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Application News

No. O65

Total Organic Carbon Analysis

TOC/TN Measurement for the Control and Evaluation of Methane Fermentation of Food Waste using TOC and TN Measurement System

The Industrial Research Institute of Shizuoka Prefecture (hereinafter referred to as "IRI Shizuoka Pref.") uses a Shimadzu TOC (Total Organic Carbon) and TN (Total Nitrogen) measurement system for controlling and evaluating methane fermentation of food waste. This Application News introduces the contents of IRI Shizuoka Pref.'s researches.

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Methane Fermentation

Methane fermentation is a biological process in which microorganisms decompose organic materials such as food waste in the absence of oxygen. Methane gas generated through the process is a renewable energy source and fermentation residue can be used as fertilizer. As shown in Fig. 1, a recycling system will be developed if food processing companies adopt methane fermentation plants.

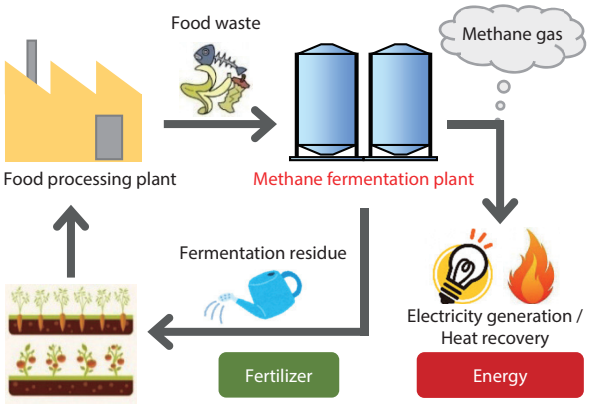

Fig. 1 Schematic of Recycling System Utilizing Methane Fermentation

Efforts in Shizuoka Prefecture

IRI Shizuoka Pref. is developing a high-efficient and low-cost methane fermentation plant for small-scale food processing companies. In early 2017, a transportable methane fermentation pilot plant with a 1,000 L fermentation tank shown in Fig. 2 was developed by industry-academia-government collaboration team. Starting from 2017, the team sets up the pilot plant at various kinds of food processing factories to verify fermentation performance and cost efficiency of each food waste. The test results will be disclosed as model case to encourage other food processing companies to adopt methane fermentation plant in the prefectural area.

Fig. 2 Transportable Methane Fermentation Pilot Plant

Significance of TOC and TN Measurement in Methane Fermentation

Fig. 3 shows food waste slurry which is raw material for methane fermentation. Fig. 4 shows methane fermentation residue which is digestion effluent after fermentation. In order to achieve stable methane fermentation, the ratio of carbon and nitrogen (C/N ratio) in the raw material must be within a certain range. IRI Shizuoka Pref. measures TOC and TN of the raw materials to adjust the C/N ratio and to calculate the gas generation efficiency. TOC and TN of the digestion effluents are also measured to calculate the decomposition rate and to evaluate fertilizer components.

Fig. 3 Food Waste Slurry (Raw material for methane fermentation)

Fig. 4 Methane Fermentation Residue (Digestion effluent after methane fermentation)

<Applications of TOC and TN Measurement for methane fermentation>

- Stable fermentation by adjusting the C/N ratio of the raw material
- Evaluation of the gas generation efficiency and the decomposition rate
- TN measurement of the fermentation residue to be used as fertilizer

IRI Shizuoka Pref. uses Shimadzu TOC-L (TOC combustion analyzer) and TNM-L (TN unit) to measure TOC and TN of methane fermentation raw materials and digestion effluents which contain high level of suspended solids. The following introduces the analysis methods and results.

Analysis Method

In addition to the transportable methane fermentation pilot plant, IRI Shizuoka Pref. has a laboratory-scale methane fermentation test system shown in Fig. 5. Food wastes from food processing companies are tested with the laboratory-scale system and examined whether they can proceed to the pilot plant test or not.

Fig. 5 Laboratory-scale Methane Fermentation Test System

TOC and TN of food waste slurry and digestion effluent are measured using Shimadzu TOC-L and TNM-L shown in Fig. 6 as follows. Firstly, the slurry and effluent are processed with an ultrasonic homogenizer because they contain suspended solids such as small food pieces and microorganisms. Then, they are diluted with ultrapure water and injected into the analyzer. Table 1 shows the measurement conditions.

Table 1 Measurement Conditions

Analyzer	:	TOC-L_{CPH} total organic carbon analyzer + TNM-L total nitrogen unit + High Suspension Kit (High concentration)
Catalyst	:	TC/TN catalyst
Measurement item	:	TOC (TC-IC)/TN
Calibration curves	:	TC : Single point calibration curve using 200 mgC/L aqueous solution of potassium hydrogen phthalate IC : Single point calibration curve using 100 mgC/L mixed aqueous solution of sodium carbonate and sodium hydrogen carbonate TN : Single point calibration curve using 100 mgN/L aqueous solution of potassium nitrate

Fig. 6 TOC-L Total Organic Carbon Analyzer + TNM-L Total Nitrogen Unit

Analysis Results

Table 2 and Fig. 7 show the analysis results of the raw material and digestion effluent. The decrease in TOC concentration indicates that more than 90 percent of organic materials were decomposed through fermentation. Also, the preservation of TN concentration indicates that nitrogen was maintained through fermentation and the effluents can be used as fertilizer.

Table 2 TOC and TN Measurements of Raw Material and Digestion Effluent

Sample name	TOC concentration (mg/L)	TN concentration (mg/L)
Raw material for methane fermentation	5,445	212
Digestion effluent after methane fermentation	374	221

* The raw material was diluted by a factor of 100 and the digestion effluent was diluted by a factor of 50. Measurement values are converted according to the respective dilution factors.

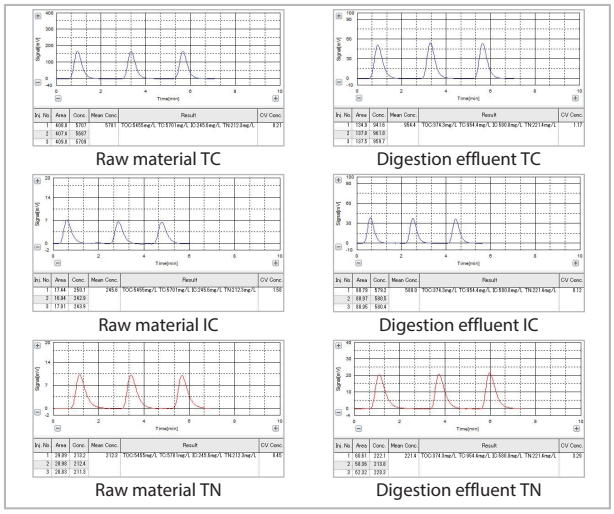

Fig. 7 Analysis Results of Methane Fermentation Raw Material and Digestion Effluent (Left: raw material, Right: digestion effluent)

Comparison of TOC and Other Method

In the field of methane fermentation research, chemical oxygen demand (COD) is more common to measure the concentration of organic substances in raw materials and digestion effluents than TOC. However, COD measurement is affected by oxidizer, reaction conditions, and the components existing in the analysis sample. On the other hand, since TOC analyzer combusts organic substances and determines the amount of CO_2 automatically, TOC measurement is free from effects described above. Also, Shimadzu TOC-L and TNM-L system can measure not only TOC but also TN which is quite important parameter to control and evaluate methane fermentation.

Methane fermentation research is one of the application which make the best use of Shimadzu TOC and TN measurement system.

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