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Conference paper

Bio-valorization of Cow Dung for Green Renewable Energy

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ABSTRACT

Recovering organic waste, mainly animal manure, to produce biogas (through bio-methanization) could be seen as an economical, decentralized and environmentally friendly solution for farm waste management since it provides energy autonomy and sustainable agricultural development in rural areas. In this work, cow manure from a cattle farm located in Bouzereah, was used as a substrate. An experimental set up consists of 1.5-liter glass batch digester with a total solid concentration of 5.15%, a heating system (thermostated bath) and a magnetic stirring system. The experiment was monitored for 36 days in a thermophilic environment (55°C). The monitored physico-chemical characteristics of cow dung samples; are: pH, acidity, alkalinity, biogas volume and chemical oxygen demand (COD). Biogas production began at a rate of 0.27 L/day on day 11, with a total biogas potential over 50 L/kg of dried solid. The observed buffering capacity indicate a promising potential to use this substrate in co-digestion process namely for acidic substrate such as chees-whey and household wastes.

1. INTRODUCTION

Cow dung are the principal source of livestock effluent, with large amounts of cow dung responsible for the majority of greenhouse gas (GHG) emissions. Moreover, poor waste processing technology for cow dung has resulted in the discharge of dangerous substances (GHG and ammonia) for soil and air, creating

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different environmental damages *(Tunafer & Avsar, 2016; Gopinathan et al. 2018)*. Manure can produce large amount of methane, which is the source of a global temperature rise 21 times greater than carbon dioxide when emitted into the atmosphere *(Gupta et al. 2016)*. Cow dung is a good raw material for producing biogas rich methane, as it produces the methanogenic bacteria needed for this process and can be used as a substrate or inoculum *(Okwu et al. 2021; Owamah et al. 2021)*. Cow dung has recently been the subject of several studies on the optimized use of this material to produce renewable energy. A comparative review of the biogas produced from a variety of manures has already found that cow dung generated between 155-323 ml CH_4/gVS with a volume of 204 ml CH_4/gVS for dairy manure *(Kafle & Chen, 2016)*. A fresh Algerian cattle manure produced more than 150 ml/gVS under thermophilic temperature *Saber et al. 2021)*. In recent studies *Adila Fazliyana et al. (2023)* show that the largest cumulative methane amount was obtained at 30 gVS/L with 63.42 ml CH_4/gVS, while the maximum biogas generation was reported at 192.53 ml/gVS with the highest methane concentration of 89%. Those investigations show the large benefits of cattle manure substrate or co-substrate for biogas production. The aim of this experimental work is to investigate anaerobic digestion using Algerian cow dung as a substrate for biomethane production, under optimum conditions and without any chemical additives.

2. MATERIAL AND METHODS

This work was carried out at the Bioenergy and Environment Laboratory of the Renewable Energy Development Centre (Algeria).

2.1 Substrate

Cow dung, considered in this study as a substrate for anaerobic digestion process, was used in its fresh state. The substrate was introduced into the fermenter at total solids of 5.25%. Fermentation in this experiment was carried out in batch mode with a residence time of 32 days.

The starting parameters for the cow dung at the beginning of the digester are indicated in Table 1.

Table 1. Initial conditions in the digester

Parameters	Ph	U (mv)	COD (mgO_2/L)	TS
Initial conditions	7,19	-19,9	39667	18.31

We have selected operating conditions to achieve maximum biogas content and prevent any inhibition of the process. Anaerobic digestion efficiency was monitored by measuring biogas volume with composition, COD and solids reduction and total alkalinity and acidity in the digester.

2.2 Analytical Methods

The pH of the solutions was measured using pH meter (INOLAB) equipped with a glass electrode, calibration is performed using buffer solutions of pH 4 and 7 at 20 ° C [10].Total solids TS and Total volatile solids VS were measured within the digester according to APHA standard methods. The Chemical Oxygen Demand was measured using close reflux micro-method *((Centre d'exêrtise en analyse environnementale du Quebec, 2006)*.The volume of biogas produced is determined by a 1.5 L glass gasmeter based on displaced liquid method. Biogas composition, including methane (CH_4), carbon dioxide (CO_2) and hydrogen sulfide H_2S, was daily determined using a portable analyser (SEWERIN, Multitec 540).

2.3 Experimental Set-Up and Operation

The tests were carried out in a 1.5 L reactor with a batch feeding mode. The reactor contains two outlets, the first for loading the substrate, and the other for the recovery and measurement of the produced biogas volume (see Fig 2). The digester is placed on a stirring plate to ensure agitation. The reactor is associated with a thermostatically controlled bath to maintain a temperature of 55 °C (Thermophilic temperature). Finally, the biogas produced was analyzed by a portable analyzer Multitec 540.

Fig. 1. Photographic view of the digester (1): Double wall reactor 1.5 L ;(2) Glass gasmeter; (3): Portable biogas analyzer; (4): Stirring plate; (5): Thermostat bath with a Temperature set at 55°C; (6): Tedlar bag.

3. RESULTS AND DISCUSSION

Several parameters, including pH, oxidation-reduction potential, the quantity of biogas generated, were monitored during this study. The figures are presented below.

3.1 Evolution of pH and Redox Potential

pH is an important parameter as the anaerobic digestion ecosystem, and in particular the methanogenic organisms are very sensitive to its variations *(Molleta, 2011)*.The pH is therefore the first indicator of a good or a wrong operating conditions. It is reported in the open literature that pH between 6.5 and 7.5 are suitable for anaerobic digestion. If the pH is below 6.5, an adjustment by adding sodium bicarbonate or NaOH will correct this anomaly *(Hagos et al. 2017)*.

Fig. 2 shows the variation pH and redox potential of cow dung in the digester. The pH at inside the digester values was ranged from 6 to 7.51 throughout the thermophilic digestion monitoring period, with an average value of 7.3, which is favorable to the stability of the process.

3.2 COD removal

The dissolved COD is estimated on the sample supernatants. The initial soluble COD in the digester was approximately 4900 mg O_2/L, decreasing to 4233mg O_2/L at the end of fermentation. (See Fig. 3)

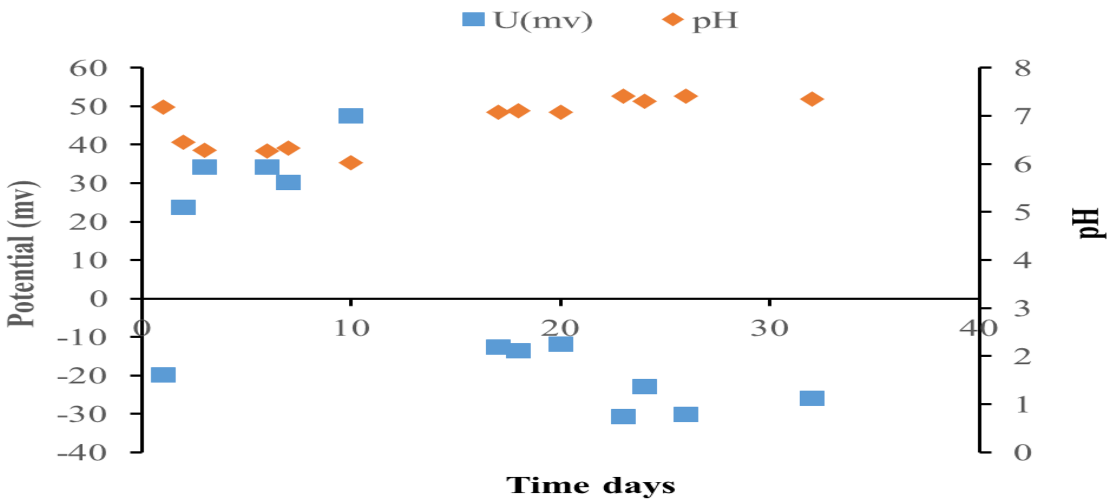

Fig. 2. Evolution of pH and redox potential as function of time

This explain the conversion of the organic elements to a biogas form. The resulted COD is still large as the digestate still contains organics. This digestate can be used as a fertilizer to increase the economic benefits in such a process.

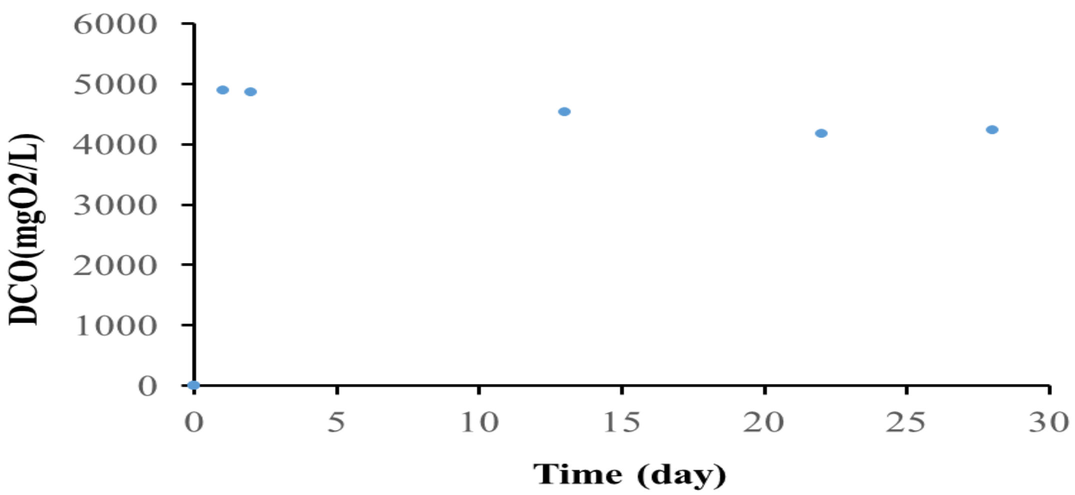

Fig. 3. Evolution of COD as function of time

3.3 Biogas Production

3.3.1 Daily Production

The volume of biogas produced is determined using the displaced liquid method. (see Fig. 4) below shows the volume of biogas as a function of time. During a residence time of 32 days, the quantity of biogas produced is estimated as 4.55 liters of biogas. We can see that the methanogenic phase is initiated on day 9 as soon as the pH value is around 7. This means that in a reaction medium with a pH close to 7 the development of methanogens is favored and consequently the start of the methanogenesis phase. However, we have detected in the first day of fermentation that a small amount of biogas was produced, with maximum production from day 11 of the process, which then decreased slightly until the end of fermentation.

3.3.2 Cumulative production

Cumulative biogas production and daily biogas production are shown in Figure 4. Cumulative production kinetics can be divided into three main phases:

Latency phase: This phase is observed during the first nine days and is characterized by low biogas production, during which hydrolysis, acidogenesis and acetogenesis take place. This phase precedes the methanogenesis stage, which is responsible for biogas production.

Exponential phase: This phase is observed from day 18 and continues until day twenty-seven. Production conditions are reached, making it possible to achieve the largest quantities of biogas, with a maximum daily production of 750 ml observed on day 20.

Stationary phase: This is the phase when biogas production became slow and then stopped. This phase was noticeable from the twenty-seventh day of our experiment, probably due to the exhaustion of the biodegradable substrate, which is the nutrient and energy source for the microbiological flora, particularly the methanogenic flora, which is directly responsible for biogas production.

A high methane content (50-65% CH_4) was reported during cow dung fermentation. Thus, based on the experimental digestion set-up, thermophilic fermentation (55°C) carried out in batch digester using cow dung produced 4.55 liters of biogas during a residence time of 32 days corresponding to a total biogas potential of 50.55 L/kg of dried substrate.

4. CONCLUSION

The cumulative biogas production reached more than 50.55 L/kg of dried substrate, which remain an interesting yield for cow dung substrate. The physico-chemical characteristics of the considered substrate have a substantial impact on the amount of methane produced from cow manure during anaerobic digestion. This Algerian feedstock exhibit an interesting potential for bioenergy production. However, it is shown that the resulted digestate obtained in a small glass reactor is still with high organic content due to the limited mixing quality. This digestate can be used as bio-fertilizer to improve arid soil quality. The buffering capacity observed in cow dung anaerobic digestion indicate a promising potential to use this substrate in co-digestion process namely for acidic substrate such as chees-whey and household wastes.

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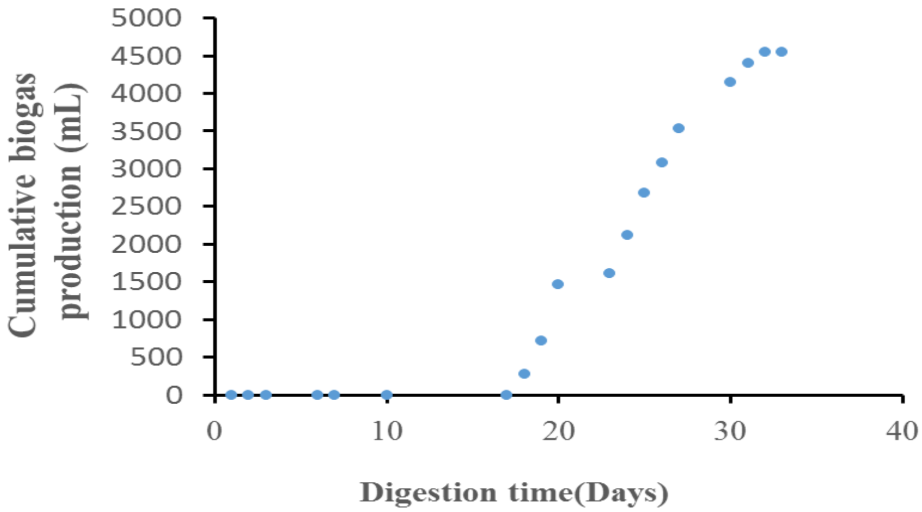
NOMENCLATURE

COD	Chemical oxygen demand [mgO_2/L]	VS	Total volatile solids
T	Temperature [°C]		Total Biogas Potential [L/kg]
TS	Total solids [%]	GHG	Greenhouse Gas
CO_2	Carbon dioxide		



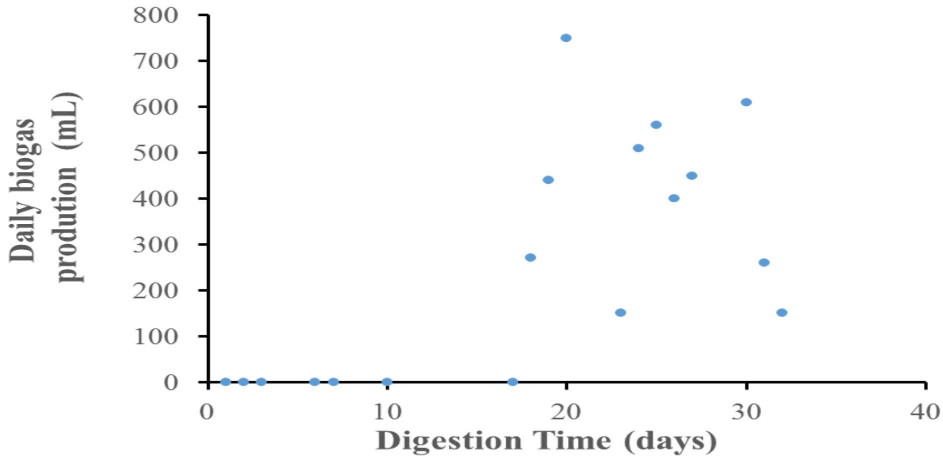


Fig. 4.Cumulative biogas production (top), Daily biogas production (down).

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