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Transportable Gas Analyzer CGT-7100

Application News

Measuring CH_4 and CO_2 Concentrations in Cow Breath for Estimating Total Methane Emissions

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User Benefits

- The transportable gas analyzer can be placed near a feed trough and continuously measure the concentrations of CH_4 and CO_2 in the breath of cows.
- The gas analyzer is simple to operate with an onboard sample pretreatment unit that includes a built-in sample pump, filter, and moisture removal system.
- The analyzer can save data on a USB flash drive to facilitate data manipulation on a computer or sharing data between groups.

■ Introduction

The greenhouse effect of methane (CH_4) is approximately 28 times that of carbon dioxide (CO_2)*1. Cow belching is a significant source of CH_4 emissions and releases enteric CH_4 generated by fermentation in the cow's digestive system. Enteric CH_4 released through cow exhalation or eructation accounts for a significant proportion of the greenhouse gas emissions in agriculture, and concerted efforts are underway to reduce these emissions through feed development, changes in living conditions, and selective breeding.

The standard method for measuring enteric CH_4 emissions from cows is to place the animal in a large, specially designed chamber for several days and measure the total enteric CH_4 emitted over that time. While this method provides extremely accurate measurements, equipment and labor requirements make it unsuitable for measuring CH_4 emissions from large numbers of animals. In 2022, Japan's National Agriculture and Food Research Organization (NARO) published a manual that describes a method of estimating CH_4 emissions based on the ratio of CH_4 to CO_2 (CH_4/CO_2) measured in the breath of cows[1]. This method has attracted interest for its relative practicality as it does not require large-scale, dedicated facilities and can be used for single, short-term measurements and to collect data from multiple animals.

■ Experiment Overview

Estimating enteric CH_4 emissions from cows requires a complete analysis system that performs all parts of the analysis, from sampling of cow breath to measuring gas concentrations. As the first step in creating such a system, this Application News describes an example experiment in which the CGT-7100 transportable gas analyzer was used to collect data on CH_4 and CO_2 concentrations over time in cow breath.

■ CH_4 Generation in the Cow's Digestive System

Fig. 1 illustrates how CH_4 is generated in the digestive system of cows. The digestive system of ruminant animals such as cows and goats includes a stomach compartment called the rumen. In cows, the rumen is the first stomach compartment of the digestive system. The rumen is home to many different types of microorganisms with a variety of roles, one being to help the cow digest food in a process called rumen fermentation. The microorganisms ferment the cow's diet, generating H_2 in this process. Other microorganisms then metabolize this H_2 into CH_4, which is released from the cow by belching.

■ CGT-7100

The CGT-7100 is a transportable, all-in-one continuous gas analyzer. The compact chassis of the CGT-7100, which contains an onboard sample pretreatment unit with an electronic cooler for dehumidifying, a filter for dust removal, and a pump to draw sample gas into the analyzer, offers a standalone solution for gas analysis*3.

The CGT-7100 can measure up to three gases: two gases from among CO_2, CO, and CH_4 by non-dispersive infrared (NDIR) absorption, and oxygen measured by an O_2 meter (optional) with a zirconia-based limiting current sensor. The concentration of each gas can be monitored over time across a wide concentration range from ppm to volume percentage levels.

With a minimum sample gas flowrate of 100 mL/min, the CGT-7100 can monitor gas concentrations in small sample gas volumes for a wide range of potential applications.

■ Non-Dispersive Infrared (NDIR) Absorption

The CGT-7100 uses non-dispersive infrared (NDIR) absorption for measurements. Heteroatomic gases, such as CO_2, have unique infrared absorption spectra. The concentration of individual heteroatomic gases in a mixed sample gas can be determined by passing infrared light through the gas sample and then detecting the amount of infrared light transmitted in absorption bands that are unique to each gas species. The NDIR analyzer uses a proven optical system that has been used in on-line gas analyzers and gives robust and stable measurements.

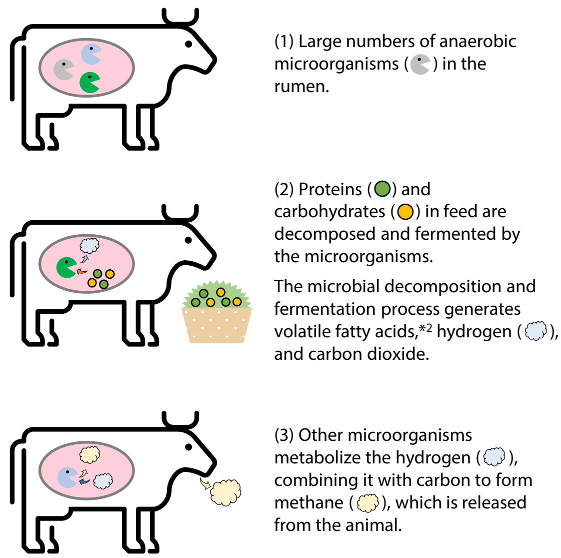

Fig. 1 Illustration of CH_4 Generation in Cow Digestive System

Fig. 2 Shimadzu CGT-7100 Transportable Gas Analyzer

*1 Figure taken from IPCC Fifth Assessment Report
*2 Acetic acid, propionic acid, butyric acid, etc.
*3 Dependent on analytical conditions. Contact a Shimadzu representative for details.

Method

The flow of measurement is shown in Fig. 3. An acrylic board enclosure was constructed around the feed trough to reduce the effects of wind and breath dispersion. A filter was also installed near the sampling line inlet to protect the system from airborne feed particles. Air was sampled from one location in the feed trough and the sample gas was aspirated into the analyzer at a flowrate of 400 mL/min.

The CGT-7100 was operated using the conditions shown in Table 1. The measurement range was set to 0 to 500 ppm for CH_4 and 0 to 1 vol % for CO_2. The concentrations of CH_4 and CO_2 were measured continuously for around 15 minutes while the cow was feeding.

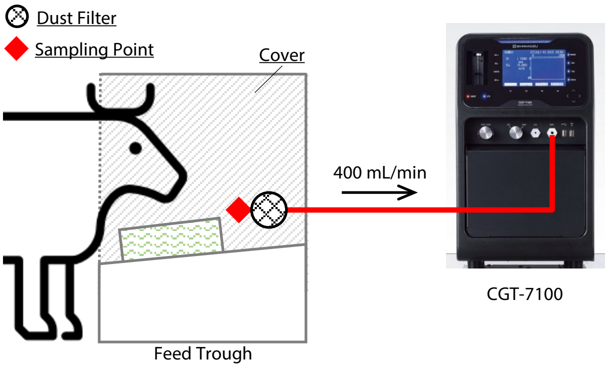

Fig. 3 Experimental Setup

Table 1 Analytical Conditions

Analyzer:	CGT-7100
Measured Components:	CH_4, CO_2
Measurement Range:	CH_4: 0–500 ppm
	CO_2: 0–1 vol %
Flowrate Type:	Low flowrate (100–400 mL/min, variable)

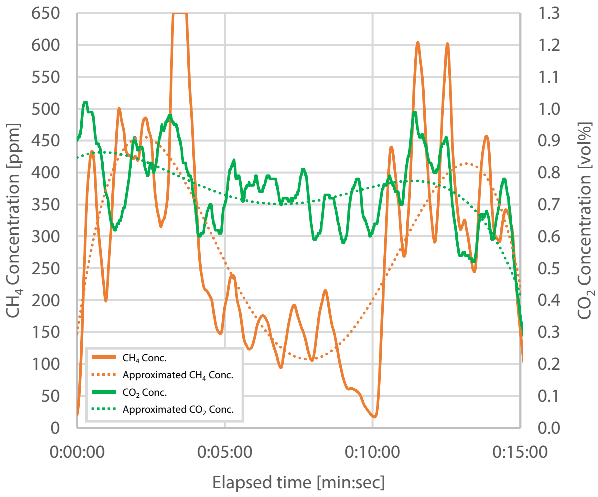

Fig. 4 CH_4 and CO_2 Concentration in Cow Breath

Fig. 5 Experimental Setup

Results

The data collected during the experiment are shown in Fig. 4. The CGT-7100 successfully measured the concentration of CH_4 and CO_2 in cow breath over time. The sudden rises in CH_4 concentration observed around once every minute are believed to coincide with the cow belching. Some measurements exceeded the upper limit of the measurement ranges set for this experiment. However, all concentrations were within the measurable range of the CGT-7100 analyzer and could be captured in future experiments by setting the measurement ranges with higher upper levels.

A fourth degree polynomial approximation of the results was created to reveal trends in the data. The approximation shows that measured CH_4 levels fell in the middle of the feeding time. This fall is believed to be caused by the cow moving its head, which changed how the cow's breath diffused in the feed trough area. Accordingly, the accuracy of estimated CH_4 emissions can be increased by taking measures to reduce the impact of breath diffusion on sampling. This could be achieved by using multiple sampling points located on the top and bottom and left and right sides of the feed trough area.[1)] Multiple sampling points would also reduce measured gas levels due to dilution of the sample gas by air collected from points further away from the mouth of the cow, but should also reduce the impact of the position of the cow's head on sampling and offer more stable measurements.

This experiment demonstrates that the CGT-7100 can measure CH_4 and CO_2 concentrations in cow breath and provides valuable insights about the measurement range and sampling method for future experiments intending to estimate CH_4 emissions in cow breath.

Conclusion

This Application News presents an example experiment that uses the CGT-7100 to measure the concentration of CH_4 and CO_2 in cow breath. The analysis demonstrates that the CGT-7100 can measure CH_4 and CO_2 concentrations in cow breath and provides valuable insights for future experiments aimed at estimating CH_4 emissions in cow breath. The results of this example experiment suggest that with adjustments to the sampling method, CH_4 emissions in cow breath can be estimated based on CH_4 and CO_2 measurements collected using the CGT-7100.

Related links

For more information about the CGT-7100, please see the product website below.
CGT-7100: SHIMADZU (Shimadzu Corporation)

For information about the NOA-7100 transportable NOx-O_2 analyzer, please see the link below.
NOA-7100: SHIMADZU (Shimadzu Corporation)

<References>
1) National Agriculture and Food Research Organization (2022). Manual for Estimating Methane Emissions from Fermentation in Cow Rumen
https://www.naro.go.jp/publicity_report/publication/pamphlet/tech-pamph/152088.html
NILGS:Development of a new calculation equation for methane emissions from cattle and its manualization (naro.go.jp)

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01-00755-EN First Edition: Jul. 2024

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CGT-7100

Transportable Gas Analyzer

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