Data Article

Bioenergy production data from anaerobic digestion of thermally hydrolyzed organic fraction of municipal solid waste

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A R T I C L E  I N F O

Article history:
Received 11 December 2018
Received in revised form 30 December 2018
Accepted 10 January 2019
Available online 14 January 2019

A B S T R A C T

The presented dataset in this data article provides quantitative data on the production of bioenergy (biogas and biomethane) from mesophilic batch anaerobic digestion (AD) of thermally hydrolyzed organic fraction of municipal solid waste (OFMSW). The discussion and interpretation of the data are provided in another publication entitled “Hydrothermal Pretreatment of Source Separated Organics for Enhanced Solubilization and Biomethane Recovery” (Razavi et al., 2019). The data and information presented in the current data article include (1) the ratio of soluble to particulate chemical oxygen demand (COD) under different thermal hydrolysis condition, (2) the daily measured biogas and biomethane data, (3) the cumulative methane yield data in terms of mL CH4 produced per gram of volatile suspended solids (VSS) as well as feedstock added, (4) the ultimate methane yield data as well as the relative improvement in methane recovery compared to the control (non-hydrolyzed) digester, (5) the data of first-order organics biodegradation rate constants, (6) the procedure of measuring biogas composition via gas chromatography, (7) the procedure of converting the biogas/methane volume data acquired under the actual experimental condition (mesophilic temperature of 38 °C and atmospheric pressure) to the standard temperature (0 °C) and pressure (1 atm) condition, and (8) the procedure of determining the first-order kinetic rate constants.

DOI of original article: https://doi.org/10.1016/j.biortech.2018.12.024

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https://doi.org/10.1016/j.dib.2019.01.018
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**Specifications table**

| Subject area                  | Environmental engineering                      |
|-------------------------------|------------------------------------------------|
| More specific subject area    | Anaerobic digestion, biological treatment, thermal hydrolysis, waste minimization, bioenergy |
| Type of data                  | Table, figures                                 |
| How data were acquired        | The gas chromatography was employed to determine the methane content of the produced biogas. A Hach spectrophotometer (model DR3900) was used the analysis the chemical oxygen demand (COD) of the samples calorimetrically. The volume of the produced biogas was measured manually with a Poulten & Graf Fortuna™ air-sealed glass syringe (capacity of 100 m) throughout the biochemical methane potential (BMP) assay. To analyze the soluble COD (SCOD), the samples were centrifuged for 20 min at 10,000 rpm using a Sorvall Legend XT centrifuge (Fisher Scientific, US). Then, the liquid fraction (supernatant) of the centrifuged samples was passed through 0.45 μm microfiber filters. The analysis including the analysis of ANOVA and the interactions analysis was done using Minitab Software 17. |
| Data format                   | Raw, analyzed                                  |
| Experimental factors          | Thermal hydrolysis parameters include temperature (°C), holding time (min), pressure (kPa), and severity index (–). All the digesters were operated at the mesophilic temperature of 38 °C. |
| Experimental features         | Thermal hydrolysis experiments were conducted under wide ranges of temperature, retention time, and pressure so that it covers the severity index range of 3–5 commonly used in industrial applications. Fifteen different thermal hydrolysis conditions were applied to the OFMSW samples. The thermal hydrolysis temperature, pressure, and holding time ranged from 150 to 240 °C, 476 to 3367 kPa, and 5 to 30 min, respectively. The BMP test was performed using raw (non-pretreated) and thermally hydrolyzed OFMSW samples. The BMP assay as well as the sample analyses were performed in triplicates. |
| Data source location          | Toronto, Canada                                |
| Data accessibility            | Data are presented in this article             |
| Related research article      | A.S. Razavi, E. Hosseini Koupaie, A. Azizi, H. Hafez, E. Elbeshbishy, Hydrothermal pretreatment of source separated organics for enhanced solubilization and biomethane recovery, Bioresour. Technol. [1] |

**Value of the data**

- The data explain the procedure for converting the gas volume data obtained under specific experimental conditions (e.g., specific temperature and/or pressure) into the values under a standard condition (e.g. 0 °C, 1 atm).
- Data standardization provide the opportunity to compare the data acquired under different experimental conditions.
The dataset covering a wide range of thermal hydrolysis conditions might be used as a benchmark to validate the findings of other studies. The data highlight the importance of selecting the optimum ranges of temperature, pressure, and retention time for thermal hydrolysis of OFMSW prior to the AD process. The kinetics rate data provide valuable information regarding the rate of the anaerobic digestion thermally hydrolyzed OFMSW.

1. Data

The ratio of soluble to particulate COD in the raw and thermally hydrolyzed OFMSW samples are compared in Fig. 1. The experimentally measured biogas and biomethane production data throughout the BMP experiment are presented in Tables 1 and 2, respectively. The cumulative biomethane yield in terms of mL CH4/g VSS-added and L CH4/L feedstock-added are illustrated in Figs. 2 and 3, respectively. The ultimate methane yield of the digesters fed with raw and thermally hydrolyzed substrates are compared in Fig. 4. The percentage improvements in the ultimate methane yield of the thermally hydrolyzed digesters in comparison with that of the control digester are shown in Fig. 5. The first-order specific biodegradation rate constants of the BMP digesters are presented in Fig. 6.

2. Experimental design, materials and methods

2.1. Procedure of volume data conversion to the standard temperature & pressure condition

The volume of the produced biogas/methane throughout the BMP assay under the mesophilic temperature of 38 °C and atmospheric room pressure was converted to the standard temperature & pressure condition (0 °C and 1 atm) using Eq. (1)

\[
V_{\text{STP}} = V_m \left( \frac{P_m}{P_{\text{STP}}} \right) \left( \frac{T_{\text{STP}}}{T_m} \right)
\]

(1)

where,

\(V_{\text{STP}}\): Biogas/methane volume of the at the standard temperature & pressure condition (mL)
\(V_m\): Actual recorded biogas/methane volume (mL)
\(P_m\): Actual atmospheric pressure at the time of recording the biogas/methane volume (atm)
\(P_{\text{STP}}\): Standard pressure (1 atm)
\(T_{\text{STP}}\): Standard temperature (273.15 ºC)
\(T_m\): Digester temperature \((273.15 + 38 = 311.15 ºC)\)
2.2. Biodegradation kinetics rate calculation

The data regarding the rate of organics (COD, VSS, etc.) biodegradation through the digestion process were defined by the first-order reaction model [2–7]. Eq. (2) shows the kinetic reaction model used to calculate the first-order rate constants data for the TCOD degradation of the digesters.

\[ r = \frac{dA}{dt} = -kA_t \]  

in which \( r \), \( k \), and \( A_t \) are respectively the organics removal rate (e.g., TCOD degradation rate in mg/L.d), the first-order specific biodegradation rate constant (1/d), and the remaining concentration of organics (e.g., TCOD concentration in mg/L) at time t. By integrating and rearranging Eqs. (2) and (3) will be obtained as follows:

\[ A_t = A_u e^{-kt} \]

in which \( A_u \) is the ultimate biodegradable organics concentration (mg/L), and the rest of the parameters are as defined before.

2.3. Analytical procedure

The amount of the daily biogas production was measured manually using a 100 mL air-tight Poulten & Graf Fortuna™ glass syringe. The composition of the biogas produced throughout the BMP assay was measured in terms of \( \text{CH}_4, \text{CO}_2, \text{and H}_2 \) gases using a gas chromatograph (Thermo Scientific Trace 1310). The Trace 1310 gas chromatograph was equipped with a packed column (model: TG-Bond Msieve 5A) with 30 m length and diameter of 0.53 mm. It was also utilized a thermal conductivity detector with oven, filament, and detector temperatures of 80, 250, and 100 °C, respectively. The analysis of COD was performed calorimetrically following the closed reflux methodology outlined by the Standard Methods [8]. A Hach spectrophotometer (model DR3900) was used for COD analysis and the measurements were done at the wavelength at 600 nm. The statistical analysis was performed using Minitab Software 17.
Table 1
Daily biogas production data from the BMP digesters at a temperature of 38 °C (mL).

| Time (day) | Severity index (SI) | temperature (°C) | holding time (min) | Control |
|------------|---------------------|------------------|-------------------|---------|
| 3          |                     | 150 °C 30 min    | 160 °C 20 min     | 170 °C 10 min |
| 3.5        |                     | 170 °C 15 min    | 180 °C 10 min     | 190 °C 10 min |
| 4          |                     | 190 °C 20 min    | 200 °C 10 min     | 210 °C 10 min |
| 4.5        |                     | 210 °C 20 min    | 220 °C 10 min     | 230 °C 05 min |
| 5          |                     | 220 °C 30 min    | 230 °C 15 min     | 240 °C 20 min |

For example:
- 0: 0
- 2: 42, 54, 43
- 4: 99, 110, 111
- 7: 199, 209, 210
- 9: 345, 355, 359
- 13: 433, 451, 464
- 15: 557, 577, 596
- 17: 692, 711, 743
- 20: 741, 755, 802
- 22: 768, 783, 831
- 27: 787, 803, 851
- 30: 826, 844, 882
- 35: 855, 873, 915
- 38: 860, 885, 919
- 41: 864, 891, 924

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Table 2
Daily biomethane production data from the BMP digesters at a temperature of 38 °C (mL).

| Time (day) | Severity index (SI) | temperature (°C)-holding time (min) | Control |
|------------|---------------------|--------------------------------------|---------|
| 3          | 150 °C  30 min      | 0                                    | 0       |
|            | 160 °C  20 min      | 0                                    | 0       |
|            | 170 °C  10 min      | 0                                    | 0       |
| 3.5        | 170 °C  30 min      | 0                                    | 0       |
|            | 180 °C  15 min      | 0                                    | 0       |
|            | 190 °C  10 min      | 0                                    | 0       |
| 4          | 190 °C  20 min      | 0                                    | 0       |
|            | 200 °C  10 min      | 0                                    | 0       |
|            | 210 °C  10 min      | 0                                    | 0       |
| 4.5        | 210 °C  20 min      | 0                                    | 0       |
|            | 220 °C  10 min      | 0                                    | 0       |
|            | 230 °C  05 min      | 0                                    | 0       |
| 5          | 220 °C  30 min      | 0                                    | 0       |
|            | 230 °C  15 min      | 0                                    | 0       |
|            | 240 °C  20 min      | 0                                    | 0       |
Fig. 2. The cumulative methane yields of the BMP digesters as mL CH₄/g VSS-added.

Fig. 3. The cumulative methane yields of the BMP digesters as L CH₄/L feedstock-added.
Fig. 4. The ultimate methane yield as mL CH4/g VSS-added.

Fig. 5. Percentage improvement in ultimate methane yield compared to the control (non-pretreated) digester (%).
Acknowledgments

The authors appreciate the financial support received from Southern Ontario Water Consortium (SOWC). The authors also thank the technical support from Disco Road organics processing facility in Toronto, Canada.

Transparency document. Supporting information

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2019.01.018.

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