DYNAMIC CHANGES OF SOIL ORGANIC CARBON UNDER DIFFERENT LAND USE TYPE IN SANJIANG PLAIN

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ABSTRACT

The Sanjiang Plain in the northeast part of Heilongjiang Province is one of the largest freshwater marshes in China, which has been experienced intensive cultivation over past 50 years. To understand the dynamic changes of soil organic carbon (SOC) after different durations of cultivation, soil samples down to a depth of 120 cm were collected in layers from the lowland and upland fields having been reclaimed for 5-25 years, with adjacent undisturbed wetland and forestland as the control. The study of the vertical distribution of SOC and its relationship with soil pH showed that the SOC content in undisturbed wetland and cultivated lowland rice fields had a marked decrease from 0-10 cm to 40-60 cm and a less change downward, and a similar variation trend was observed in undisturbed forestland and cultivated soybean fields, only with the difference that the SOC content in 0-10 cm layer was much higher in forestland than in wetland, and lower in soybean fields than in rice fields. For undisturbed wetland, its SOC content in surface layer was decreased by 49.3% and 14.3% after reclaimed for 10 and 25 years, and for undisturbed forestland, 81.9% and 68.3% of its SOC in surface layer were lost after reclaimed for 5 years and 18 years, respectively. The soil pH in surface layer was decreased in the sequences of undisturbed wetland > lowland rice field reclaimed for 25 years > lowland rice field reclaimed for 10 years, and soybean field reclaimed for 5 years > soybean field reclaimed for 18 years > undisturbed forestland. All of these suggested that reclamation made a great loss of SOC in surface layer both in wetland and forestland, and the SOC loss was much greater in forestland than in wetland. The variation of surface soil pH under reclamation could be one of the factors inducing the SOC loss, and a longer period of reclamation combining with rational management could be favorable to the stabilization of SOC.

INTRODUCTION

Soil organic carbon (SOC) is a main factor affecting soil quality and agriculture sustainability. Being a source and sink of plant nutrients, SOC plays an important role in terrestrial C cycle (Freixo et al., 2002).

Land use type has a deep effect on SOC storage, since it affects the amount and quality of litter input, litter decomposition rate, and stabilization of SOC. The SOC loss from irrational land use often leads to some negative impacts on both terrestrial and aquatic ecosystems, and on atmospheric environment (Reeder et al., 1998; Bronson et al., 2004).

The Sanjiang Plain, one of the largest freshwater marshes in China, has been experienced intensive cultivation over past 50 years. About 3.8 Mha of its native marshland has been converted into cultivated land, resulting in a significant change in hydrological properties of the Plain (Liu and Ma, 2000). Many researches were made on the dynamics of methane emission due to this land use change (Ding et al., 2002, 2003, 2004), but the effects of the land conversion on SOC remain largely unknown.

With the cultivated lowland and upland and adjacent undisturbed wetland and forestland as test objects, this paper studied the dynamic changes of SOC under different land use type in Sanjiang Plain.

MATERIALS AND METHODS

1. Study area

The Sanjiang Plain lies in the northeast part of Heilongjiang Province, with a total area of 66,600 km2. This Plain is characterized by smooth terrain, humid climate, and large areas of marsh and forest. Its main soil types are albic soil, meadow soil and bog soil, and its natural vegetations are mainly of marsh vegetation, with woodland meadow scattered on relatively high altitudes. The wetland in Sanjiang Plain is the biggest in area in China (Hao and Wang, 2003).

Sanjiang Plain kept its name of "the Great Northern Wilderness" until the reclamation in mid-1950s. The cultivated land increased from 7.2% in 1949 to 50.0% in 1994, while wetland decreased by 72.2% from 1949 to 1994 and forestland reduced from 30.4%in 1949 to 23.2% in 1983 (Liu and Ma, 2000). Due to the irrational reclamation, regional environmental deterioration, e.g., frequent disasters, regional soil sandification and salinization, soil pollution, water resources decrease, soil fertility decline, and biodiversity worsening, occurred (Marsh Research Department, Changchun Institute of Geography, Academia Sinica, 1983)

2. Sampling sites

The undisturbed wetland and forestland and cultivated lowland and upland in Sanjiang Honghe Farm were selected as test objects, with their sampling sites listed in Table 1.

Table 1. Description of sampling sites

No.	Location	Land use type	Reclamation history
Site 1	47°31.918′N, 133°52.987′E	Wetland	Undisturbed
Site 2	47°31.609′N, 133°53.047′E	Lowland rice field	Reclaimed for 10 years
Site 3	47°32.272′N, 133°30.610′E	Lowland rice field	Reclaimed for 25 years
Site 4	47°32.375′N, 133°30.781′E	Forestland	Undisturbed
Site 5	47°35.299′N, 133°30.172′E	Upland soybean field	Reclaimed for 5 years
Site 6	47°35.405′N, 133°30.012′E	Upland soybean field	Reclaimed for 18 years

3. Soil sampling and analysis

Soil samples were taken from the depths of 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-90 cm and 90-120 cm, and duplicates were installed at each sampling site. Soil organic carbon content was determined by TOC 5000A autoanalyzer, and soil pH was measured in 1:2.5 soil:water suspension by using Elico Digital EC meter. Statistic analyses were made with SPSS 10.0.

RESULTS AND DISCUSSION

1. Soil organic carbon

The SOC content in undisturbed wetland and cultivated lowland rice fields had a marked decrease from 0-10 cm to 40-60 cm and a less change downward (Figure 1a). In 0-10 cm layer, there was a significant difference in SOC content ($P < 0.01$), with the sequence of undisturbed wetland > lowland rice field reclaimed for 25 years > lowland rice field reclaimed for 10 years. Compared with that in undisturbed wetland, the SOC content in 0-10 cm layer in the lowland rice fields having been reclaimed for 10 and 25 years was decreased by 49.3% and 14.3%, respectively.

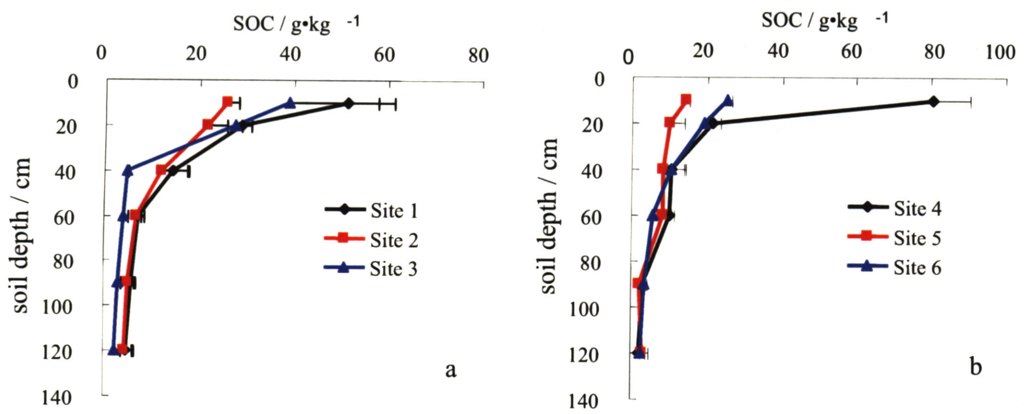

Figure 1. Vertical distribution of SOC under different land use type in Sanjiang Plain.

A similar distribution pattern of SOC was observed in undisturbed forestland and cultivated soybean fields (Figure 1b), only with the difference that the SOC content in 0-10 cm layer was much higher in forestland than in wetland, and lower in soybean fields than in lowland rice fields. Compared with that in undisturbed forestland, the SOC content in 0-10 cm layer in the soybean fields having been reclaimed for 5 and 18 years was decreased by 81.9%and 68.3%, respectively.

The higher storage of SOC in surface layer was closely related with the accumulation of plant materials, while the differences in the dynamics of SOC in this layer should have close relations with the amount and quality of plant residues, as well as the environmental and soil conditions (Dick, 1983; Wander *et al.*, 1998; Needelman *et al.*, 1999).

2. Soil pH

Soil pH decreased with depth in undisturbed wetland, but had a uniform vertical distribution in cultivated lowland rice fields. It was higher throughout the profile in the rice field with a longer reclamation history than in that with a shorter one. In 0-10 cm layer, there was a significant difference in soil pH, with the sequence of undisturbed wetland > lowland rice field reclaimed for 25 years > lowland rice field reclaimed for 10 years (Figure 2a). On the contrary, the soil pH in undisturbed forestland and the soybean field having been reclaimed for 18 years was increased with depth, and in 0-10 cm layer, soil pH was decreased in the sequence of soybean field reclaimed for 5 years > soybean field reclaimed for 18 years > undisturbed forestland (Figure 2b).

The different distribution patterns of soil pH suggested that reclamation had different effects on soil acidity of wetland and forestland, especially that in surface layer, which should have definite effects on SOC storage. Regression analysis revealed that there was a significant negative correlation between soil pH and SOC in undisturbed forestland and the soybean field having been reclaimed for 18 years, indicating that the higher soil pH after reclamation led to a decreased SOC storage, probably due to the enhanced mineralization of SOC by soil microbes (Motavalli et al., 1995).

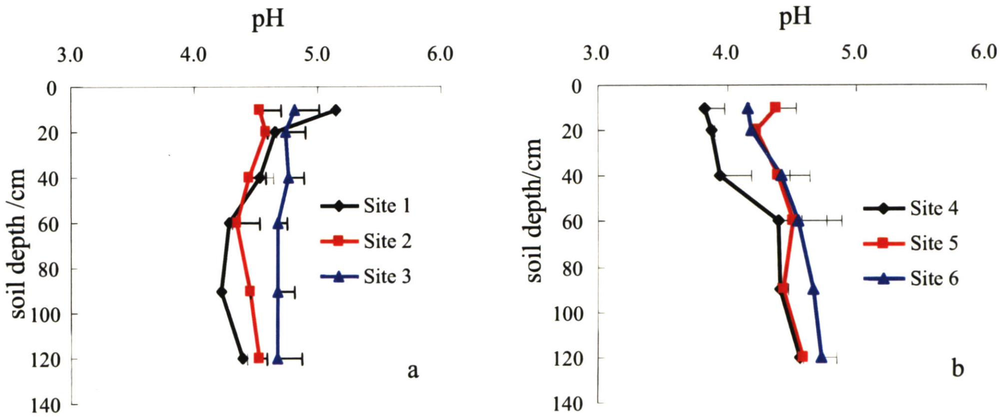

Figure 2. Vertical distribution of soil pH under different land use type in Sanjiang Plain

CONCLUSION

A similar vertical distribution pattern of SOC, i.e., decreased markedly from 0-10 cm to 40-60 cm and less changed downward, was observed in undisturbed wetland and forestland and in their reclaimed fields. The only difference was that the SOC content in 0-10 cm layer was much higher in forestland than in wetland, and lower in soybean fields than in rice fields. Reclamation made a great loss of SOC in surface layer, with a loss rate of 49.3% and 14.3% in wetland after reclaimed for 10 and 25 years, and 81.9% and 68.3% in forestland after reclaimed for 5 years and 18 years, respectively.

Land use type had a significant effect on soil pH. In surface layer, soil pH was decreased in the sequences of undisturbed wetland > lowland rice field reclaimed for 25 years > lowland rice field reclaimed for 10 years, and soybean field reclaimed for 5 years > soybean field reclaimed for 18 years > undisturbed forestland. The variations of surface soil pH under reclamation could be one of the factors inducing the SOC loss.

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