

Comparison of kinetic model for biogas production from corn cob

By Lukhi Mulia

PAPER • OPEN ACCESS

Comparison of kinetic model for biogas production from corn cob

To cite this article: L M Shitophyta and Maryudi 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **345** 012004

View the [article online](#) for updates and enhancements.

Related content

- [Effect of temperature on methanogenesis stage of two-stage anaerobic digestion of palm oil mill effluent \(POME\) into biogas](#)
B Trisakti, Mahdalena Irvan, Taslim et al.
- [Effect of cellulose nanocrystals from corn cob with dispersion agent polyvinyl pyrrolidone in natural rubber latex film after aging treatment](#)
H Harahap, M Ridha, Halimatuddahlia et al.
- [Influence of Nutrient Impregnated into Zeolite Addition on Anaerobic Digestion of Palm Oil Mill Effluent \(POME\)](#)
M Mellyanawaty, F M A Chusna, H Sudibyo et al.

Comparison of kinetic model for biogas production from corn cob

L M Shitophyta and Maryudi

Department of Chemical Engineering, Faculty of Industrial Technology, Universitas Ahmad Dahlan, Postal Code 55164, Yogyakarta, Indonesia

E-mail: lukhi.mulia@che.uad.ac.id

Abstract. Energy demand increases every day, while the energy source especially fossil energy depletes increasingly. One of the solutions to overcome the energy depletion is to provide renewable energies such as biogas. Biogas can be generated by corn cob and food waste. In this study, biogas production was carried out by solid-state anaerobic digestion. The steps of biogas production were the preparation of feedstock, the solid-state anaerobic digestion, and the measurement of biogas volume. This study was conducted on TS content of 20%, 22%, and 24%. The aim of this research was to compare kinetic models of biogas production from corn cob and food waste as a co-digestion using the linear, exponential equation, and first-kinetic models. The result showed that the exponential equation had a better correlation than the linear equation on the ascending graph of biogas production. On the contrary, the linear equation had a better correlation than the exponential equation on the descending graph of biogas production. The correlation values on the first-kinetic model had the smallest value compared to the linear and exponential models.

1. Introduction

The rising impact of fossil energy consumption on global climate patterns and the environment has initiated the invention of renewable energy sources. Biomass is a type of renewable energy which has zero carbon emission [1]. Biomass can be converted into biofuel such as biogas by anaerobic digestion. Biogas is a mixture composed of methane (CH_4), carbon dioxide (CO_2), hydrogen (H_2), nitrogen (N_2) and hydrogen sulfide (H_2S) [2]. Anaerobic digestion is a process that breaks down organic matter through the action of microorganisms [3]. The steps of biomass conversion into biogas consist of three stages, i.e. hydrolysis, acid formation, and methane production [4].

Corn cob can be used as a raw material for biogas production. Corn cob is one of the agricultural wastes which is widely available in Indonesia. The total production of corn in Indonesia is 19.61.435 in 2015 [5]. Corn is also considered as an important agricultural crop for over 70 million farm families worldwide [6]. In addition to corn cob, food waste can also be used as biogas feedstock. Currently, food waste only is utilized as animal feedstock or landfilling, as a result, it causes serious health and environmental problems [7]. Food waste has high organic and moisture content [8]. Several factors which affect biogas production include temperature, pH, Carbon/Nitrogen ratio, total solid, volatile solid [9]. This study concentrated on the kinetic rate of biogas production at the variation of total solid (TS) content. Hence, the objective of this research was to compare kinetic models of biogas production from corn cob.



5

2. Material and methods

2.1. Feedstock and inoculum

Corn cob was dried and chopped into 2-3 cm then stored at room temperature. Corn cob was used as feedstock. Food wastes were used as co-digestion. Cow's rumen was used as an inoculum.

5

2.2. Solid-state anaerobic digestion

Corn cob, food waste, and inoculum were mixed and loaded into 2 L digester. Water was added to adjust TS content of 20%, 22%, and 24%. This research was conducted at room temperature and neutral pH. Biogas volume was measured every 2 days by water displacement method.

4

3. Kinetic model for biogas production

The kinetic of biogas production was modeled by linear and exponential equations. On the linear equation, the rate of biogas production will increase along with the increase of time, then it attains a peak value and decreases linearly to a zero point. The linear equation is stated as follows [10] :

2

$$y = a + bt \quad (1)$$

where, y = the biogas production rate (ml/g/day); t = the biogas production time (day); a = the intercept (ml/g/day); b = the slope (ml/g/day). On the ascending graph of biogas production, b is positive, while on the descending graph, b is negative.

On the exponential equation, the rate of biogas production increases exponentially with the digestion time. After reaching a peak value, it will decrease exponentially to a zero point. The exponential equation is expressed as follows [11] :

8

$$y = a + b \exp(ct) \quad (2)$$

2

where, y = the biogas production rate (ml/g/day); t = the biogas production time (day); a , b = constants (ml/g/day); c = constant (ml/g/day). c will be positive on the ascending graph of biogas production, while c will be negative on the descending graph.

The kinetic of biogas production can be also modeled using first-order kinetic model as performed previously by Brown et al [12]. The first-kinetic model is stated as follows

$$\ln \left(\frac{y_m}{y_m - y_t} \right) = kt \quad (3)$$

where, y_m = biogas yield obtained in 40 days (ml/g/day); y_t = biogas yield obtained at the time t (ml/g/day); k = biogas rate constant (1/day); t = biogas production time (t)

4. Results and discussion

The kinetic of biogas production was performed by linear and exponential equation models. The kinetic study was divided into two rate periods, namely the ascending rate period and the descending rate period. The linear graph of biogas production is shown in Figure 1.

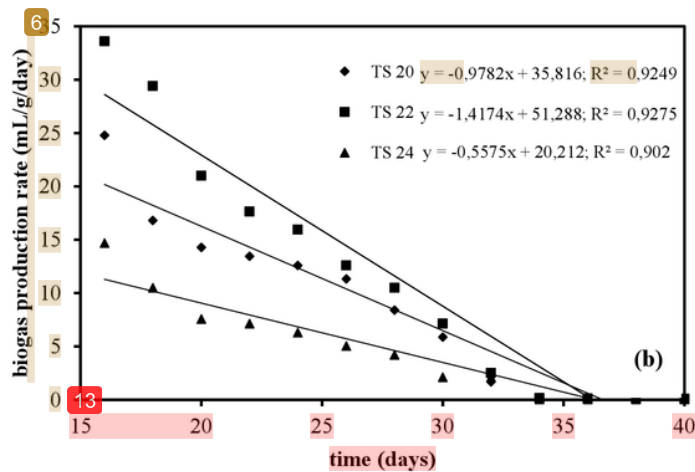
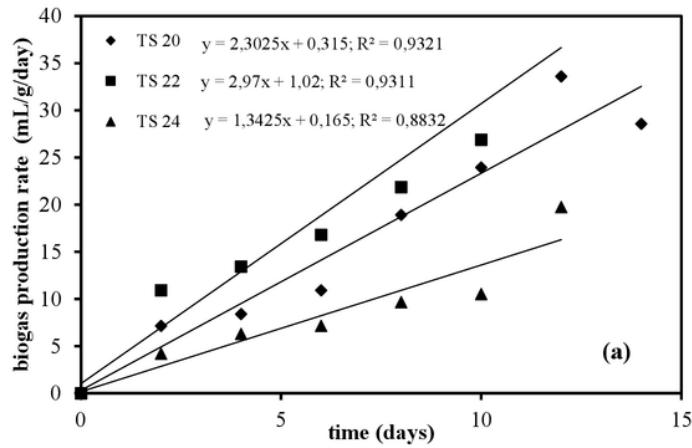


Figure 1. The linear graph of biogas production rate (a) the ascending period of biogas production rate (b) the descending period of biogas production rate.

Figure 1a and 1b shows the linear graph of biogas production rate at the TS contents of 20%, 22%, and 24%. As shown in Fig. 1(a), the regression coefficient (R^2) ranged from 0.88 to 0.93, while in Fig. 1(b) the R^2 ranged from 0.90 to 0.92.

The descending biogas production graph of the linear equation had the $R^2 > 0.9$ at the TS contents of 20%, 22%, and 24%. On the contrary, the ascending biogas production graph obtained the $R^2 > 0.9$ only at TS contents of 20% and 22%.

The exponential graph is presented in Figure 2.

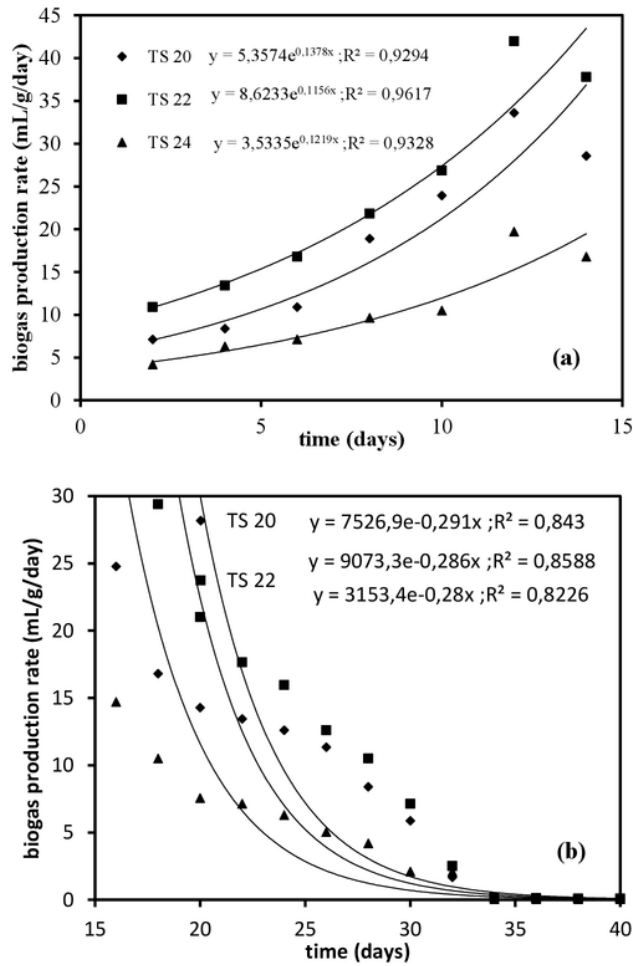


Figure 2. The exponential graph of biogas production rate (a) the ascending period of biogas production rate (b) the descending period of biogas production rate.

As presented in Figure 2, the R² ranged from 0.82 to 0.96. The R² on the ascending graph using exponential equation was greater than the R² on the ascending graph using linear equation. Therefore, the exponential equation had a better simulation than the linear equation on the ascending graph. The similar result was also reported by Lo et al. [11] who stated that the exponential equation model had a larger R² compared to the linear equation model.

On the ascending graph of the exponential equation, the R² > 0.9 was obtained at TS contents of 20%, 22%, and 24%, but on the descending graph of the exponential equation had the R² < 0.9. As seen in Figure 2b, the R² on descending graph was smaller than descending graph using linear equation. Therefore, the linear equation had a better simulation than the exponential equation on the

12

descending graph of biogas production. The rate constants of biogas production by the first-kinetic model is shown in Table 1.

Table 1. The rate constants and regression coefficient of biogas production from corn cob by a first kinetic model

TS contents (%)	k (1/day)	R ²
20	0.2219	0.8351
22	0.2160	0.8477
24	0.2114	0.8461

11

The value of k represents the rate constant of biogas. As shown in Table 1, the greatest value of k was obtained at TS content of 20%. However, the value of R² had a smaller value compared to the value of R² using linear and exponential models. Therefore, the kinetic of biogas production from corn cob was more suitable modeled by linear or exponential models compared to the first-kinetic model

1 Conclusions

The exponential equation has a better correlation value than the linear equation during the ascending period of biogas production. While linear equation has better correlation than exponential equation on the descending period of biogas production. The R² obtained by first-order kinetic model has the smallest value than both linear and exponential models.

References

- [1] Poudel J and Oh S C 2014 Effect of torrefaction on the properties of corn stalk to enhance solid fuel qualities *Energ.* **7** 5586-5600
- [2] Eze J I and Ojike O 2012 Anaerobic production of biogas from maize wastes *Int. J. Phys. Sci.* **7** 982-987
- [3] Grando R L, Valeria F, Maria A, and Antunes D S 2017 Mapping of the use of waste as raw materials for biogas production *J. Environ. Prot.* **8** 120-130
- [4] Horváth I S, Tabatabaei M, Karimi K, and Kumar R 2016 Recent updates on biogas production - A review *Biofuel Res. J.* **10** 394-402
- [5] BP Statistical 2016 *BP Statistical Review of World Energy*, June 2016
- [6] Zhang Y, Ghaly A E and Li B 2012 Physical properties of corn residues *Am. J. Biochem Biotechnol.* **8** 44-53
- [7] Mir M. A, Hussain A, and Verma C 2016 Design considerations and operational performance of anaerobic digester : A review *Cogent Eng.* **28** 1-20
- [8] He M, Sun Y, Zou D, Yuan H, Zhu B, Li X, and Pang Y 2012 *Proc. Int. Conf. on Waste Management and Technology* vol 16 (Procedia Environmental Sciences) p 85-94
- [9] Length F 2013 A comparative study of biogas production using plantain/ almond leaves and pig dung, and its applications *Int. J. Phys. Sci.* **8** 1291-1297
- [10] Ghatak M D and Mahanta P 2014 Comparison of kinetic models for biogas production rate from saw dust *Int. J. Res. Eng. Technol.* **3** 248-254
- [11] Lo H M, Kurniawan T A, Sillanpaa M E T, Pai T Y, Chiang C F, Chao K P, Liu M H, Chuang S H, Banks C J, Wang S C, Lin K C, Lin C Y, Liu W F, Cheng P H, Chen C K, Chiu H Y, and Wu H Y 2010 Modeling biogas production from organic fraction of MSW co-digested with MSWI ashes in anaerobic bioreactors *Bioresour. Technol.* **101** 6329-6335
- [12] Brown D, Shi J and Li Y 2012 Comparison of solid-state to liquid anaerobic digestion of lignocellulosic feedstocks for biogas production *Bioresour. Technol.* **124** 379-386

Comparison of kinetic model for biogas production from corn cob

ORIGINALITY REPORT

16%

SIMILARITY INDEX

PRIMARY SOURCES

- 1 journal.unnes.ac.id Internet 109 words — 6%
- 2 Manjula Das Ghatak .. "COMPARISON OF KINETIC MODELS FOR BIOGAS PRODUCTION RATE FROM SAW DUST", International Journal of Research in Engineering and Technology, 2014 40 words — 2%
Crossref
- 3 Fang, Wei, Panyue Zhang, Guangming Zhang, Shuguang Jin, Dongyi Li, Meixia Zhang, and Xiangzhe Xu. "Effect of alkaline addition on anaerobic sludge digestion with combined pretreatment of alkaline and high pressure homogenization", Bioresource Technology, 2014. 18 words — 1%
Crossref
- 4 Ziemiński, Krzysztof, and Monika Kowalska-Wentel. "Effect of enzymatic pretreatment on anaerobic co-digestion of sugar beet pulp silage and vinasse", Bioresource Technology, 2015. 15 words — 1%
Crossref
- 5 Wang, Zhongjiang, Fuqing Xu, and Yebo Li. "Effects of total ammonia nitrogen concentration on solid-state anaerobic digestion of corn stover", Bioresource Technology, 2013. 14 words — 1%
Crossref
- 6 meisternet.sakura.ne.jp Internet 13 words — 1%

Yuyao Zhang, Huan Li. "Energy recovery from wastewater

- 7 treatment plants through sludge anaerobic digestion: effect of low-organic-content sludge", Environmental Science and Pollution Research, 2017
Crossref 13 words — 1%
-
- 8 Kalp Bhusan Prajapati, Rajesh Singh. "Kinetic modelling of methane production during bio-electrolysis from anaerobic co-digestion of sewage sludge and food waste", Bioresource Technology, 2018
Crossref 13 words — 1%
-
- 9 "Biogas", Springer Nature, 2018
Crossref 12 words — 1%
-
- 10 www.answers.com
Internet 10 words — 1%
-
- 11 Iqbal Syaichurrozi. "Biogas production from co-digestion *Salvinia molesta* and rice straw and kinetics", Renewable Energy, 2018
Crossref 9 words — < 1%
-
- 12 Sunwanee Jijai, Chairat Siripatana. "Kinetic Model of Biogas Production from Co-digestion of Thai Rice Noodle Wastewater (Khanomjeen) with Chicken Manure", Energy Procedia, 2017
Crossref 9 words — < 1%
-
- 13 lib.dr.iastate.edu
Internet 9 words — < 1%
-
- 14 ncsu.edu
Internet 9 words — < 1%
-
- 15 nauka-nanrk.kz
Internet 8 words — < 1%
-
- 16 "Comparison of digestate from solid anaerobic digesters and effluent from liquid anaerobic digesters as inocula for solid state anaerobic digestion of yard trimming", 2015 ASABE International Meeting, 2015.
Crossref 8 words — < 1%

EXCLUDE QUOTES OFF

EXCLUDE MATCHES OFF

EXCLUDE BIBLIOGRAPHY ON