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CARBON DYNAMICS OF WETLAND IN THE SANJIANG PLAIN

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ABSTRACT: Methane (CH_4) and carbon dioxide (CO_2) emission was measured from mires in the Sanjiang Plain, Northeast China, by using a static chamber technique during free snow-covered periods. The seasonal mean emission of CH_4 was 12.4mg/(m^2·h) and the emission range of CO_2 was 8.7–16.6g/(m^2·d) (gross CO_2 flux) during plant growth period. CO_2 emission rate in the day was stronger than that at night, and the daily peak appears at 19:00. The mire plants in the Sanjiang Plain begin to sprout at the end of April. The aboveground biomass of the mire plants increased from zero to the peak from July to September and showed single peak form. The aboveground biomass of *Carex lasiocarpa* (464.8g/m^2) was lower than that of *Deyeuxia platyphylla* (530.8g/m^2), but the underground biomass was higher than that of *Deyeuxia platyphylla*. Gross CO_2 flux showed the significance positive correlation relationship with plant biomass. Gross CO_2 flux and CH_4 emission were also correlated with soil temperature (0–5cm) and water temperature. However, the highest CH_4 emission rate lagged behind the highest soil temperature in the root area during plant growth period. The data also indicated that wet and warm conditions during the early spring led to greater value of CH_4 emission flux. Inundation is the necessary condition for the existence of methane bacteria, but there is no significant positive correlation between the inundation depth and CH_4 emission rate in this region. Within the same growing season and under the same inundation condition, the variations of CH_4 emission rate could be markedly different.

KEY WORDS: mire; methane emission; gross carbon dioxide; static chamber technique; soil temperature

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1 INTRODUCTION

Wetlands play an important role in the process of carbon storage. The total carbon stored in different kinds of wetlands is about 15%–35% of the total carbon in the global land soils (POST *et al.*,1982; GORHAM, 1991). In addition, wetlands are significant natural sources for the atmospheric CH_4 (MOORE,1994). It is estimated that about 110×10^{12}g CH_4 originates from anaerobic decomposition in the natural wetlands, CH_4 emission from the natural wetlands is 15%–30% of the global CH_4 emission and the CH_4 emission from the peat land at high latitude areas are 50%–60% of the natural wetlands (MATTHEWS and FUNG, 1987; CICERONE and OREMLAND, 1988; BARTLETT and HARRISS,1993). The changes of the distribution of the global wetlands, especially reclamation for agricultural land, possibly make the CH_4 content increase in the atmosphere.

Due to the climatic change and the human activities, the area of the global wetland decreases very quickly. The evolution of the wetland ecosystem may possibly be an important factor for global CO_2 increase. Historically, there were many wetlands distributed in the northeast, southwest and the watersheds of the large rivers in China; unfortunately, the natural wetlands decreased very quickly by reclamation and irrigation. Recently, there has only a total area of 11.97×10^6ha of mires in China, which is mainly distributed in the Sanjiang Plain, Zoigê Plateau and along coastal area

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and rivers and around lakes in China. There has the largest area of the centralized mires with a total area of 1.13×10^6ha in the Sanjiang Plain in 1996 (LIU and MA, 2000).

The dynamics of the CH_4 and CO_2 emissions from mires in the Sanjiang Plain are reported in this paper. We have also studied the relations between the soil temperature, water depth, evaporation and the emission velocity of the CH_4 from the mires in the Sanjiang Plain and estimated the ability of the vegetation in the mires to fix CO_2 from atmosphere during a year.

2 MATERIALS AND METHODS

The Sanjiang Plain, located in Northeast China, was selected as studied area. In the area, annual average temperature is 1.6–3.9℃ and precipitation is 500–650mm, which mainly concentrated in the period from July to October. The Sanjiang Plain belongs to the seasonally frozen area, the main kind of wetland is the eutrophic herbage mire, the area of the peat mires is about 32.6×10^3ha, the content of the organic matter in the peat is 50%–60% and the organic carbon content is about 17.73%–36.48%.

The field experiment was carried out in the Sanjiang Wetland Ecology Station, Chinese Academy of Sciences. The station is located in the northeast of the Sanjiang Plain(47°35′N ,133°31′E), with an altitude of 55.4–57.9m. In the studied area, the average annual temperature is 1.9℃, average annual precipitation is 600mm, and the depth of the seasonal frozen soil layer is 1.5–1.8m. Many kinds of herbage mire and mire meadows are distributed in this station. The main plants include *Carex lasiocarpa, Carex pseudocuraica, Calamagrostis angustifoia* and *Glyceria angustifolia.* Five different sampling plots to monitor the CH_4 and CO_2 emission were placed in the experiment field, and trestles were built around the sampling plots to avoid disturbances.

The CH_4 emission was determined by the static chamber technique and CH_4 flux were measured by using transparent polyvinyl chloride (PVC) chamber. The chamber seat, made of stainless steel, was pegged and inundated. The samples were collected with 60ml gas-tight syringes at 2-min intervals for 10 minutes. The samples were analyzed for gas CH_4 concentration within 48 hours after collecting by using gas chromatograph (HP 5890). The flux rate was determined by the change in gas concentrations with time within the chamber headspace versus time. Gross CO_2 flux was measured with an opaque PVC chamber. The CO_2 concentration in chamber was measured by using infrared gas analyzer. While the air samples were collected, soil temperature (0–5cm), water temperature, water level, relative humidity as well as evapotranspiration were also measured.

The aboveground biomass of the vegetation was measured weekly when the carbon flux were scaled. Four 0.2m×0.2m plots were randomly selected in the mires for harvest. Plants was clipped at the sediment surface and collected , then oven-dried for 24–36h at 85℃ and weighed. The dried plant samples were mixed equally and the carbon were measured in laboratory.

3 RESULTS AND DISCUSSION

3.1 Seasonal Variation of Methane and Carbon Dioxide Flux

The seasonal variation of the CH_4 emission flux in 2002 was very great (Fig. 1). The CH_4 emission flux in June was 9.6mg/(m²·h) ; in August, the CH_4 flux reached to 19.8mg/(m²·h); in September, the CH_4 flux began to decrease with the average emission of 13.5mg/(m²·h). The average seasonal emission rate was 12.4mg/(m²·h), which shows the positive correlation with mire water and soil temperature (Fig. 1). The CH_4 flux in May was greater than that in June, this was caused by the thaw of the frozen layers with respect to the increasing temperature in May. In the late ten days of June, the plant growth was at the forepart period of a growth season. The precipitation was little and the water stored by the mires was also

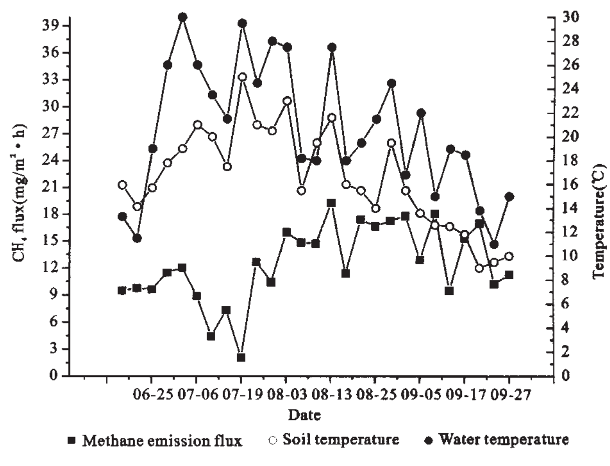

Fig. 1 Seasonal pattern of CH_4 flux in mire, and its relation with water temperature and soil temperature (0–5cm) in 2002

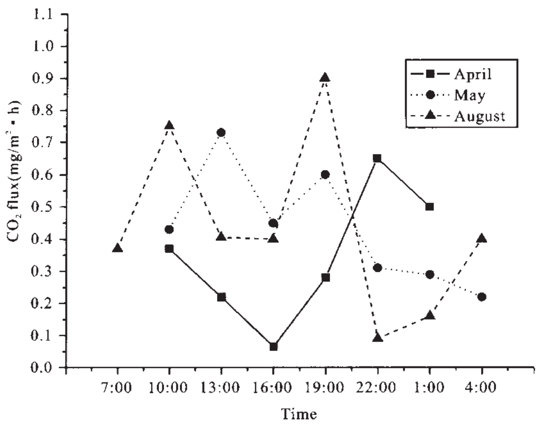

Fig. 2 Daily change of CO_2 emission flux of mire in various seasons (MA *et al.*, 1996)

little, so the CH_4 production of mires was weak. In September, the plant matured, the plant trunk was highest and the area shaded by plant was also wide. At the same time, the water storage condition was suitable and the CH_4 production became greater.

According to the observing results of the gross CO_2 flux (Fig. 2), the daily and seasonal CO_2 emission rates of the mire soil changed obviously. In April, plants began to sprout, the CO_2 emission rate was 8.7 g/(m^2·d), the CO_2 flux in the day was less than that at the night and the emission peak was at about 22:00. In May, the CO_2 emission rate rose to 12.9g/(m^2·d), and the respiration capacity in the day was greater than that at the night, with the peak at 13:00. In the late August and early September, the plant grew quickly, the CO_2 emission rate was 16.6g/(m^2·d), which showed the significance positive correlation with plant biomass. The CO_2 emission rate in the day was stronger than that at the night, and the daily peak appears at 19:00.

3.2 Biomass Variation of Mire Plants and Carbon Storage

The mire plants in the Sanjiang Plain begin to sprout at the end of April. The aboveground biomass increases from zero and gets the peak in the period between May and September. The aboveground biomass has the variation pattern with the single peak form (Fig.3). The aboveground biomass of *Carex lasiocarpa* (464.8g/m^2) was lower than that of *Deyeuxia platyphylla* (530.8g/m^2), but the underground biomass of *Carex lasiocarpa* was higher than that of *Deyeuxia platyphylla.* According to the estimating results on the primary productivity of the mire plants, *Carex lasiocarpa,* the indicator plant of mire, had the highest net primary productivity of 1318.9g/m^2. While the *Carex pseudocuraica,* living in the much deeper water areas, had the least primary productivity of 465.9g/m^2. With respect to the total carbon content of the mire plant in this area, the aboveground biomass changed from 36.45% to 41.48% of the total carbon, while the underground biomass varied from 40.80% to 44.33% of the total carbon. Based on the carbon content and the primary productivity of the mire plants in the Sanjiang Plain, the annual CO_2 fixed from atmosphere by the mires can be estimated primarily. The result shows that annual CO_2 fixation from atmosphere by mire plants in this area was estimated to be as high as 10.6506×10^6t.

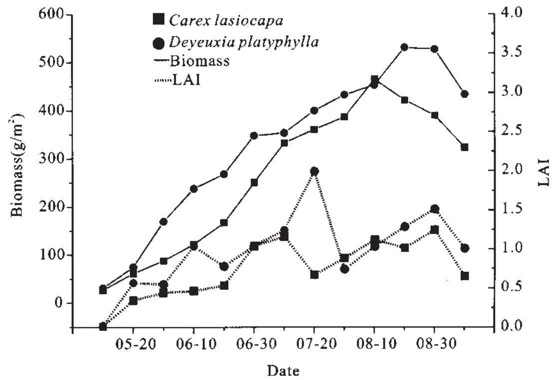

Fig. 3 Seasonal change of aboveground biomass and LAI (Leaf Area Index) of mire plants in 2002

3.3 Influence of Environmental Factors on Methane Emission

Soil temperature is the key factor that determines the emission of CH_4 from wetlands (MOORE *et al.*, 1998; ROULET *et al.*, 1992; CUI and MA, 1998). The variation of CH_4 emission rate from mires in the Sanjiang Plain accorded and synchronized with soil temperature in the root areas (Fig. 1), the highest soil temperature in the root areas occured in July, while the highest CH_4 emission rate appeared in August. This indicates that, within one year, the highest CH_4 emission rate laged behind the highest soil temperature in the root areas. High soil temperature in the root areas is favorable for the discharge and re-oxidation of CH_4, and relatively low soil temperature in the root zone can restrain these two processes. So the balance of these two processes determines the final discharge of CH_4. In addition, during different growth seasons of plants, changes of other environmental factors, especially the aerenchyma of plants, can also greatly influence the net flux of CH_4.

Inundation is the necessary condition for the existence of methane bacteria. There is no significant positive correlation between the inundation depth and CH_4 emission rate (Fig. 4). Within the same growing season and under the same inundation condition, the variation of CH_4 emission rate can be markedly different. It is determined by other environmental factors such as air temperature. During the maturation phase of plants, though mire was flooded by deep water, CH_4 emission rate was still low. This is due to the soil temperature and the condition of plants. Therefore, when the water depth reaches a given degree and the condition is favorable, CH_4 emission rate is also possibly determined by the integrative effect of other environmental factors.

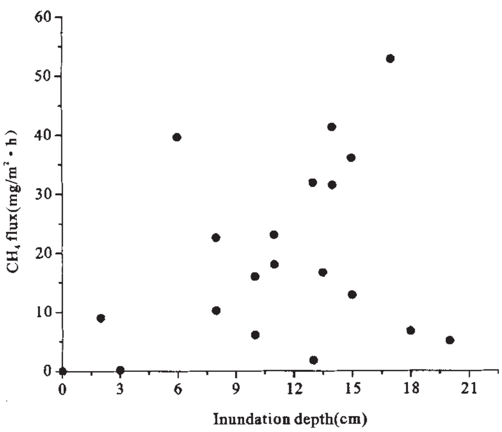

Fig.4 Relationship between inundation depth and methane flux

4 CONCLUSIONS

The variation of CH_4 and CO_2 emission flux in mires in the Sanjiang Plain during growing seasons was comparatively distinct. The highest value occurred in August. These variations were in close correlation with environmental factors. Our research shows that during growing seasons, soil temperature in the root areas (0–5cm) and water temperature were the key factors that determined the emission of CH_4 and CO_2. Inundation condition was significant factor controlling CH_4 production but there was no significant positive correlation between the inundation depth and CH_4 emission rate. Besides, during the melting season of frozen soil in wetlands, the CH_4 emission flux was markedly higher than that during the sprouting season of plants. It is due to the freeze-and-thaw process of soil within this region. The highest value of above-ground biomass of mire plants in this region occurred in August and its variation was in accordance with that of the CH_4 and CO_2 emission flux.

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