Enhanced greenhouse-gases emissions in an irrigated rice paddy fertilized with biofiltration leachate

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Abstract
To investigate how biofiltration leachate (BL) affects carbon dioxide (CO_2), methane, nitrous oxide (N_2O) emissions in rice paddies, we periodically collected air samples and soil-entrapped gas samples. Compared with the control plot where mineral fertilizers were applied, the BL plot showed significantly higher emissions of CO_2 and methane for both gas emissions through rice plants and the soil surface. We also found that the amounts of soil-entrapped CO_2 and methane were higher in the BL-treated plot. On the other hand, N_2O emission was not significantly different between the treatments. The results suggest that biofiltration leachate, which had been subjected to various nitrogen processes in the biofile and thus is usually of low N content, mainly influences belowground carbon flux under anaerobic conditions, rather than nitrogen turnovers in the soil.

Key Words
Methane production, microbial decomposition, entrapped gas, water management, soil temperature, flux.

Introduction
Although rice paddies share many common biogeochemical traits, it has been well documented that the individual emission strengths of CO_2, methane, and N_2O depend largely on various factors that control decompositions of organic matter, production or consumption of the gas in the soil, and transport of belowground gases into the atmosphere. On the other hand, biofiltration is an odour removal technology in which an odorous fluid (or slurry) is passed through a moist, porous medium prior to emission into the atmosphere. Recently, biofiltration coupled with concurrent composting is getting widely adopted in Korea, with the aim to control the environmental harmfulness of livestock wastes, especially of swine slurry. The anaerobic storage conditions and the excessive use of slurry itself for agricultural fertilization contribute to emission of greenhouse gases and to aquatic pollution. One practical limitation of biofiltration is that it produces large amounts of liquid waste (leachate). Ideally, the biofiltration leachate has quite less carbon and nutrient (N and P) contents compared with that of swine slurry, thus mitigating its adverse effects on the environment. In the present study, we conducted a field experiment in a rice paddy to investigate how CO_2, methane, N_2O emissions are affected by treatment of biofiltration leachate as the sole external nutrient source.

Materials and methods
Study site
The study was done in an irrigated rice filed (100 x 30 m) in Yoju, central Korea (36°47′N, 127°98′E; 30 m above sea level) from 24 May to 5 October, 2009. The field was planted with rice seedlings on 23 May in rows 25 cm apart. The soil was flooded 2 weeks and fertilized with biofiltration leachate twice at a rate of 43 Kg N/ha, and puddled before the transplanting. A control plot of the same area was managed similarly, but with compound mineral fertilizers of N, P, and K. Soil moisture content and soil temperature were monitored with reflectometry sensor (CS616, Campbell Scientific, Utah, US) and T-type thermocouples, respectively.

Flux measurements and soil gas sampling
To determine fluxes of CO_2, CH_4, and N_2O, the closed chamber technique was used. To take gas emissions from both rice plants and soil surface into account, triplicate phytochambers (60 x 60 cm, covering 4 rice hills) and soil chambers (27 x 60 cm; between plant rows) were installed right after the transplanting. During a sampling period of 25 min, air samples were drawn into 100-ml sample gas containers every 5 min using 3-way solenoid valves and a datalogger (CR1000, Campbell Scientific, Utah, US). The air pressure, air temperature and relative humidity inside the chamber were monitored during the sampling period with appropriate sensors and the datalogger. Soil-entrapped gas samples at the depths of 3, 8, and 15 cm were collected biweekly using a capillary rhizosampler (Eijkelkamp, Giesbeek, Netherlands) and 20-ml amber

vials that had been fully evacuated and then half-filled with pure He.

Laboratory analyses

The gas concentrations for CO_2 and methane in the collected air samples or in the headspace gas samples were measured with a GC (YL-6100, Younglin, Anyang, Korea) equipped with TCD and FID. CO_2 in the sample gas was quantitative converted into methane right after passing TCD using a methanizer at 350 °C prior to entering into FID. N_2O concentrations were determined with a μECD-equipped GC (Agilent 6890).

Results and discussion

Throughout the growing season, we observed that methane emission was consistently higher in the BL-treated plot than in the control plot (Figure 1a). Many previous studies demonstrated that, in flooded rice paddies, belowground methane is mainly transported into the atmosphere via rice plants. Therefore, methane emission depends largely on rice growth. We found little difference in plant growth or in crop yield between the BL and control plots. In addition, we observed enhance methane emission through the soil surface (Figure 1b). Although distinguishing the relative proportions of each transport pathway is not feasible in this study, our results indicate that BL amendment increased methane emissions via both rice plants and the soil surface. We have observed a similar increase in CO_2 emission through the soil surface when fertilized with BL. These increases in methane and CO_2 emission were further confirmed by the amounts of methane and CO_2 entrapped in the soil. However, N_2O emission was not significantly different between the treatments, which may be attributed to the generally low nitrogen content of biofiltration leachate. As reported in the previous studies, we also found a strong correlation between soil temperature and methane emission flux. In addition, similar relationship was observed between CO_2 flux from the soil surface and soil temperature. By utilizing those relationships between flux and soil temperature, we could evaluate every 30-min fluxes of methane and CO_2 throughout the growing season. The cumulative methane and CO_2 fluxes over the growing season were estimated to be around 1.3 and 10 times, respectively, greater in the BL-amended rice paddy.

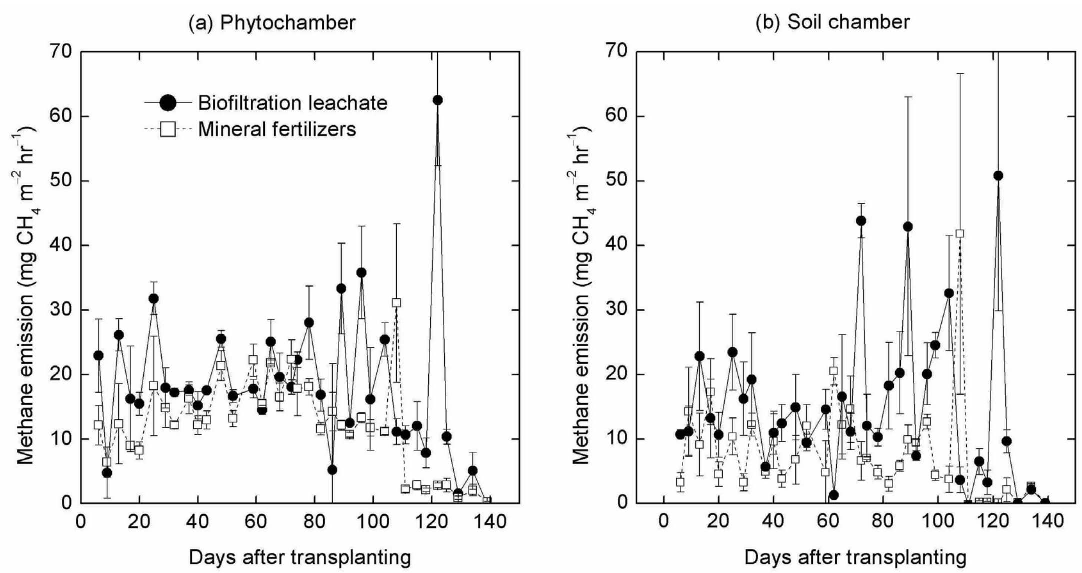

Figure 1. Comparison of methane emissions between rice paddies amended with biofiltration leachate and mineral fertilizers. (a) Methane emission from plant + soil. (b) Methane emission through the soil surface. Error bars are standard errors (n=3).

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