GHG Emission Measurement in Rice-Based Systems: Guidelines and Methodologies

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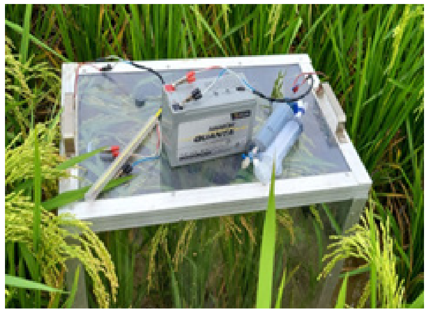
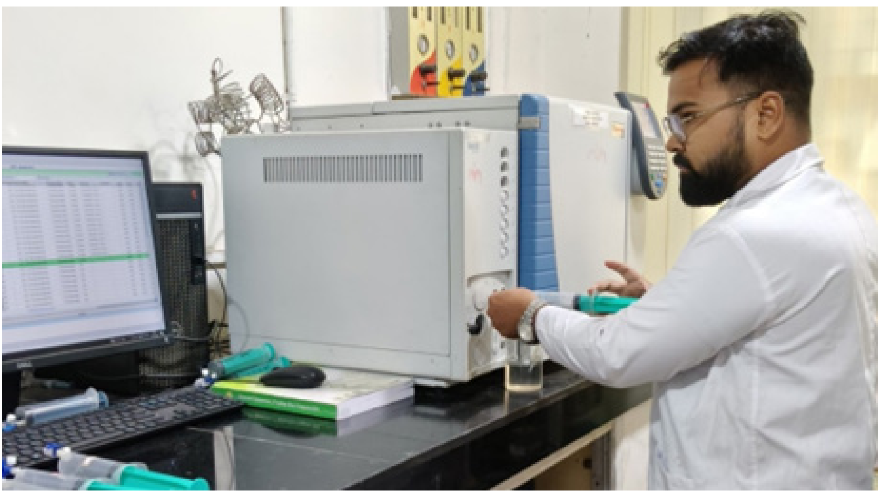




Despite its challenging terrain and agro-climatic conditions, rice farming has been practiced in Uttarakhand for centuries, contributing significantly to the livelihoods and food security of its rural population. In Uttarakhand, rice cultivation is primarily practiced in the fertile valleys and terraced fields carved out of the rugged mountains. Greenhouse gas (GHG) emissions from rice fields in Uttarakhand, like in many other regions where rice is cultivated, are primarily attributed to the anaerobic decomposition of organic matter in flooded paddy fields. Methane, a potent greenhouse gas, is the predominant emission from rice cultivation due to microbial activity in waterlogged soil. Additionally, nitrous oxide emissions, albeit in smaller quantities, can also occur due to the microbial processes involved in nitrogen cycling, particularly during fertilizer application and decomposition of organic matter. In Uttarakhand, where traditional methods of rice cultivation such as flooded paddy fields and water management practices are prevalent, methane emissions from rice cultivation contribute to the state's overall greenhouse gas footprint. However, the magnitude of emissions from rice fields in Uttarakhand may vary depending on factors such as soil type, water management practices, rice varieties cultivated, and agronomic practices employed by farmers.

Accurate measurement and monitoring of these emissions from rice fields in Uttarakhand would provide valuable insights into the state's contribution to climate change and help identify opportunities for mitigation interventions. These emission data may serve as a basis for formulating evidence-based policies and setting targets for reducing emissions from rice cultivation in Uttarakhand. Policy interventions such as promoting climate-smart agricultural practices, improving water and nutrient management, and incentivizing low-emission farming techniques can be designed based on this data to achieve emission reduction targets. Accurate emission data is also essential for fulfilling reporting obligations such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement and tracking progress towards emission reduction goals.

Field level measurements of GHG:

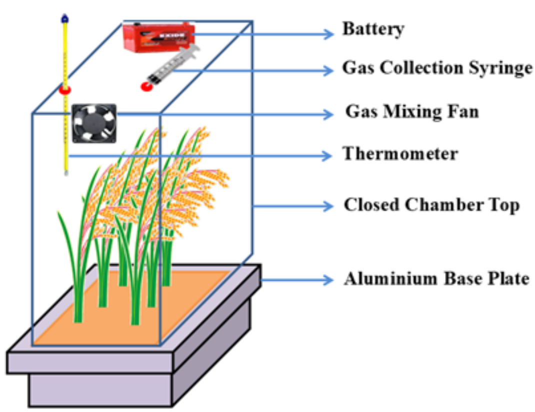
Measuring greenhouse gas (GHG) emissions at the field level involves quantifying emissions from diverse sources such as agricultural fields, forests, wetlands, and livestock systems. These field-level assessments are critical for formulating effective mitigation strategies, guiding climate change policies, and curbing the progression of climate change.

On-field measurement of CO_2 is commonly performed using portable CO_2 meters or sensors to directly assess atmospheric CO_2 concentrations on-site. Various techniques are employed at the field level, including gas sampling via the manual chamber method followed by analysis using gas chromatography; in-situ measurement using infrared gas analyzers (IRGA); and advanced approaches such as non-dispersive infrared (NDIR) spectroscopy and mass spectrometry.

Manual chamber method:

Principle

The manual chamber method is one of the most commonly employed techniques for measuring greenhouse gas (GHG) fluxes, particularly CO_2, CH_4, and N_2O from soils. This method involves placing a closed chamber over a defined soil area, creating an enclosed space that enables gas exchange between the soil surface and the chamber headspace. The rate of gas emission or uptake is then determined by monitoring changes in gas concentration within the chamber over time, which reflects the flux between the soil and the atmosphere.



Materials

Closed Chamber: Chambers constructed from plastic or acrylic sheets are commonly used to trap gases emitted from agricultural fields.

Standard dimensions are approximately 50 × 30 × 100 cm, typically made from 6-mm thick acrylic sheets, especially for use in rice paddies.

Base Plate: Made of aluminum, the base plate is inserted at least 10 cm below the soil surface to ensure stability and airtight sealing. Water is added to the channels to create an effective seal between the base and chamber.

Thermometer: A Celsius (°C) thermometer is placed inside the chamber to monitor internal temperature, which is necessary for accurate volume correction during gas analysis.

Pulse Pump / Fan: To ensure uniform air mixing inside the chamber, a battery-operated fan is installed within the chamber at varying heights, while a pulse pump may be mounted externally.

Measurement Scale: A ruler or scale marked from 0 to 50 cm is used to measure the water depth inside and outside the chamber, which helps assess flooding conditions.

Tedlar Bag: Gas samples from the chamber are collected into a Tedlar bag, which is designed for safe and inert gas storage.

Syringe: Gas is extracted from the Tedlar bag using a syringe for further analysis.

Needles: Gas samples are drawn using needles inserted through designated ports at time intervals of 0, 15, and 30 minutes after the chamber is sealed.

Stopcock: A three-way stopcock is mounted on top of the chamber to facilitate gas sampling. After each collection, the syringe is sealed with the stopcock to prevent any leakage.

Method Installation of Base Plate

A permanent aluminum base plate is inserted into the soil of each rice plot before the initial gas sampling event.

Chamber Placement

During each sampling session, a static chamber is positioned onto the pre-installed base plate to enclose a portion of the rice field for gas flux measurement.

Gas Sampling Setup

A syringe is used to extract gas samples from the chamber's headspace at specific time intervals to monitor changes in gas concentrations (e.g., CO_2, CH_4, or N_2O).

Syringe Specifications

Gas samples are collected using 20–50 mL pharmaceutical-grade plastic syringes equipped with 2-way or 3-way stopcocks.

Sampling Duration

After sealing the chamber, gas samples are taken from the headspace at regular time intervals for up to 2 hours.

Sampling Frequency

Greenhouse gas emissions are measured at 3–7 day intervals throughout the rice growing season until 15 days prior to harvest using the static chamber technique.

Additional Sampling Events

Extra samples are taken one day before and one day after fertilizer application to capture emission spikes.

Chamber Accessories

The chamber lid is equipped with a gas sampling port (valve) and a thermometer to record internal temperature during sampling.

Time of Sampling

Gas collection is conducted between 8:00 AM and 11:00 AM, as this time frame yields representative daily emission estimates.

Chamber Coverage

In transplanted rice fields, each chamber is placed to cover at least six rice hills to ensure adequate sampling area.

Sampling Intervals

Headspace gas samples (60 mL) are withdrawn using a polypropylene syringe connected to a clamp at 0, 15, and 30 minutes after sealing the chamber.

Advantages

- The manual static chamber method is cost-effective and suitable for use in remote areas, as it does not depend on an external power supply.
- It is ideal for large-scale greenhouse gas (GHG) assessments, making it valuable for both national emission inventories and localized measurements at the field or farm level.
- Chamber size and dimensions are flexible and can be easily adjusted to meet specific research needs.
- The chambers are simple in design, inexpensive to construct, and can be assembled from commonly available materials.
- This method is sensitive enough to detect even small differences in treatment effects and minor variations in gas fluxes, making it useful for small plot experiments.
- It operates as a self-contained system that can be powered by a small battery or solar energy, eliminating the need for an external power source.
- Due to its ease of operation, sampling can be carried out without requiring specialized training or technical expertise.
- The method causes minimal disturbance to the crop during the sampling process, ensuring the integrity of experimental conditions.

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