A discussion on the paper "Tunable diode laser measurements of methane fluxes from an irrigated rice paddy field in the Philippines"


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Outline

- Background
- Objectives
- Experimental Design
- Results and Discussion
- Summary and Conclusion
Background: Methane

- CH$_4$ is an important greenhouse gas. The global warming potential per unit mass of CH$_4$ is 63 times that of carbon dioxide in a 20-year time frame; In addition, CH$_4$ may be an agent for stratospheric ozone layer depletion.

- The atmospheric CH$_4$ concentration has been rapidly increasing 160% since the industrial revolution (1750) to 1819 ppb.

- Methane emission from paddy field is one of the major anthropogenic sources of global atmospheric CH$_4$ emission. However, there were few reports about CH$_4$ flux measurement in Asia where over 90% of the globle rice are culitivated.
Background: Box Chamber

Advantage: **Multi point observation**; Disadvantage: **Bag effects**

New Method: Tunable Diode Laser Trace Gas Analyzer System

Fig 1. Schematic illustration of the chambers and the sampling system.
Outline

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Objectives

• By using TDLAS and the other three micrometeorological techniques, the effects of drying, irrigation and traditional hand weeding experiment on CH$_4$ emissions were investigated.

• The overall goal of the research is to contribute to the current understanding of CH$_4$ release from rice paddies and thus help in the search for options to mitigate CH$_4$ emissions.
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### Experimental Design: Sampling Site

<table>
<thead>
<tr>
<th>Location</th>
<th>14.2° N, 121.2° E (Los Banos, Philippines)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice seedling</td>
<td>semidwarf rice variety IR72</td>
</tr>
<tr>
<td>Area</td>
<td>80m × 100m</td>
</tr>
<tr>
<td>Soil</td>
<td>Clayey: PH: 6.5</td>
</tr>
<tr>
<td></td>
<td>Organic carbon: 1.90%</td>
</tr>
<tr>
<td>Times</td>
<td>March 9 and 24, 1992</td>
</tr>
<tr>
<td>Wind direction</td>
<td>northeast</td>
</tr>
</tbody>
</table>
Experimental Design: Floodwater depth

Fig 2. Rice field floodwater depth changes.
\[ F_{me} = -K(\Delta C_{me} / \Delta z) \]

- \( F_{me} \): flux of \( \text{CH}_4 \) (\( \mu g \text{ m}^{-2} \text{ s}^{-1} \))
- \( K \): eddy diffusivity
- \( \Delta C_{me} \): change in \( \text{CH}_4 \) concentration (\( \mu g \text{ m}^{-3} \))
- \( \Delta z(\text{m}) \): vertical height difference

**Bowen Ratio**

**Wind Profile Technique**

**Eddy Correlation Method**
Tunable diode laser absorption spectroscopy (TDLAS) technique is a new method to detect trace-gas qualitatively or quantificationally based on the scan characteristic of the diode laser to obtain the absorption spectra in the characteristic absorption region.

**Experimental Design: TDLAS Technique**

<table>
<thead>
<tr>
<th>TGAS parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k$</td>
<td>$2968.4034\ cm^{-1}$</td>
</tr>
<tr>
<td>width</td>
<td>$10^{-4}\ cm^{-1}$</td>
</tr>
<tr>
<td>laser noise</td>
<td>0.4 ppbv/h</td>
</tr>
<tr>
<td>accuracy</td>
<td>$\geq 92%$</td>
</tr>
</tbody>
</table>
Experimental Design: TDLAS Technique

Fig 3. Field assembly for the trace gas analyzer system (TGAS).
Outline

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Results and Discussion: Irrigation Experiment

Fig 4. \( \text{CH}_4 \) fluxes generated using Micrometeorological techniques (March 14).
Results and Discussion: Weeding Experiment

- Up to 80% of CH$_4$ produced in soils will be oxidized before they can reach the atmosphere.

- Emission pathway:
  - Plant-mediated transport
  - Ebullition
  - Diffusion through the floodwater
Results and Discussion: Weeding Experiment

Fig 5. CH$_4$ fluxes from a rice paddy field during irrigation, weeding, and drying experiments.
Results and Discussion: Drying Experiment

Fig 6. CH$_4$ fluxes from a rice paddy field during irrigation, weeding, and drying experiments.
Results and Discussion: Micrometeorological Techniques

1. Daily means of the Bowen ratio fluxes were not statistically different from either the wind profile or eddy correlation.
2. The wind profile and eddy correlation means were significantly different.

**Table 1.** Average Daytime CH$_4$ fluxes Calculated Using Three Micrometeorological Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Average Daytime CH$_4$ Flux, $\mu g$ m$^{-2}$ s$^{-1}$</th>
</tr>
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<tbody>
<tr>
<td>Bowen ratio</td>
<td>6.22</td>
</tr>
<tr>
<td>Wind profile</td>
<td>5.61</td>
</tr>
<tr>
<td>Eddy correlation</td>
<td>6.24</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>6.02 ($\sigma = 0.29$)</strong></td>
</tr>
</tbody>
</table>

significance level: $\alpha=0.05$
Results and Discussion: The literature

The differences among paddies are caused by some factors: irrigation, soil characteristics, cultivation history, temperature and season, measurement techniques.

Table 2: CH$_4$ Emissions Measured From Rice Paddies

<table>
<thead>
<tr>
<th>Location</th>
<th>Flux, $\mu$g m$^{-2}$ s$^{-1}$</th>
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<tr>
<td>California</td>
<td>2.1</td>
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<td>Philippines</td>
<td>6.0</td>
<td>micrometeorology; daytime average</td>
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The differences among paddies are caused by some factors: irrigation, soil characteristics, cultivation history, temperature and season, measurement techniques.
Results and Discussion: Box Chambers

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The discrepancy between the measured CH$_4$ fluxes from two adjacent fields prompts us to investigate whether or not micrometeorological techniques consistently exceed fluxes measured using the box chamber technique.
Results and Discussion: Reservoir Experiment
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Gas intake

3m

1.5m

1L Buffer

1L Buffer

Filter

Solenoid

Flow meter

1.5L/min

Flow meter

1.5L/min

LGR: UGGA

Bypass

Pump
Results and Discussion: Reservoir Experiment
Results and Discussion: Reservoir Experiment
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Summary and Conclusion

Irrigation Experiment: The CH$_4$ fluxes displayed a diurnal trend similar to the daily soil temperature curves, with peak emissions of about 8 µg m$^{-2}$ s$^{-1}$.

Simulated Weeding Experiment: A tenfold increase in CH$_4$ emissions (to about 70 µg m$^{-2}$ s$^{-1}$) during a brief weeding experiment resulted from soil disturbance.

Drying Experiment: Drying appears to facilitate the release of CH$_4$ via ebullition and bubble breakage; The CH$_4$ flux was also arrested when the field was flooded with oxygen-rich water during a heavy rainstorm.

Comparison with Box Chambers: More extensive comparisons of the box chamber and micrometeorological techniques are required to determine whether or not TGAS fluxes consistently exceed those determined by the box chamber technique.
Thank you