ton T.S manure as the agitation speed increased from 200 to 500 rpm at 30°C, 123.98 to 133.79 m^3/ton T.S manure at 35°C and from 159.24 to 214.48 m^3/ton T.S manure at 50°C for the same previous range of the agitation speed (200 to 500 rpm). Biogas composition depends on the type of substrate [7], differing mainly due to total solids and fraction of volatile solids concentrations [8]. Methane yield is closely related to the feedstock's characteristics (carbon to nitrogen ratio, pH, particle size, and total solids content), type of reactor, operational factors (mainly Fermentation temperature and retention time), and microbial communities [9,10]. Other factors affecting methane yield are the type of ration, age and degree of contamination of manure [11]. Multiple Regression analysis was carried to obtain the relation between the biogas yield (YBio), AS and FT. The best fit for the relationship between the biogas yield, fermentation temperature and agitation speed was as follows:-

YBio = -43.43+3.99(FT) +0.09(AS) R^2 = 0.89 (1)

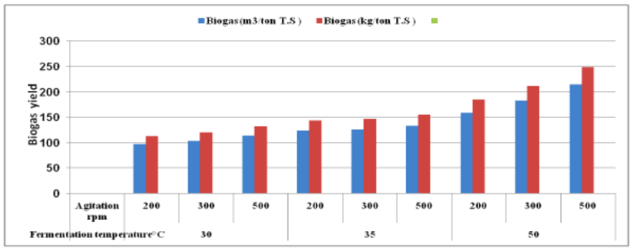

Figure 2: Effect of fermentation temperature and agitation speed on cumulative biogas production.

Effect of fermentation temperature and agitation speed on methane yield: Figure 3 show the effect of (FT) and (AS) on methane yield production from dairy manure anaerobic fermentation. It could be seen that the methane yield production increased with increasing all treatments under study (FT and AS). The average methane yield production increased from 58.15 to 128.69 m^3/ton T.S manure as the fermentation temperature increased from 30 to 50°C, on the other hand, The average methane yield production increased from 58.15 to 68.15 m^3/ton T.S manure as the Agitation speed increased from 200 to 500 rpm at 30°C, 74.39 to 80.27 m^3/ton T.S manure at 35°C and from 95.54 to 128.69 m^3/ton T.S manure at 50°C for the same previous range of the agitation speed (200 to 500 rpm). Methane yield depends on various factors including age, storage conditions, solids content, cattle feed characteristics, digestion period, type of reactor, and operational conditions. The efficiency of anaerobic conversion of organic waste to methane ranges from 50% to 70% [12]. Regression analysis was carried out to obtain a relationship between the methane yield (Ym), AS and FT. The best fit for the relationship between the methane yield, fermentation temperature and agitation speed was as follows:-

YM = -26.057+2.39(FT) +0.05(AS) R^2 = 0.89 (2)

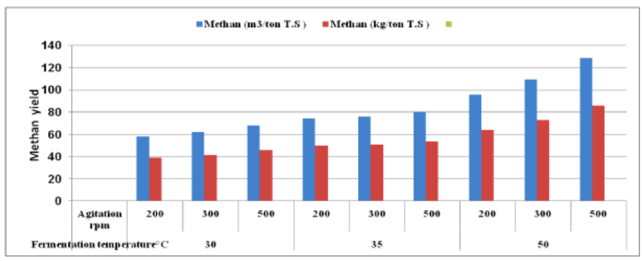

Figure 3: Effect of fermentation temperature and agitation speed on methane yield.

Effect of fermentation temperature and Agitation speed on carbon dioxide: Figure 4 show the effect of (FT) and (AS) on carbon dioxide (CO_2) production from dairy manure anaerobic fermentation. It could be seen that the CO_2 production rose with increasing all treatments under study (FT and AS). The average CO_2 production increased from

38.77 to 85.79 m^3/ton T.S manure as the fermentation temperature increased from 30 to 50°C, on the other hand, The average CO_2 production increased from 38.77 to 45.43 m3/ton T.S manure as the agitation speed increased from 200 to 500 rpm at 30°C, 49.59 to 53.52 m^3/ton T.S manure at 35°C and from 63.70 to 85.79 m^3/ton T.S manure at 50°C for the same previous range of the agitation speed (200 to 500 rpm). Regression analysis was carried out to obtain a relationship between the carbon dioxide (Yco_2), AS and FT. The best fit for the relationship between the carbon dioxide, fermentation temperature and agitation speed was as follows:-

$YCO_2 = -17.37+1.59(FT) +0.04(AS)$ $R^2 = 0.89$ (3)

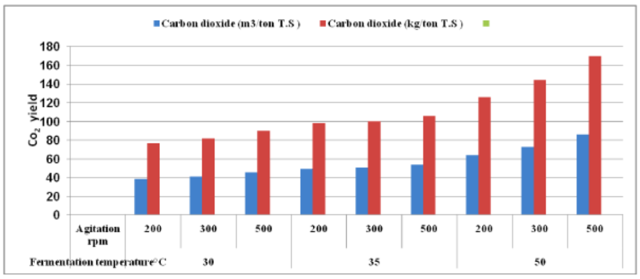

Figure 4: Effect of fermentation temperature and agitation speed on carbon dioxide.

Effect of fermentation temperature and agitation speed on degradation efficiency: Figure 5 show the effect of (FT), (AS) and time (T) on degradation efficiency (De). The results showed that the De increased with raising both agitation speed and time, where it increased from 0.65 to 1 as the time increased from 3 to 7days, while it increased from 0.65 to 0.78, 0.71 to 0.88 and from 0.92–0.0.97 as the agitation speed increased from 200-500 rpm at 30, 35and 50°C, respectively. Regression analysis was carried out to obtain a relationship between the De and studied factors (FT(30°C -50°C), AS (200 – 500 rpm) and T(3- 7days), the best form was follows show the effect of fermentation temperature (FT) and Agitation speed on degradation efficiency (De) of dairy manure anaerobic fermentation as follows:-

$De = 0.40+0.005(FT) +0.0002 (AS) +0.05(T)$ $R^2 = 0.79$ (4)

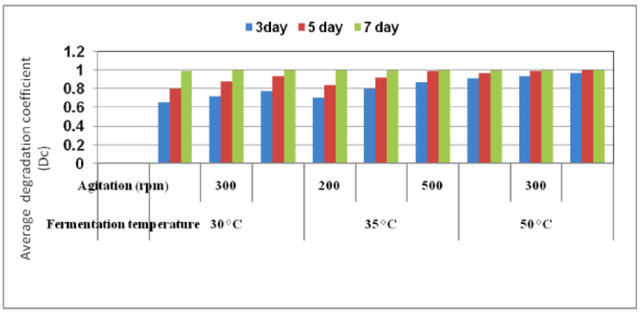

Figure 5: Effect of fermentation temperature and agitation speed on degradation efficiency.

The validity of the equation was studied by compares the predicted and measured degradation efficiency and the most suitable forms are shown as follows (Figures 6-11):

At 3 day $Dc_p = 0.449Dc_M +0.443$ $R^2 = 0.948$ (5)

At 5day $Dc_p = 0.65Dc_M +0.305$ $R^2 = 0.81$ (6)

At 7 day $Dc_p = 14.40Dc_M -13.38$ $R^2 = 0.417$ (7)

Where:

Dc_P is the predicted degradation efficiency, %.

Dc_M is the measured degradation efficiency, %.

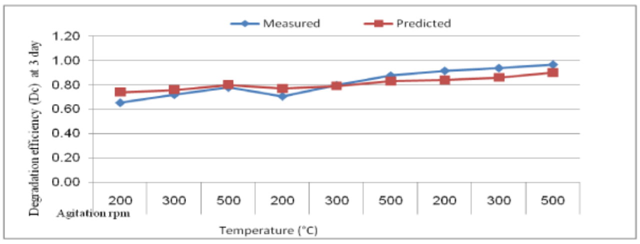

Figure 6: The predicted and the measured degradation efficiency during biogas production at 3 day.

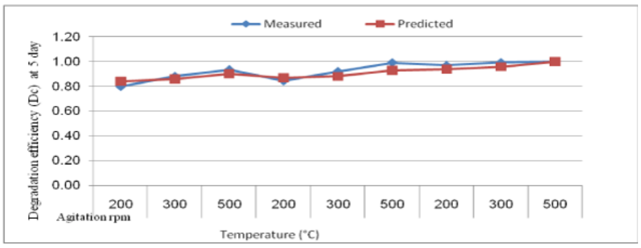

Figure 7: The predicted and the measured degradation efficiency during biogas production at 5 day.

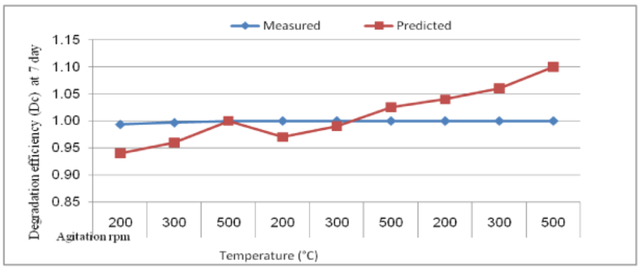

Figure 8: The predicted and the measured degradation efficiency during biogas production at 7 day.

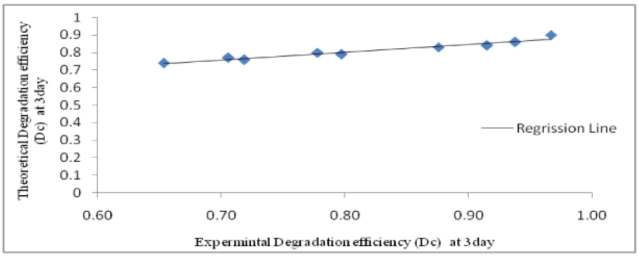

Figure 9: The comparison between the predicted and the measured degradation efficiency (De) during biogas production at 3 day.

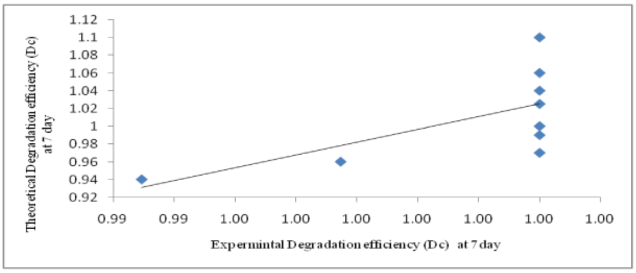

Figure 10: The comparison between the predicted and the measured degradation efficiency (De) during biogas production at 5 day.

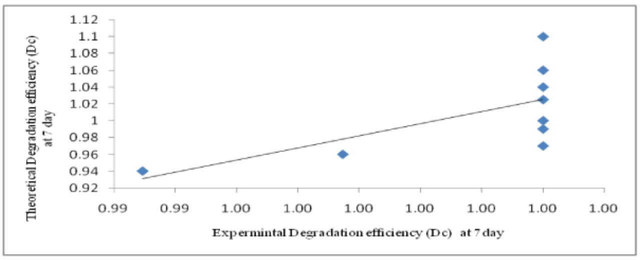

Figure 11: The comparison between the predicted and the measured degradation efficiency (De) during biogas production at 7 day.

Conclusions

This study was carried out to investigate the most important factors affecting the biogas production such as temperature, agitation and speed to obtain the proper factors for optimum production of the methane rate. The most important results could be summarized as follows:-

1. The Biogas production rose with increasing all treatments under study (FT and AS).
2. The average Cumulative Biogas production increased from 96.91 to 214.48 m^3/ton T.S manure as the fermentation temperature increased from 30 to 50°C.
3. The average Cumulative Biogas production increased from 96.91 to 113.58 m^3/ton T.S manure as the agitation speed increased from 200 to 500 rpm at 30°C, 123.98 to 133.79 m^3/ton T.S manure at 35°C and from 159.24 to 214.48 m^3/ton T.S manure at 50°C for the same previous range of the agitation speed (200 to 500 rpm).

References

1. Ogbeide SE, Aisien FA (2000) Biogas from Cassava peelings. Afr J Environ Stud 1: 42-47.
2. Audu TO, Aisien FA, Eyawo EO (2003) Biogas from Municipal Solid Waste. NJEM 4: 26-30.
3. Speece RE (1996) Anaerobic biotechnology for industrial wastewater.
4. Li D, Yuan Z, Sun Y (2010) Semi-dry mesophilic anaerobic digestion of water sorted organic fraction of municipal solid waste (WS-OFMSW). Bioresour Technol 101: 2722–2728.
5. Morris JG (1975) The physiology of obligate anaerobiosis. Adv Microb Physiol 12:169–246.
6. Parkin GF, Owen WF (1986) Fundamentals of Anaerobic Digestion of Wastewater Sludges. Journal of Environmental Engineering 112: 867-920.
7. FEC Services Ltd (2003) Anaerobic digestion, storage, oligolysis, lime, heat, and aerobic treatment of livestock manures: Final report.
8. Wilkie AC (2005) Anaerobic Digestion of Dairy Manure: Design and Process Considerations.
9. Zeikus JG (1980) Chemical and fuel production by anaerobic bacteria. Annual Reviews in Microbiology 34: 423-464.
10. Kaparaju PLN, Rintala JA (2003) Effects of temperature on post-methanation of digested dairy cow manure in a farm-scale biogas production system. Environmental Technology 24: 1315-1321.
11. Hashimoto AG, Varel VH, Chen YR (1981) Ultimate methane yield from cattle manure: effect of temperature, ration constituents, antibiotics and manure age. Agricultural Wastes 3: 241-256.
12. Texas A&M University (2004) Graduate Assistant, Department of Health & Kinesiology.