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Characteristics of greenhouse gas emission in the Yellow River Delta wetland

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ABSTRACT

The Yellow River Delta wetland is the most integrated, broadest, youngest wetland ecological system in China. Due to the affection by human activities, the wetland is under a degraded risk and urgently require for ecological restoration. Moreover, the wetland is an influenced and responsive region of global change because of its unique water-heat effect and greenhouse gas metabolic process. In this study, five typical salt marsh plant communities were selected to study the characteristics of greenhouse gas emission of the wetland. The results indicated that the greenhouse gas emission, especially for the CO_2 and CH_4, showed a distinctly spatial variation. The sample site (HW4) discharged the maximum emissions concentration of CH_4 and CO_2, reaching 691.6 and 1.32 mg/m^3 in the static opaque chamber, respectively. The total annual emissions of CH_4 and CO_2 were approximately 1.20×10^4 t a^{-1} and 18.4×10^4 t a^{-1} in the five plant communities. It was also found that the relationship of the soil moisture to CH_4 emissions was positive correlation, but that to CO_2 emissions was negative correlation. In addition, there was a linear correlation ($y = 0.0196x + 0.0252$, $R^2 = 0.9872$) between the content of Fe and Mn in the soil.

1. Introduction

Global climate change has been considered as an important issue, which becomes one of the greatest challenges for sustainable development of the world economy and the international society. Both CO_2 and CH_4 are considered as the most important greenhouse gases, accounting for 70% and 23% of the contribution to the temperature rising efficiency respectively (Nnoby, 1997). Due to the affection of human activities, the volume fraction of CO_2 and CH_4 increases about 26% and 148%, respectively after industrialization (Wang et al., 2000).

Wetland ecosystem is one of the major types of territorial ecosystems on the earth, which is estimated to contain 15% of total carbon in global territorial ecosystems (Franzen, 1992; Kayranli et al., 2010; Liu and Zhou, 2012). Natural wetland ecosystems are usually considered as the sink of free carbon from the atmosphere, due to the low decomposition rates of its plant residues. The carbon cycle in wetland largely contributes for global climate changes. Due to CO_2 flux is a key of carbon cycle in wetland, which has been considered as an important role in carbon cycle of continental ecosystem. Meanwhile, wetland is a main natural source of CH_4 in the atmosphere. The annual emission amount of CH_4 is 110×10^{12} g from anaerobic digestion of natural wetland, which account for 15%–30% of the total amount around the world (Bartlett and Harriss, 1993; Cicerone and Oremland, 1988; Khalia et al., 1993).

More than 90% of total carbon can be stored in wetland soil. Without human intervention, only 15% carbon of the net assimilation by natural wetland plant could be released into the atmosphere. Therefore, the natural wetland can be considered as a "carbon sink", which can inhibit the concentration of CO_2 rising in the atmosphere (Brix et al., 2001). The wetland in the geochemical elements cycle, especially for the fixation and release of CO_2 and CH_4, plays an important role as the "switch", which is called "converter". Once the wetland was intervened by human activities, the decomposition rate of plant residues and peat would be greatly improved. With the loss of organic carbon from wetland soil and the enhancement of soil oxidation performance, the storage of organic carbon would be degraded largely, thus the wetland would be a "carbon source" of greenhouse gas. Consequently, the carbon cycle of wetland ecological system, especially the storage change, might have a significant influence on terrestrial ecosystem carbon cycle and global climate change.

The Yellow River delta wetland is one of the three major river delta wetlands in China, which has a regional representativeness and uniqueness. Human activity, which has a serious impact on the

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process of greenhouse gas emission and the carbon cycle, has been becoming a new and powerful driving force on element migration, transformation and cycling. Over decades, the area of Yellow River delta wetland has been shown a significantly reduction, which might be mainly affected by human activities and global climate change. At the same time, the wetland has been regarded as the most serious delta affected by sea levels rising at the United Nations Climate Change Conference 2009 in Copenhagen. The hydrology and soil salinity of the wetland are the key environmental factors for the vegetation growth, distribution and diversity (He et al., 2008; Tan and Zhao, 2006; Cacador et al., 2007; Funk et al., 2004; Li et al., 2011) in the other marsh wetlands.

In the study, the characteristics of the greenhouse gas emissions in the Yellow River delta wetland were investigated, including: (1) the concentrations of carbon emission from different vegetation communities in the Yellow River delta wetland ecosystem; (2) the estimation of fluxes and annual emission loads of CH_4 and CO_2 in different vegetation communities. This study may have a large contribution to the protection of new-born frangibility, typical habitat and biodiversity in the wetland ecological system. It will also be beneficial for investigating the influence of the wetland carbon storage change on the terrestrial ecosystem carbon cycle and the global climate change.

2. Materials and methods

2.1. Site description

The study was conducted at the Yellow River delta wetland (N36°55′-38°16′, E117°31′-119°18′), which is located in the southern bank of the Bohai bay and western bank of the Bohai sea (Fig. 1). It belongs to the warm temperate and semi-humid monsoon climate zone, with 594.3 mm of mean annual precipitation, 2049.4 mm of average annual evaporation, 12.4 °C of mean annual temperature and 217.8 days of mean annual frost-free period.

The vegetations of this zone belong to the temperate deciduous broad-leaved forest community, with the mainstay of meadow landscape. In the above, the woody plants of natural growth are only *Tamarix* and *Salix purpurea*, distributing at both sides of the Yellow River and close to the old course of the Yellow River. The cultivated species are salt-tolerant species such as *Elm*, *Locust*, *Tamarisk*, *Dryland* willow, and the herbaceous plants are mainly *Imperata cylindrica* and *Phragmites australis*, et al (Chen, 1989). The soil types of this zone have high salinity, including tidal soil, saline tidal soil and coastal tidal soil (Liu and Drost, 1997). Tidal soil is neutral or alkalescence, mainly distributed along the river and south central plains. Salt soil distributes in the coastal areas, with a small amount of salt cultivated.

2.2. Sampling sites selection

The monitoring sites, which were distributed on the Yellow River delta wetland, were shown in Fig. 1, Table 1 and Table 2. There were 10 sites of soil samples and 5 kinds of typical salt marsh plant communities as carbon emissions monitoring site, including beaches bare land, *Suaeda salsa* community, mixed community of *Phragmites australis* and *Suaeda salsa*, *Phragmites australis* community, *Tamnrix chinesi* community and farmland community. The five types of vegetation communities in Yellow River delta wetland are most typical and representative, and have a zonal distributing phenomenon from the coastal to the inland (Funk et al., 2004; He et al., 2009).

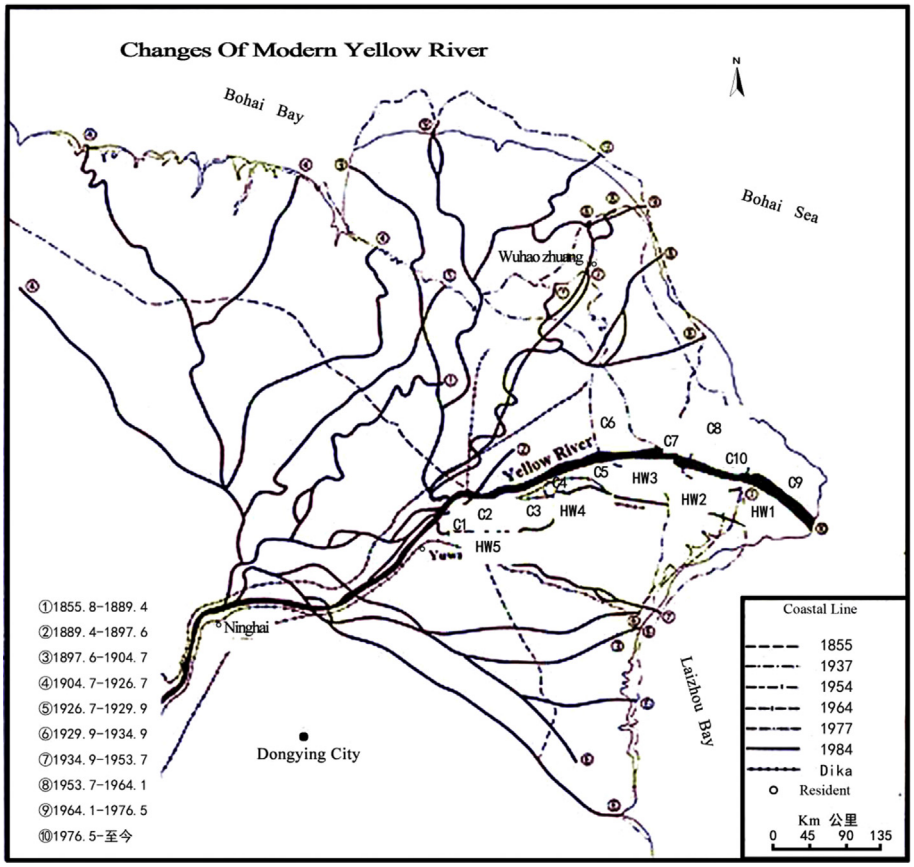

Fig. 1. Location of the Yellow River delta wetland and sampling.