Research Advance on Carbon Storage of Artificial Grassland in China

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Abstract As an essential part of the grassland ecological system, study on the carbon storage has great significances to the carbon reduction in grassland ecological system. The carbon storage in biomass, carbon storage in soil and soil respiration are summarized in this paper to provide scientific reference for the evaluation of carbon storage in artificial grassland.

Key words Artificial grassland, Carbon storage, Organic carbon in soil, Land Respiration

Global climate change and the increase of carbon have won worldwide attention[1]. The land plant turns CO_2 in the atmosphere into organic carbon through photosynthesis, some going into the atmosphere in the form of CO_2 while others penetrating into the land through withered leaves[2]. Grassland is one of the most important part of the ecological system and plays an important role in the global carbon circulation and climate changes[3-4]. Accounting for 40% of the global land, the Chinese grassland, as a large carbon bank, has saved 145.5×10^6 t [5] of biomass in average, which plays an essential role in the carbon circulation of the ecological system on land in China[6-7]. The artificial grassland plays a significant role in the agricultural and husbandry development in China. Therefore, it is essential to study the influence of carbon storage on the ecological system, and the accuracy of carbon balance. In recent years, Chinese scholars have done much research about the carbon circulation on the grassland[8-10]. However, there are few studies on the carbon circulation. Especially in recent 30 years, with the expansion of artificial grassland, there should be more and more studies on the carbon circulation in the grassland ecological system [11-12]. Considering the carbon storage in the grassland in China and abroad, this paper analyzed the studies about the carbon storage in the grassland in China, hoping to provide reference to the evaluation of carbon income and expense in the artificial grassland in China and carbon mechanism.

1 Study on the carbon storage of biomass in the artificial grassland

The plants on the artificial grassland in China include *Medicago sativa*, *E. dahuricus*, *Elymus sibiricus*, *A. adsurgens*, *Melilotus officinalis*, *Lolium perenne*, *Astragalus sinicus*, *Onobrychis viciifolia*, *Coronilla varia*, *Trifolium alexandrinum*, *Bromus inermis*, *Agropyron cristatum*, *Lotus corniculatus*, *Festuca arundinacea Schreb*, *Avena sativa*, *Vicia sativa*, *Vicia villosa*, *Sorghum sudanense*(*Piper*) Stapf., *Lathyrus sativus*. *Medicago sativa* is the kind of fodder which is the most widely cultivated. Since the 21st century, *Medicago sativa* has been planted for 2.3 million to 2.6 million hm^2[13], which accounts for 78.5% of the general artificial grassland in China[14]. So far, most studies are about *Medicago sativa* [15]. The carbon energy is related to the vegetation and soil types[16]. The artificial grass plantation can greatly improve and recover the carbon consolidation capacity[17].

The carbon storage in the artificial grassland is closely related to the production power and biomass on the grassland. The carbon storage in the artificial grassland includes vegetation carbon storage and organic carbon storage in the soil. As an essential part of the ecological system, the carbon storage in the grassland concentrates on the soil layer, and includes underground biomass carbon storage and organic carbon storage in the soil[18]. Study on the biomass and accumulation of carbon element has significant roles in the evaluation of climate changes[19]. The data of biomass is the fundamental prerequisite of the carbon density and carbon storage. The biomass of artificial grassland directly influences its carbon storage. If the grassland quality increases, its assimilated carbon is larger than the amount it releases. On the contrary, the artificial grassland would become a huge carbon source, which would aggravate the global warming and greenhouse effect. The root is an essential carbon source and the artificial grassland is the main source of carbon in the soil. The biomass in the underground is two to five times of that on earth[20]. The fixed amount of carbon in the underground may be an essential part of the global carbon collection[21]. The carbon being transmitted from the root to the soil is larger than that in the leaves which are fell onto the ground. The carbon amount in the soil is huge and its relation to the bio-

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mass is worth studying[22-23]. The influences of different plants on the nutrition transition and microorganism are different[24]. The fallen product can enhance the organic material in the soil and the carbon amount in the microorganism in the soil[25]. Li Linghao has pointed out that there are few studies on the things which are fell onto the ground[27-28].

2 Study on the organic carbon in the artificial grassland

The organic carbon in the soil is an essential part of the carbon bank on the land and is a key in the study of global carbon circulation and global changes[29]. The organic carbon storage in the soil refers to the amount of organic carbon in the soil of 1 m deep[30-31]. However, some soils are too thin to calculate, so it should be calculated based on depth[32]. The organic carbon in the soil is the material basis of the fertility of soil and the core in the study of global carbon circulation and climate changes[33,34]. The organic material of soil influences the soil structure and fertilizer, which directly leads to the reduction of agricultural productivity and environmental quality[35]. The active organic carbon refers to the reaction of some components towards the general organic carbon, and it can be considered as the indicator of early changes of organic carbon[36]. According to the density group technology, the organic carbon in the soil can be divided into LFOC and HFOC[37]. LFOC is an intermediate carbon bank of the animals and plants residue and humus[38], and it is considered as the indicator of the ground mass and soil fertility during the adjustment of biomass[39-40] and the changes of carbon in the soil[41]. Therefore, the study on the distribution and changes of organic carbon in soil means a lot to the carbon circulation in the system[42]. The carbon element in the grassland ecological system largely stores in the underground soil bank [43]. There are many studies about the carbon circulation in the ecological system [44]. Carbon in the soil is an effective way to ease the greenhouse effect and the carbon level is an essential indicator to balance the soil quality[45]. In recent years, there are many studies on the organic carbon in the soil and its significance [46]. Many scholars have done research on the characteristics of soil carbon under different grassland forms [47-50]. There are many studies on the organic carbon storage in China[51-53], and some scholars focus on the changes of soil carbon[54-55]. Generally speaking, the study on the carbon storage is in the initial stage[56], and there are limited observed data. It is difficult to reveal the actual carbon in the grassland through evaluation of the vegetation or soil types.

In recent years, there are many studies on the carbon storage through grazing of natural grass and other management measures[58] Studies on the dynamic changes of organic carbon bank focus on the surface [59]. Xu Lijun *et al*. studied the biomass of microorganism, but the depth of soil was only 0 to 10 cm, 10 to 20 cm [60]. Studies on the carbon in the soil are not clear, which need to be observed for a long time.

3 Study on the microorganism in the soil of the artificial grassland

The microorganism in soil is an essential part of the ecological system, and the amount and changes of microorganism is a significant indicator of the land fertility[61]. Soil microorganism biomass refers to the general biomass which is smaller than 5×10^3 μm^3. The soil microorganism biomass include SMB-C, SMB-N, SMB-P and SMB-S in broad sense, and the microorganism means the carbon in the microorganism in the narrow sense[62]. The soil microorganism biomass, as a biological indicator, has been widely studied by scholars in China and abroad[63-64]. The carbon in the soil microorganism biomass is also considered as one of the common indicator to evaluate the soil quality and to reflect the microorganism groups[65-66]. Compared with forest and the ecological system of farmland, studies on the soil microorganism in the grassland ecological system began late[67]. Right now, most studies are about the background of soil in the grassland [68-69]. All in all, the study of the field experiment can result in a convincing argument.

4 Study on the respiration of soil in the artificial grassland

Soil respiration is a main way to transmit carbon into the atmosphere through the land ecological system and an important component in the carbon circulation of ecological system. In order to learn about the general situation of carbon circulation, it is necessary to study and determine the supply, accumulation, decompose and transmission of organic material in the soil and to learn about the withered leaves and soil respiration[70]. Soil respiration is a main way to study the metabolism within microorganism, the root of plants, and the chemical oxygen in soil [71]. As a main way of soil carbon expose, the soil respiration has become the key issue in the study of global carbon circulation [72]. Studies on the land respiration include farmland, grassland, forest, wetland and tundra[73-74]. Currently, people have different understanding towards the soil respiration and [75]. People have many studies on the ecological system[76-77], and scientists in China and abroad have carried out a series of studies on the observation method, process, influence mechanism, and evaluation [78-81]. Raich *et al*. pointed out the influence of temperature and precipitation on the temporal and spatial changes of soil respiration [82]. Ryan *et al*. studied the influence of changes in land respiration on the climate and plants[83]. In conclusion, land respiration is essential to the carbon balance in ecological system[84]. The understanding of the relation between ecological system and soil respiration needs long-term field location experiment[85]. The measurement of soil respiration dates back to 1990s[86-87]. Studies on the land respiration largely focus on the influence of meteorological factors on the land respiration instead of the biological factors, which led to poor comparability [89-91]. There are few studies on the land respiration[11]. Pang Yingying *et al*. studied the daily changes and seasonal changes of land respiration[12]. Xu Lijun *et al*. measured the land respiration of different kinds of plants[92]. However, the observed data was not systematic, especially in terms of artificial grassland[93].

5 Conclusions

At present the study on the carbon storage in the artificial grassland largely focus on the *Medicago sativa*. The study of carbon storage in the artificial grassland includes carbon storage of biomass, organic carbon of soil, and microorganism of soil and land respiration. However, most studies of soil carbon storage paid attention to the surface soil[94]. Studies on the carbon storage on the grassland were mostly carried out incessantly and can not reflect the characteristics of carbon storage on the grassland Different studies result in different evaluation values of carbon storage on the artificial grassland. The disadvantages of soil respiration in the artificial grassland are short observation time, few materials on the daily and seasonal dynamic changes and their influences on factors. Studies on the carbon storage in the artificial grassland and studies on the long – term location observation are hardly seen in China. The evaluations of carbon storage in different artificial grasslands are uncertain. In conclusion, the priority, right now, is to study the carbon storage in the grassland, to reveal the carbon consolidation mechanism, and to intensify the mechanism of reduction of carbon emission and increase of carbon storage.

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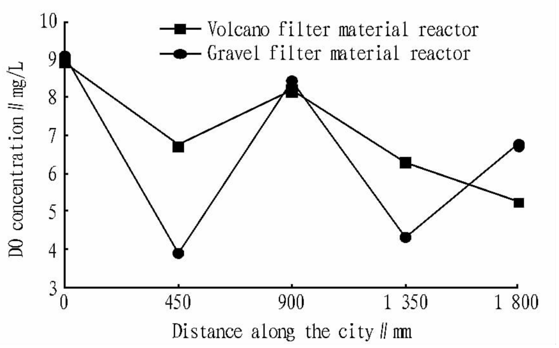

Fig. 4 DO concentration of filter bed in the first and third aeration filter bed

2.3 Study on the congestion of stuff in the filter bed The stuff congestion in the artificial strengthened ecological filter bed is a hard core to crack in the operation[5]. The way to solve the stuff of traditional biological filter bed should be to take out the stuff automatically or mechanically and then to clean the filter bed. During the operation, proper measures should be applied to ease or avoid congestion. First of all, the pre-treatment of influent was the key to solve the congestion in the filter bed. There was sediment zone in this experiment so as to get clean water, and then put the clean water into the cascade aeration machine. Through twice precipitation, the suspended substances and particles can be reduced by 50% and 70%. The effect of such kind of technology was distinct. Secondly, while the artificial strengthened ecological filter bed was designed, the space between the filter bed and the aeration zone changed the way traditional biological filter tube was deployed. The design of aeration not only solved the congestion of tube in the operation, but also enhanced the efficiency to use DO. Besides, the equipment can put off the congestion caused by falling biological membrane through the control of operation form. There was a discharge in the equipment. After certain time, when the entire biological filter bed was empty and the falling biological membrane became dry, large amount of water was put in to cleanse the filter bed so as to prolong the period of using filter bed. In the actual operation, the proper congestion had positive influence on the degradation of organisms and the removal of N and P. The congestion of stuff was a sign of appropriate ecological filter bed.

3 Conclusion

Firstly, the distinct pretreatment of cascade aeration can satisfy the requirement of artificial strengthened ecological filter bed. When the height of cascade aeration was within 0.6 m, the DO of cascade aeration was stable, and both had positive relation. The data suggested that the optimal cascade height should be 0.6 m. Secondly, through the study of the property of the artificial strengthened ecological filter bed, the dissolution and use efficiency of volcano rock and gravel were quite different. In order to enhance the degradation of filter bed on the organism, the volcano filter material greatly improved the efficiency to process water quality. Thirdly, the study on the technology to filter materials relieved the congestion of traditional biological filter bed, and promised a broad future for the application of artificial strengthened ecological filter bed in the purification of living sewage in the north China.

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