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Optimization of key factors affecting biogas production from milk waste using experimental design

Benmehdi Houcine*[1], Bensmail Larbi[2], Bentaleb Zahra[3], Khoudja Salim[3], Lasbet Mohamed[3]

[1]*Laboratory of Chemistry and Environmental Sciences, University of TAHRI Mohamed-Bechar, P.O. Box 417, Bechar*
[2]*Laboratory of ENERGARID, University of TAHRI Mohamed-Bechar, P.O. Box 417, Bechar 08000, Algeria*
[3]*Faculty of technology, University of TAHRI Mohamed-Bechar, P.O. Box 417, Bechar 08000, Algeria*
Corresponding author: h_ben90@yahoo.fr

***Abstract*— The study was undertaken at Bechar University and focuses on production of biogas as an alternative energy by using milk waste of Igli milk factory. The optimization of the factors affected the anaerobic digestion using experimental design gave the following results: pH = 7.5, temperature (T= 38°C) and moisture content 90%. The application of these parameters conducted to an excellent production of the biogas. The experiments were carried out in two digesters and daily gas yield from milk waste was monitored for 70 days and the total volume of gas production was found to be 25.472 L. The measurement of the percentages of the essentials nutriments needed for the biomethanization gave the values of 48.28%, 2.857% (75.65 mg / kg P) and 5.56% for the total organic carbon, phosphorus and nitrogen, respectively. The biogas formed is flammable, so very rich in methane (62%).**

***Keywords*— milk waste, experimental design, biogas, anaerobic digestion, parameters**

I. INTRODUCTION

Anaerobic digestion has a number of environmental benefits including production of 'green' energy and natural fertilizers. The process of converting biodegradable wastes into biogas can serve as a substitute for fossil fuels and artificial fertilizers, reducing the amount of greenhouse gases released into the atmosphere [1,5].

Milk waste in Igli urea contain 50-60% of organic waste. This portion can be treated using anaerobic biological treatment to produce biogas such as methane. However, there are a large number of factors that affect biogas production efficiency such as digester temperature, volatile solids input, pH, Temperature, moisture rate and retention time.

With regard to the Igli dairy unit, and for several years, discharges of wastes from the treatment station are to the vicinity of the diary unit, the farmer exploiting it as fertilizer. In order to address this concern, we have been entrusted the determination of performance for energy recovery of this waste and the study of its physico-chemical characteristics for biogas production.

II. MATERIALS AND METHODS

Harvest waste was carried out at the dairy Igli unit in March 2016. After the cleaning process, the waste is ground and preserved in glass bottles until required.

A. Optimisation des paramètres physico-chimiques pour la production du biogas (pH, T, Humidité)

The optimisation and measurement of the pH, temperature and moisture content were carried out using experimental setup shown in the figure 1. This later measure the height of displaced water during the anaerobic digestion [2].

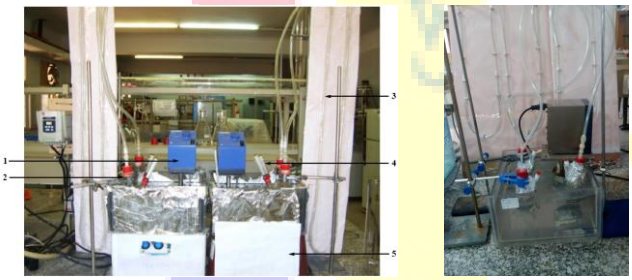

Fig.1 Digesteur pilote 1 (1. Therrlostat, 2. Flask (digester), 3. Graduated tube in U form, 4. Syringe, 5. Water bathter).

Experimental design has been used for the optimisation of parameters affecting biogas generation as described below.

Parameters	-1	0	+1
pH	4.5	6.5	8.5
T (°C)	26	42	58
H (%)	70	81	92

N° (Experience)	Matrix code vrs parameters		
01	-1	-1	-1
02	+1	-1	-1
03	-1	+1	-1
04	+1	+1	-1
05	-1	-1	+1
06	+1	-1	+1
07	-1	+1	+1
08	+1	+1	+1
09	0	0	0

For the analyses of the results, a Mode 5 software has been used.

B. Daily Kinetic monitoring of biogas production

About 222g of the waste milk were diluted with distilled water (2L). The experiment was operated at the thermophilic temperature (38-42°C); pH (6.5– 8.5) and moisture rate of 90-92% . The experiment was conducted for residence time of 70 days (figure 2).

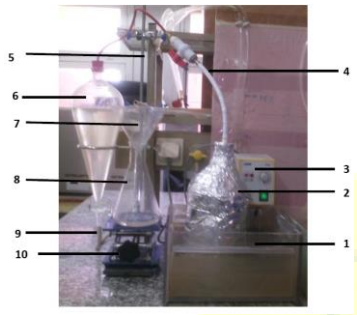

Fig. 2 Digestor pilote 2

C. Production and generation of biogas

The experiment of anaerobic digestion of the substrate is carried out using an experimental device as shown in figure 3. The experiment is conducted for residence time of 70 days.

Fig. 3 Digestor pilote 3

D. Analysis of generated biogas

The obtained biogas was analysed *via* GEM500-Geotech apparatus.

Fig. 4 Bioga analyzer

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IV. RESULTS AND DISCUSSION

A. Determination of some parameters of milk wast

As seen in table I, some parameters of milk wast were determined.

Parameters	Pourcentage (%)
Residual Humidity (RH)	8,58
Dry Matter (DM)	91,42
Organic Matter (OM)	71
Ash	27,2

As described in table I, the waste under study is rich in organic matter which make it an important source of methane.

B. Determination of nutrients rate (Carbon, Nitrogen and Phosphorus)

The determination of the concentrations of the nutrients in the substrate gave the percentages of 48.36%, 5.56% and 1.83 mg/kg P for the total carbon, nitrogen and phosphorus, respectively [3,4].

C. Optimisation of physico-chemical parameters for the production of biogas (pH, T, Humidity)

In the present study, the optimisation of the pH, temperature and moisture rate parameters using Mode 5 software gave the values of 8.5-7,5, 38-42°C and 90-92%, respectively.

The evolution of the volume of biogas formed during the anaerobic digestion of organic materials from the milk waste over time is shown in Figures 1 and 2.

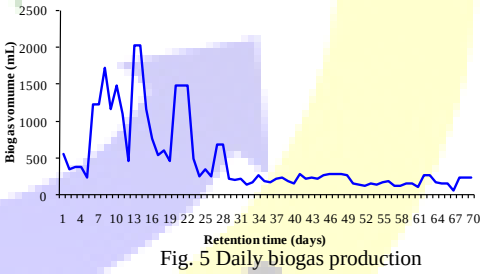

Fig. 5 Daily biogas production

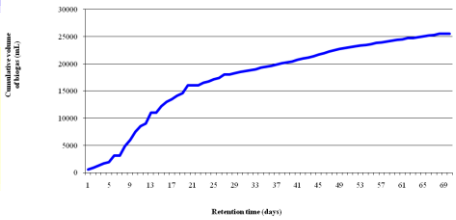

Fig. 6 Cumulated volume of biogas = f (days)

It should be noted that during a period of 70 days, a volume of 25.472 liters was generated from 222 g of the milk waste.

D. Analysis of the generated biogas

The analysis of the composition of the biogas shown in table II, revealed that the biogas is rich in methane with percentage of 63.6% followed by CO_2 with 29.3%.

E. Flammability test

The flammability test was performed successfully on the biogas formed (Figure 3). The blue color of flame confirmed well that this biogas is reaching in methane thane other constituents such as CO_2, O_2, H_2S…etc

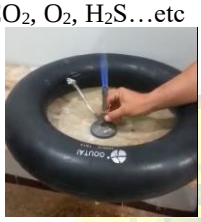

Fig. 8 Flammability test of the biogas

III. Conclusions

In the present study, anaerobic digestion process led to the production of biogas from milk waste. Several factors affecting the volume yield of biogas production have been optimized in this work such as temperature, pH, moisture content and nutrients rate. The flammability test and anlaysis of the generated biogas showed that this latter is rich in methane (63.6%). This research revealed further that milk waste has great potentials for generation of biogas and its use should be encourage due to high volume of biogas yields (25.472 litres).

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