The Pharma Innovation Journal 2022; SP-11(12): 590-595

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(12): 590-595

www.thepharmajournal.com
Received: 22-10-2022
Accepted: 29-11-2022

Viresh Kumargoud
Project Coordinator, Biogas Development and Training Centre, UAS, GKVK, Bangalore, Karnataka, India

SR Meena
Scientist, Ministry of New & Renewable Energy, Govt. of India, New Delhi, India

Pabitra Mohan Barik
Scientist, Ministry of New & Renewable Energy, Govt. of India, New Delhi, India

Shrinivas Deshpande
Scientist, Department of Agriculture Engineering, ICAR-Krishi Vigyan Kendra, Kandali, Hassan, Karnataka, India

Corresponding Author:
Viresh Kumargoud
Project Coordinator, Biogas Development and Training Centre, UAS, GKVK, Bangalore, Karnataka, India

Development and application of biogas technology for the remediation of poultry excrement: A case study

Viresh Kumargoud, SR Meena, Pabitra Mohan Barik and Shrinivas Deshpande

Abstract
The use of biogas technology offers the potential to increase rural energy availability while reducing dependency on fossil fuels. This technique is crucial, particularly in rural regions where there are sometimes energy shortages. In addition to being converted into power for use in industry, biogas may be utilised for heating and cooking in residential settings. The purpose of this study was to see whether Bharat Agro Vet Industries could generate energy and biogas from chicken waste. A appropriate technique for turning trash into biogas is described along with an estimation of the amount of waste produced by chicken raising. The amount of power produced from the poultry waste was then calculated. A 62.50 HP biogas generator working for 10–12 hours per day produces 680 units of energy per day when fed 5–6 tonnes of chicken waste each day. The use of this technology results in annual fuel savings of 113150 ltr. and annual LPG savings of 78475 kg. The project will meet all of the industry's energy needs for 54.50 lakhs with a payback time of 2.58 years.

Keywords: Biogas technology, poultry waste, electricity, biogas generator and payback period

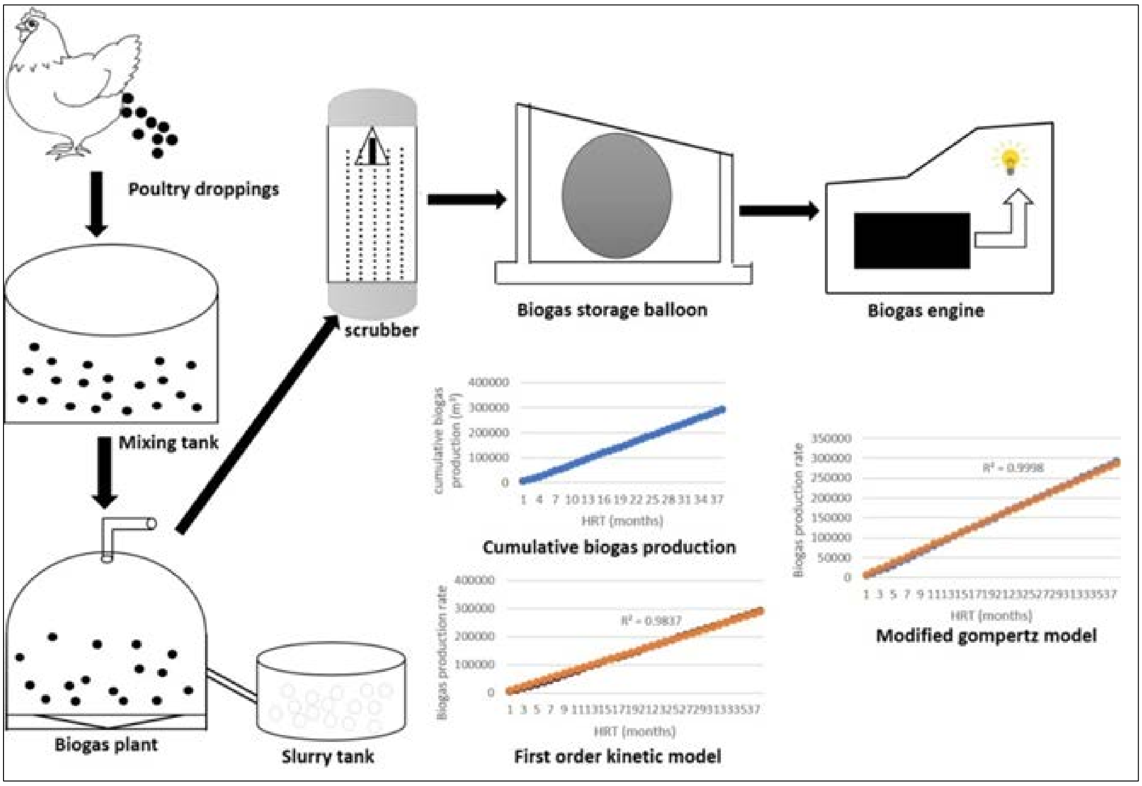
1. Introduction
The exponential growth of the world's population has led to a host of problems, the most significant of which are energy security and ecological worries (Zhang and Xu, 2020) [18]. (Kavan Kumar et al., 2021) [8]. When opposed to coal-fired power generation, the production of biogas has significant environmental advantages. Biogas production is developing into a fantastic method for greener manufacturing by taking into account the need for energy and the creation of surplus trash (Holm-Nielsen et al., 2009) [7]. Since the previous two decades, awareness of the anaerobic digestion process has grown. A practical method for waste stabilization and energy generation in the form of biogas for industrial use will be the manufacture of biogas from chicken waste (Kumar et al., 2022) [9]. Technology for producing biogas not only provides energy but also fertilizer for the land (Chen et al., 2017) [3]. The anaerobic digestion of wastes can create biogas, which has the potential to lower greenhouse gas emissions (Lyng et al., 2018) [15]. Despite its advantageous environmental and economic assessments, which were given in table.1, which is the future study direction for power production projects, biogas power production projects are only often employed in industrialized nations (Govender et al., 2019) [6]. (Cucchiella et al., 2019) [4]. Another possible feedstock for the creation of biogas is poultry waste. Therefore, the capacities of the poultry waste are developed in this study.

2. Materials and Methods
2.1 Location of the study
In this study, Bharat Agro Vet Industries, Hacha Gondanahalli, Hosakote Hobli, Alur Taluk, Hassan District was selected for the installment of 500 m^3 capacity/day biogas plant for the performance evaluation under the public private partnership for installation of the biogas plant and generation of electricity by utilizing poultry industrial waste with central financial assistance from Ministry of New and Renewable Energy (MNRE)-Govt. of India.

2.2 Physico-chemical properties of poultry droppings
The collection of chicken droppings was gathered from the targeted industry and kept at room temperature before being characterized. The American Public Health Association's standard techniques for water and wastewater (Apha, 1998) [2] were used to determine the pH, total solids (TS), volatile solids (VS), total kjeldahl nitrogen (TKN), chemical oxygen demand (COD), and total organic carbon (TOC) (Walkley and Black, 1934) [17].

2.3 Design of experiment

The amount of organic industrial waste produced is influenced by a variety of variables, including dietary preferences, level of living, intensity of commercial activity, and seasons. Planning for collection and disposal systems can benefit from information on amount fluctuation and generation. Under the financial support of MNRE, a 500m^3 biogas plant based on UASB technology was created at the chosen location with daily feeding of 5–6 tonnes of chicken waste. To create power, a generator is supplied with collected, cleaned biogas. The produced electricity is delivered to Bharat Agro Vet Industries' chicken processing facility in Hassan for the operation of the feeding unit, the operating of the grinder and chaff cutter, the processing machine, and captive consumption. They are using the power they produced for 10 to 12 hours every day. Figure 1 depicts the general layout and process flow of the biogas power production facility.



Graphical Abstract

Table 1: State-wise power generation under waste to energy programme in India 2012-2013 to 2014-2015

States/UT	Estimated Power Generation (In Million Units)
Andhra Pradesh	1161.62
Bihar	15.76
Chhattisgarh	8.67
Delhi	355.94
Gujarat	249.68
Haryana	63.07
Himachal Pradesh	10.50
Karnataka	167.73
Madhya Pradesh	69.00
Maharashtra	543.36
Punjab	271.68
Rajasthan	58.34
Tamil Nadu	333.49
Uttar Pradesh	728.08
Uttarakhand	79.15
West Bengal	18.38
India	4134.45

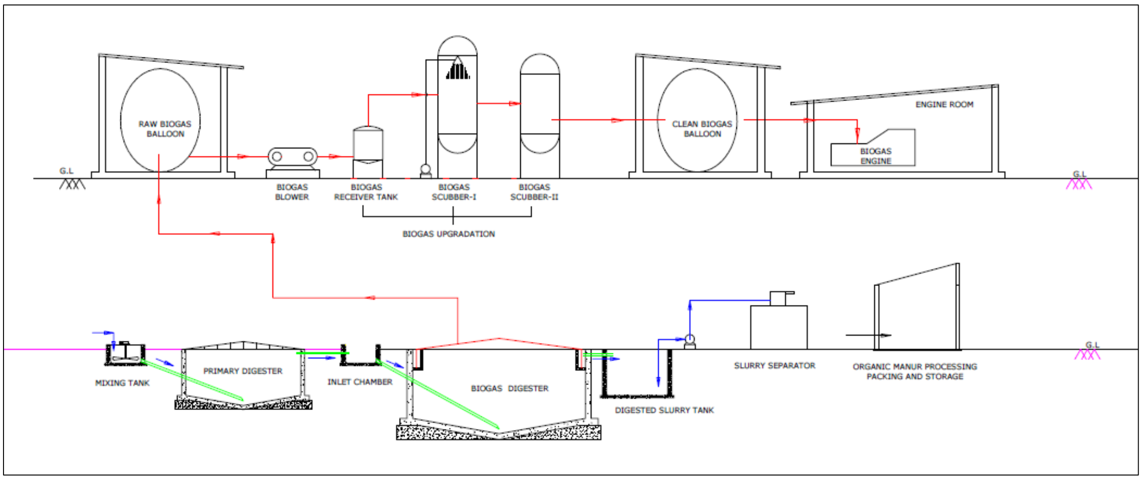


Fig 1: Setup of the 500m^3 biogas plant

2.4 Kinetic model study

According to Lopez et al. (2002), kinetic research is a commonly used concept for assessing the applicability of interactions between variables in order to direct experimental design, assess experimental findings, and define particular system performance. It is possible to simulate digester behaviour and forecast the biogas production of a running plant using the findings of experimental kinetic studies (Lim et al., 2021) [13]. A first order model and modified Gompertz models were used in this work to forecast biogas output and evaluate kinetic parameters. The parameters were predicted using non-linear regression using the IBM SPSS software 25.0 and the experimental cumulative biogas.

2.4.1 First order kinetic model

The first order kinetics equation is used to predict the biogas yield production (Membere and Sallis, 2018) [16] (Lafratta et al., 2021) [10].

$$P = Po * (1 - EXP(-k * t))$$

Where, k is the first order rate constant, P is the cumulative biogas production, P_o is the final biogas yield, and t is the period. In order to calculate the rate of reaction using first order kinetics, an empirical linear regression was utilized. The features of the substrate were represented by the slope of the linear plot (Angelidaki et al., 2009) [1]. However, following the exponential phase, the first order model's linear form, which is an exponential form, cannot be utilized to properly account for and anticipate cumulative biogas output (Li et al., 2011) [12].

2.4.2 Modified Gompertz model

The Modified Gompertz model is a non-linear kinetic model which is used to calculate length of lag phase, biogas production rate.

$$P = Po * EXP(-EXP(((R * 2.7183)/Po) * (L - t) + 1))$$

In the following equation L is the lag phase duration, R is the biogas production rate and P_o is the biogas potential at time. The standard statistical metric used to study the model performance (Lahbab et al., 2021) [11].

3 Results and Discussion

3.1 Physico-chemical properties of poultry droppings

The poultry droppings is selected as feedstock and the characterization of the feedstock was done as per the standard procedures and the results were mentioned in the Table 2. The influent and effluent pH of the poultry droppings as an average value was shown in the Fig 2 as given below which is an essential for the biogas production.

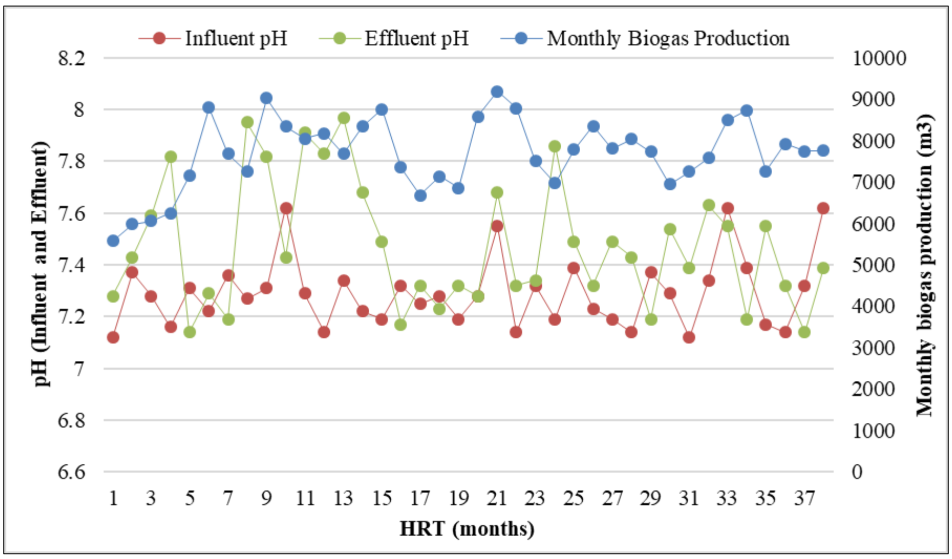


Fig 2: Average influent and effluent pH and monthly biogas production from poultry droppings

Table 2: Physico-chemical properties of poultry droppings

Parameter	Fleshing
pH	7.2-7.9
Total solids (%)	17.4±0.60
Volatile solids (%)	37.5±0.35
Chemical Oxygen Demand (g/g)	1.03±0.01
Total Organic Carbon (g/kg)	36.8±0.34
Total Kjeldahl Nitrogen (g/kg)	9.62±0.13
C:N ratio	3.82

3.2 Working of the biogas plant
A 62.50 HP biogas generator is installed and works for 10–12 hours per day, producing up to 680 electrical units per day. The energy produced is equal to the 215 kg of LPG per day that 3 ton of organic manure per day likewise produces. The table displays the work's Table 3.

Table 3: Particulars of biogas plant installed

Design capacity	500m^3 biogas/day
Feed material	Poultry droppings
Electricity generation	620-680 electrical units/day runs for 10-12 hrs
Energy yield	Equivalent to 215 kg LPG/day
Organic manure	3 tonnes/day
Total project cost	Rs. 54.50 lakhs

3.3 Daily biogas production
The daily biogas production was measured and the cumulative biogas production values are shown in the Fig. 3.

3.4 Kinetic model studies
First order kinetics and a modified Gompertz model were used to conduct a kinetic research for the cumulative biogas output from the biogas plant. Non-linear regression was used to calculate the kinetic constants of the models. The Tables 4 and 5 show the findings of the kinetic investigations, respectively. In figures 4 and 5, the cumulative biogas production's experimental and anticipated values were compared.

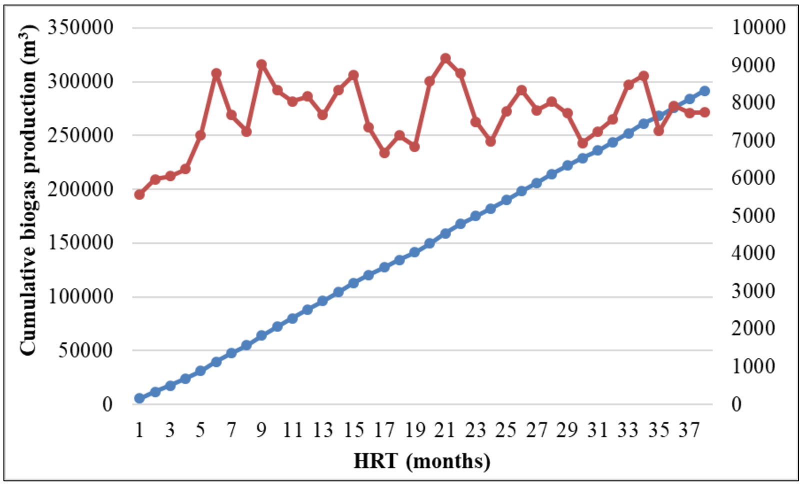


Fig 3: Monthly and cumulative biogas production from poultry droppings

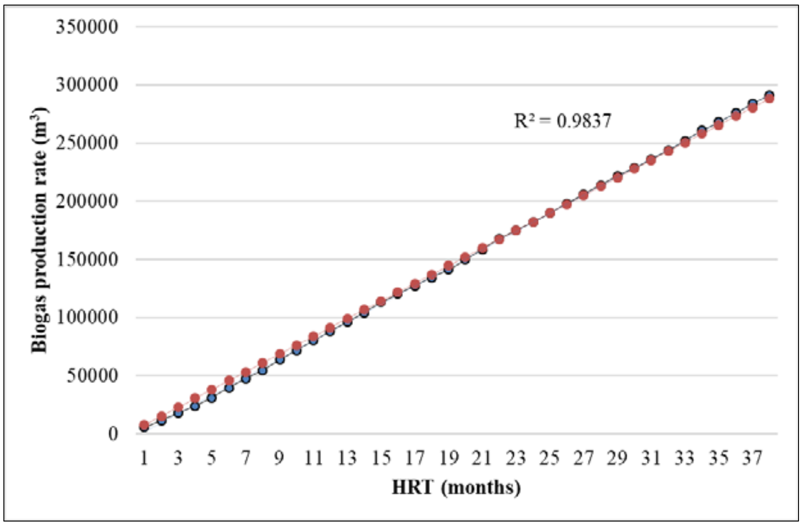


Fig 4: Comparison of experimental data and the first order kinetic model predicted values.

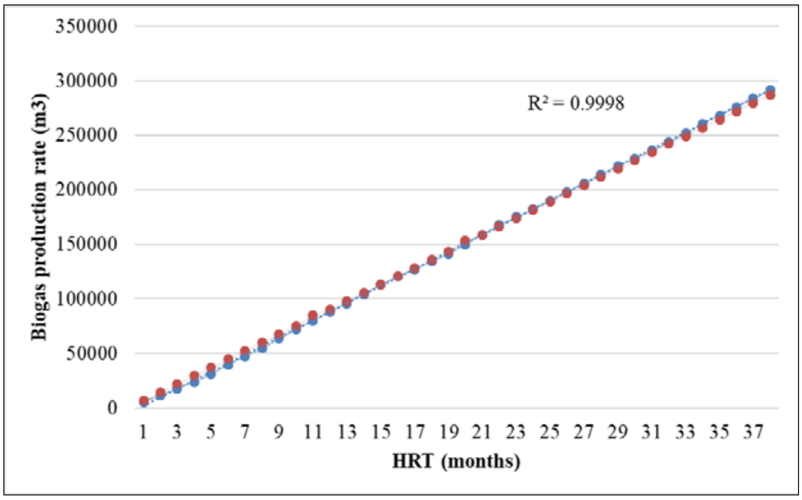


Fig 5: Comparison of experimental data and the Modified Gompertz model predicted values

Table 4: Results of kinetic study – first order kinetic model

Kinetic model	First order kinetics
C- experimental	291640.6
C- predicted	287229.8
k	0.017
R^2	0.9837

Table 5: Results of kinetic study – modified gompertz kinetic model

Kinetic model	Modified Gompertz model
C- experimental	291640.6
C- predicted	288229.8
P	291984.3
R	279.70
L	1.77
R^2	0.9998

From the above kinetic models, it shows that the experimental biogas yield from the biogas plant is 291640.6 m^3. The predicted biogas yield based on first order kinetics was287229.8 m^3 with a rate constant of 0.041 and the biogas yield from Modified Gompertz model was 288229.8 m^3 with a production rate of 279.70 m^3/day with a lag phase of 2.77. based on the results obtained from these models modified gompertz model is best suitable for this study than the first order kinetic model (Deepanraj et al., 2015) [5].

3.5. Environment Impact of the Project

In terms of greenhouse gas emissions, biogas systems having two significant consequences first and foremost, biogas is 21 times more effective than CO_2 at reducing methane emissions that occur during the storage of animal waste. Second, converting biogas to electricity minimises CO_2 emissions created by fossil fuels. The environment impact of biogas was given in the Table 6.

Table 6: Environment impact of the biogas technology

Annual greenhouse gas (GHG)emissionreduction of CO_2 (tons/year)	2500
Saving of firewood (tons/year)	638
Generation of electricity (units/year)	680
Generation of organic-manure (tons/year)	3246
Saving of forest (ha/year)	5
Annual saving of trees (Nos)	916
Total kg of CO_2 absorb/year	19785
Replacement of diesel (ltr/year)	113150
Replacement of LPG (kg/year)	78475

3.6 Cost economics of the study

In the case of biogas plants, a detailed cost economics was elaborated to analyze the payback period of biogas generation plant. The complete details of the cost are shown in Table 7.

Table 7: Cost economics of the biogas generation plant

	1-year	3-years
Revenue generation		
Cost of electricity @ Rs. 7.00/kWh (7×620×30)	15,62,400.00	46,87,200.00
Cost of organic manure @ Rs.2000/ton (3t×2000×30)	21,60,000.00	64,80,000.00
Total cost	37,22,400.00	1,11,67,200.00
Operation and maintenance cost		
Cost of organic waste @ Rs.0.5/kg (0.5×5000×30)	9,00,000.00	27,00,000.00
Cost of labour @ Rs. 6000/month	72,000.00	2,16,000.00
Auxiliary consumption	18,000.00	54,000.00
Total	9,90,000.00	29,70,000.00
Payback period (years)	2.58	

4. Conclusion

The benefits of biogas power generation from the poultry waste were generated 680 units of electricity to run a 62.50 HP biogas generator for 10-12 hours. The biogas power generations are independence from the irregular and costlier state grid power, ensure continuity of electricity due to self-efficiency in power generation. This technology is environment friendly and also ensure for good quality organic manure. The cost of the project is Rs. 54.50 lakhs and payback period was about 2.58 years.

5. References

1. Angelidaki I, Alves M, Bolzonella D, Borzacconi L, Campos JL, Guwy AJ, et al. Defining the biomethane potential (BMP) of solid organic wastes and energy crops: a proposed protocol for batch assays. Water Sci. Technol. 2009;59:927-934.
2. Apha A. Standard methods for the examination of water and wastewater, 20. Washington, DC Am. Public Heal. Assoc; c1998.
3. Chen L, Cong R-G, Shu B, Mi Z-F. A sustainable biogas model in China: The case study of Beijing Deqingyuan biogas project. Renew. Sustain. Energy Rev. 2017;78:773-779.

4. Cucchiella F, D'Adamo I, Gastaldi M. An economic analysis of biogas-biomethane chain from animal residues in Italy. J Clean. Prod. 2019;230:888-897.
5. Deepanraj B, Sivasubramanian V, Jayaraj S. Kinetic study on the effect of temperature on biogas production using a lab scale batch reactor. Ecotoxicol. Environ. Saf. 2015;121:100-104.
6. Govender I, Thopil GA, Inglesi-Lotz R. Financial and economic appraisal of a biogas to electricity project. J Clean. Prod. 2019;214:154-165.
7. Holm-Nielsen JB, Al Seadi T, Oleskowicz-Popiel P. The future of anaerobic digestion and biogas utilization. Bioresour. Technol. 2009;100:5478-5484.
8. Kavan Kumar V, Mahendiran R, Subramanian P, Karthikeyan S, Surendrakumar A. Deliming process of leather fleshings as lime free feedstock for biomethanation process in tannery industry, 2021.
9. Kumar VK, Mahendiran R, Subramanian P, Karthikeyan S, Surendrakumar A. Optimization of inoculum to substrate ratio for enhanced methane yield from leather fleshings in a batch study. J Indian Chem. Soc; c2022. p. 100384.
10. Lafratta M, Thorpe RB, Ouki SK, Shana A, Germain E, Willcocks M, et al. Development and validation of a dynamic first order kinetics model of a periodically operated well-mixed vessel for anaerobic digestion. Chem. Eng. J. 2021;426:131732.
11. Lahbab A, Djaafri M, Kalloum S, Benatiallah A, Atelge MR, Atabani AE. Co-digestion of vegetable peel with cow dung without external inoculum for biogas production: Experimental and a new modelling test in a batch mode. Fuel. 2021;306:121627.
12. Li C, Champagne P, Anderson BC. Evaluating and modeling biogas production from municipal fat, oil, and grease and synthetic kitchen waste in anaerobic co-digestions. Bioresour. Technol. 2011;102:9471-9480.
13. Lim YF, Chan YJ, Abakr YA, Sethu V, Selvarajoo A, Singh A, et al. Evaluation of potential feedstock for biogas production via anaerobic digestion in Malaysia: kinetic studies and economics analysis. Environ. Technol; c2021. p. 1-18.
14. López I, Benzo M, Passeggi M, Borzacconi L. A simple kinetic model applied to anaerobic digestion of cow manure. Environ. Technol. 2021;42:3451-3462.
15. Lyng K-A, Stensgård AE, Hanssen OJ, Modahl IS. Relation between greenhouse gas emissions and economic profit for different configurations of biogas value chains: A case study on different levels of sector integration. J Clean. Prod. 2018;182:737-745.
16. Membere E, Sallis P. Effect of temperature on kinetics of biogas production from macroalgae. Bioresour. Technol. 2018;263:410-417.
17. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 1934;37:29-38.
18. Zhang C, Xu Y. Economic analysis of large-scale farm biogas power generation system considering environmental benefits based on LCA: A case study in China. J Clean. Prod. 2020;258:120985.