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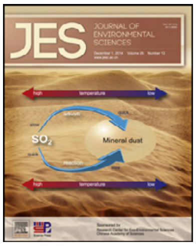

Salinity influence on soil microbial respiration rate of wetland in the Yangtze River estuary through changing microbial community

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ABSTRACT

Estuarine wetland, where freshwater mixes with salt water, comprises different regions (rivers and marine ecosystems) with significantly varying tidal salinities. Two sampling areas, ZXS and JS, were selected to investigate the effect of tidal salinity on soil respiration (SR). ZXS and JS were located in Zhongxia Shoal and Jiangyanan Shoal of Jiuduansha Wetland respectively, with similar elevation and plant species, but significantly different in salinity. The results showed that with almost identical plant biomass, the SR and soil microbial respiration (SMR) of the tidal wetland with lower salinity (JS) were significantly higher than those of the tidal wetland with higher salinity (ZXS) ($p < 0.05$). However, unlike SMR and SR, the difference in the soil microbial biomass (SMB) was not significant ($p > 0.05$) with the SMB of ZXS a little higher than that of JS. The higher SMR and SR of JS may be closely connected to the soil microbial community structures and amount of dominant bacteria. Abundant β- and γ-Proteobacteria and Actinobacteria in JS soil, which have strong heterotrophic metabolic capabilities, could be the main reason for higher SMR and SR, whereas a high number of ε-Proteobacteria in ZXS, some of which have carbon fixation ability, could be responsible for relatively lower carbon output. Path analysis indicated that soil salinity had the maximum negative total influencing coefficient with SMR among the various soil physical and chemical factors, suggesting that higher soil salinity, restricting highly heterotrophic bacteria, is the principle reason for lower SMR and SR in the ZXS.

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Introduction

Soil is the largest terrestrial carbon pool in earth. The soil pool can be as high as 1.5×10^3–2×10^3 Pg, which is greater than the atmospheric and vegetation carbon pool (Post and Kwon, 2000). Soil carbon pool consists of soil inorganic carbon (SIC) pool and soil organic carbon (SOC) pool (Lal, 2004a). Furthermore, depletion of SOC pool has contributed to (78 ± 12) Pg C (carbon) in the atmosphere (Lal, 2004b). Hence, the storage of SOC is of great importance for the circulation of C.

Input and output are two aspects that can affect SOC pool. The input is mainly from plant biomass materials, while the output is mainly affected by soil respiration (SR), which comprises three biological components (soil microbial respiration (SMR), root respiration, and soil animal respiration), and one chemical component. Among them, SMR accounts for half of the carbon flow from terrestrial ecosystems to the atmosphere, and is closely associated with microbial activity, microbial community, as well as soil environmental conditions (Zou et al., 2006; Xi et al., 2012).

Wetlands are water–land complex ecosystems. Undisturbed natural wetlands are considered to be very important for carbon sequestration because of their low rate of organic decomposition and SR, which might be related to long flooded periods (Bernal and Mitsch, 2012).

Many previous studies had primarily focused on interior freshwater wetlands, especially the boreal wetland, and demonstrated their ability of high SOC accumulation (Hirota et al., 2006). Estuarine salt marsh has high primary productivity and its carbon sequestration ability has drawn a lot of attention with the increase of global greenhouse effect (Li et al., 2011; Tang et al., 2011; Hu et al., 2012, 2014). Estuarine wetland is usually formed from the upstream sediments. It is an ecotone between river and marine ecosystems, and is located where the fresh water meets the salt water and the land connects to the sea. This property often leads to its combination of riverine and coastal mud flat. Tiding is an important factor that separates estuarine wetland from the interior wetland, and the duration of being submerged and nutrient input from the tide vary with the succession of different elevations. As a result, tiding can have an effect on soil property and SR, and thus, on the carbon sequestration ability of estuarine wetland. The soil salinity of different regions (river and marine ecosystem) of the estuarine wetland may vary significantly owing to the difference in tidal salinity. Wichern et al. (2006) indicated that SR and SMB decreased with the increasing levels of salinity in the pasture sites in Heringen (Germany). Furthermore, the study by Wong et al. (2008) with soil samples collected from a vegetated soil under controlled conditions demonstrated that low- and mid-salinity treatments produced the highest and lowest SR, but lowest and highest SMB, respectively. In general, soil salinity restrains SR, and an increase in soil salinity leads to a decrease in SMB and soil enzyme activities. Studies on the effects of salinity on SMR and SMB in the estuarine wetland are relatively rare and have not focused on the microbial community structures of the soil.

Jiuduansha, which is the only original wetland situated in the Yangtze River estuary, Shanghai, China, has a significant ecological environment function (Qiao et al., 2012). This wetland spans about 40 km from west to east. Similar to other estuarine wetlands, Jiuduansha is also an ecotone between a river and a marine ecosystem and from its west to east, river water reaches the marine water, resulting in obvious difference in the tidal water salinity. Some studies have been conducted on the SR and carbon turnover of the Jiuduansha Wetland. Tang et al. (2011) investigated the response of soil microbial community in Jiuduansha Wetland to different successional stages and its effects on SMR and carbon turnover. Qiao et al. (2012) studied the distribution and characteristics of the total petroleum hydrocarbons in the Jiuduansha Wetland, and indicated their potential impact on SMR. Nevertheless, few studies had been conducted to clarify the effect of tidal salinity on SR and carbon turnover of the Jiuduansha Wetland.

In the present study, two sampling areas, ZXS and JS, located in Zhongxia and Jiangyanan Shoals of the Jiuduansha Wetland, respectively, in the Yangtze River estuary were selected. These two sampling areas were found to have similar elevation and plant species, but significantly different tidal salinities. The effect of tidal salinity on SR and its underlying mechanism were investigated by analyzing the SMR, soil microbial characteristics, and physicochemical properties.

1. Materials and methods

1.1. Site description

Jiuduansha Wetland (31°03′N–31°17′N, 121°46′E–122°15′E) is located between the southern and northern watercourses of the Yangtze Estuary, Shanghai, China. This wetland initially emerged above the water surface in the 1920s and rapidly became an independent wetland in the 1960s. It is affected by the East Asian subtropical monsoon climate, with an average annual temperature of 17.3°C, average summer temperature of 28.9°C, and average winter temperature of 5.6°C (Gaoqiao Monitoring Station, Shanghai, China). Furthermore, the mean salinity of the wetland water from west to east varies significantly.

The wetland covers 423.2 km^2 and consists of the following three shoals from west to east: Jiangyanan Shoal, Shangsha Shoal, and Zhongxia Shoal. The vegetation mainly includes *Zizania aquatica* L., *Phragmites australis*, *Spartina alterniflora*, and *Scirpus triqueter* L.

1.2. Experimental design

The two sampling areas, JS and ZXS, with significantly different tidal salinities, were selected for investigation. JS is the nearest to the Yangtze River, while ZXS is located at the outermost part of the Yangtze Estuary area, near East China Sea.

To eliminate the effect of different kinds of plants and elevation on SR, sampling areas with similar elevation and identical plant species (*S. triqueter*) at the low tidal flat were selected, where carbon flux was more sensitive to tides than at the high-elevation (Guo et al., 2009). *S. triqueter* is the typical and pioneer plant of the Jiuduansha Wetland, and is widely spread in areas with an elevation of about 2.6 m. The sampling areas are shown in Fig. 1 and the characteristics of the sampling areas are listed in Table 1.