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Transportable Gas Analyzer CGT-7100

Application News

Real-Time Measurement of CH_4 and CO_2 Concentrations for Estimating Methane Emissions from Rice Fields

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User Benefits

- The portability of this gas analyzer means the user can decide where to place it, such as near a rice field, to continuously measure CH_4 and CO_2 emissions.
- The CGT-7100 analyzer unit has a built-in pump, filter, dehumidifier, and other sample pretreatment equipment, so it does not require other equipment to perform measurements.
- Data can be stored on a USB flash drive for easy editing on a computer or sharing with other departments.

■ Introduction

CH_4 is a gas that has a greenhouse effect about 28 times greater*1 than CO_2. One source of CH_4 gas emissions is flooded rice fields. They release the CH_4 gases generated by microorganisms living in the soil into the atmosphere. Since CH_4 emissions from rice fields account for a significant proportion of greenhouse gases emitted from the agriculture, forestry, and fishery industry, various measures are being implemented to reduce emissions, such as managing the water and soil used in rice fields and improving the fertilizers used.

The closed chamber method measures variations in gas concentrations due to gases exchanged with plants, such as rice.[1] In this article, a CGT-7100 portable gas analyzer measures the concentration of CH_4 and CO_2 generated inside a specialized chamber placed on the surface of rice paddy soil.

*1 Refer to values in the IPCC Fifth Assessment Report

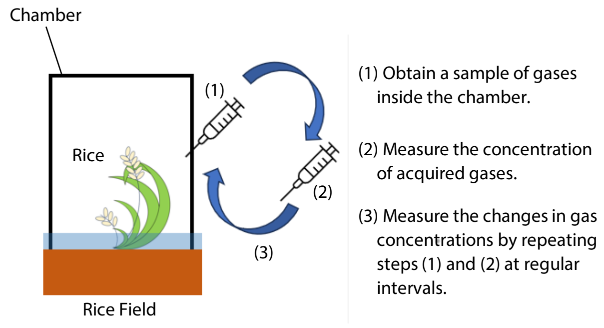

Fig. 1 Measuring Changes in Gas Concentrations by the Closed Chamber Method

■ CH_4 Emitted from Rice Fields

The amount of CO_2 emitted from a rice field depends on the amount breathed (emitted) from the rice plant and photosynthesized (absorbed), whereas the amount of CH_4 emitted depends on the microorganisms in the soil. Fig. 2 illustrates the process of CH_4 emission from rice fields. The microorganisms generate CH_4 by decomposing organic matter in the soil. When a rice field is flooded with water, the supply of oxygen to the soil stops and anaerobic microorganisms actively generate CH_4. It is thought that the generated CH_4 is emitted into the atmosphere via two pathways. One pathway is via the roots and stalks of the rice plants (pathway 1).[2),3)] Due to the functions of the microorganisms, CH_4 concentrations in the soil become higher than inside the plant, resulting in a concentration gradient that dissolves into the root cells. The dissolved CH_4 becomes a gas within the narrow gaps between cells and moves along the gaps to the leaf sheath above ground. Pores on the leaf surface then discharge the CH_4 into the atmosphere. In the other pathway (pathway 2), CH_4 in the soil forms bubbles that are released directly into the atmosphere without passing through the rice plant. Pathway 1 increases the CH_4 concentration inside the chamber by a certain proportion, but the quantity and frequency of CH_4 emissions via pathway 2 are not clearly known, so there is an element of uncertainty about the estimated quantity of CH_4 emitted from rice fields[4)]. Therefore, the frequency that bubbles formed was estimated by analyzing the CH_4 concentration measurement results to determine how quickly the CH_4 concentration increased per unit area (methane flux).[5)]

$$\text{Methane flux} = \frac{\Delta C}{\Delta t} \times \frac{V}{A} \times \rho \times \frac{273}{273 + T}$$

$\Delta C/\Delta t$: Change in CH_4; V: Chamber volume
A: Surface area of chamber bottom; ρ: CH_4 density

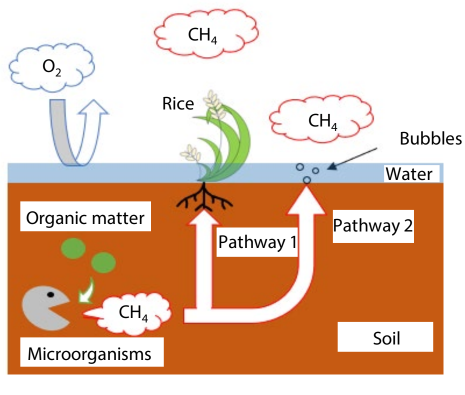

Fig. 2 Illustration of CH_4 Generation from Rice Fields

■ CGT-7100 Portable Gas Analyzer

The CGT-7100 is an all-in-one portable continuous gas concentration measuring system (Fig. 3). Because the compact main unit includes a pretreatment unit with a built-in electronic cooler for removing water moisture, a filter for removing dust, and a pump for suctioning sample gas into the analyzer system, the analyzer can be operated independently*2.

Up to three components can be selected for measurement. In addition to two of the CO_2, CO, and CH_4 components being measured by the non-dispersive infrared absorption (NDIR) method, one component can also be selected for measurement by an O_2 analyzer (optional), based on the limiting current type zirconia method. Changes in concentrations over time can be monitored with a wide range of measurements, from ppm to vol%.

With the minimum sample gas flowrate of 100 mL/min (optional), gas concentrations can be measured in small sample quantities, and the sample gas flowrate can be varied within the range of 100 to 400 mL/min. As shown in the measurement process flow diagram below, samples can also be measured without losses by including a recirculation system that returns the sample gas discharged from the analyzer to the measurement location (inside the chamber in this case).

*2 Depends on measurement parameters. For more details, contact a Shimadzu representative.

■ Non-Dispersive Infrared Absorption (NDIR) Method

The CGT-7100 uses the non-dispersive infrared absorption (NDIR) method for measurements. CO_2 and other heteronuclear gases have unique infrared light absorption spectra. Gas concentrations can be measured selectively by passing infrared light through the sample gas and using the detector to measure the quantity of infrared light in the absorption band that is unique to a given type of gas. Robust and reliable measurements are achieved with the optical system in the NDIR unit, which has an excellent track record among online gas analyzers.

Fig. 3 Shimadzu CGT-7100 Portable Gas Analyzer

■ Measurement Method

The measurement process flow is shown in Fig. 4 and the analysis conditions are indicated in Table 1. Before the chamber is placed at a measurement location, it must be ventilated thoroughly to ensure the CH_4 and CO_2 concentrations are the same as in the atmosphere when measurements start. A gas sample is obtained from a location inside the chamber, and it is suctioned into the analyzer at a flowrate of 100 mL/min. Gas discharged from the analyzer can be sent back into the chamber so that samples of CH_4 and CO_2 emitted from the rice fields can be measured continuously. The air inside the chamber can be stirred with a fan that is installed inside it to prevent the CH_4 and CO_2 from accumulating in any particular location..

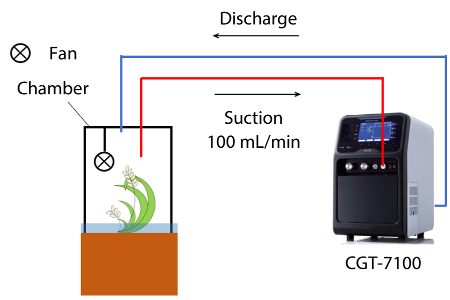

Fig. 4 Measurement Process Flow

Fig. 5 Measuring the Samples

Table 1 Analysis Conditions

Analyzer:	CGT-7100
Measured Components:	CH_4, CO_2
Measurement Range:	CH_4: 0 to 200 ppm
	CO_2: 0 to 1000 ppm
Flowrate Type:	Low flow (100 mL/min)

■ Measurement Results

Measurement results are shown in Fig. 6. The CGT-7100 can obtain trend data about CH_4 and CO_2 concentrations inside the chamber placed in a rice field.

The data show that CH_4 concentrations rapidly increased to 80 ppm immediately after measurements started. Given that bubbles were confirmed to be emitted from the rice field, the rapid increase is probably due to CH_4 bubbles being discharged from the rice field as the soil was disturbed by the action of placing the chamber.

After the chamber is placed, CH_4 concentrations will steadily increase as a function of time. So the methane flux was calculated to better understand the CH_4 emission trends via pathways 1 and 2. The points when CH_4 concentrations increased sharply (indicated by arrows in Fig. 6) were presumably the timings of bubbles by the sudden emission of CH_4.

In contrast to CH_4, the CO_2 concentration trend curve does not indicate a steady increase. The quantity of CO_2 absorbed by rice plant photosynthesis was probably affected by the weather. Presumably, CO_2 absorption from photosynthesis could be inhibited by placing rice plants in a chamber that blocks out light to reduce the effects of weather on measurements.

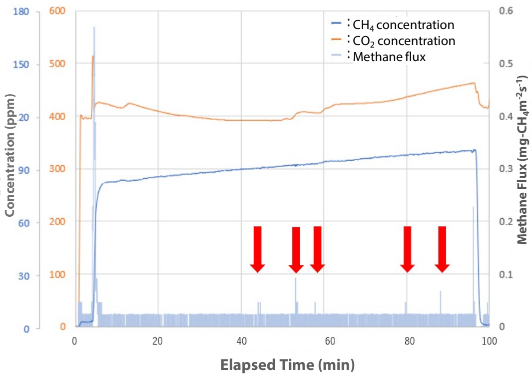

Fig. 6 Results from Measuring CH_4 and CO_2 Concentrations Emitted from Rice Fields

■ Conclusion

This article describes an example of using a CGT-7100 portable gas analyzer to estimate the amount of CH_4 and CO_2 emitted from a rice field by continuously measuring CH_4 and CO_2 concentrations inside the chamber placed in a rice paddy.

Since the CGT-7100 is a continuous gas analyzer, it is ideal for measuring changes in gas concentrations in real time.

The CGT-7100 can be used to observe changes in the levels of CH_4 and CO_2 or the effects of bubble formation when implementing rice field water and soil management or fertilizer improvement measures.

With its built-in sample gas pretreatment and sampling functionality, gas concentrations can be conveniently measured without the need for additional equipment, and the portability of the analyzer means it can measure gas concentrations in a wide variety of locations. If used with a communication unit, measurement data can be viewed and saved remotely via a computer or tablet to accommodate a wide range of testing and research applications.

■ 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 NO_x-O_2 analyzer, please see the link below.

NOA-7100: SHIMADZU (Shimadzu Corporation)

References

1) http://envbio. envi. osakafu-u. ac. jp/omu-content/uploads/sites/592/2015/12/Chamber-3. pdf

2) https://www. jstage. jst. go. jp/article/taiki1995/36/6/36_6_A59/_pdf

3) https://www. jstage. jst. go. jp/article/taiki1995/36/2/36_2_A15/_pdf/-char/ja

4) https://agrmet. jp/wp-content/uploads/2023-H-4. pdf

5) https://www. naro. affrc. go. jp/archive/niaes/techdoc/mirsa_guidelines. pdf

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