Research Progress of CO2 Flux in Saline and Alkali soils in Arid area

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Abstract. Study on CO2 flux of saline and alkali soil in arid area is of great significance to greenhouse gas control. At present, the main research contents at home and abroad focus on the ways of CO2 sequestration and migration and transformation in saline-alkali soils in arid areas. The influencing factors of CO2 flux in saline-alkali soil in arid area include soil temperature, humidity, pH, EC and soil physical and chemical properties. Inorganic carbon equilibrium process of CO2(g)—CO2 (aq)—HCO3⁻ (aq)—CaCO3(s) is common in soil, its dynamic process dominates the inorganic carbon exchange at the ground-gas interface. This is of great significance to the study of soil-atmospheric carbon circulation system for exploring the principle and mechanism of greenhouse gas change in order to slow down global warming and strengthen the management and control of greenhouse gases. It contributes to China's energy conservation and emission reduction planning and international carbon balance negotiations.

1. Introduction
In recent years, climate change has been paid more and more attention by researchers. Greenhouse gas emission reduction and control has become one of the main problems perplexing human development, and the study of soil-atmosphere carbon cycle has become a hot research topic in greenhouse gas research. CO2 is an important greenhouse gas, which has a wide range of sources, large total emissions, long retention life in the atmosphere, and its contribution rate to Greenhouse Effect is about 60%. The Kyoto Protocol, promulgated in 1997, strongly requires countries around the world to strengthen the control of CO2 emissions, reduce carbon sources and emissions, advocate afforestation, and increase carbon sequestration in terrestrial ecosystems [1]. Therefore, it has set off an upsurge in the study of global carbon cycle, especially to strengthen the discussion of soil-atmosphere carbon balance imbalance. Soil carbon pool, as the largest carbon pool in terrestrial ecosystem, is about 3 times as much as atmospheric carbon pool and 3.8 times as much as biological carbon pool [2]. Soil has the dual function of absorbing and emitting carbon. It is estimated that the change of soil organic carbon reservoir by 0.1% will cause the change of CO2 concentration 1 mg/L. Therefore, accurate calculation of soil carbon reserves has become the core problem of global carbon cycle research [3]. It is estimated that the soil releases about 76.5 pg C into the atmosphere every year in the form of CO2 flux, which is much higher
than the amount released by fossil fuel combustion \[4\]. Therefore, the soil CO2 flux is the key process affecting the concentration of CO2 in the atmosphere. Because the area of semi-arid area accounts for 41% of the global surface area\[5\], and climate change and human activities may lead to the continuous expansion of its area\[6\], the slight change of soil CO2 flux in this region will significantly affect the global carbon budget, so it is very important to understand it. Soil carbon pool is mainly composed of soil organic carbon pool and soil inorganic carbon pool. As one of the main determining factors of terrestrial ecosystem carbon balance, soil CO2 flux is considered to be an important regulator of climate change \[7\]. According to the results of global carbon flux estimates, since 1980, human activities have emitted about 7.1 Pg C·yr\(-1\) into the atmosphere on an average annual basis. In addition to being absorbed and retained in the atmosphere by the ocean, about 1.8 Pg C·yr\(-1\) (24%) of CO2 is unknown \[8\]. The negative fluxes of soil CO2 were detected in Mexico, the United States and the desert areas of China. In 2008, the journal science comprehensively reported the absorption of CO2 in alkaline soils in Xinjiang, China and the Mojave Yancheng Desert in the United States, indicating that the carbon pools lost in the atmosphere may exist in saline-alkali soils in a widely distributed arid area\[9\]. The carbon sequestration effect of saline-alkali soil in arid desert has gradually entered people's attention. The huge "carbon source" of soil and the function of "carbon sink" play an important role in the study of global carbon cycle\[10\]. The inorganic carbon equilibrium process of CO2(g)\(\rightarrow\)CO2(aq)\(\rightarrow\)HCO3\(^{-}\)\(\rightarrow\)CaCO3(s) is common in soil. Its dynamic process dominates the inorganic carbon exchange at the ground-gas interface, and also controls the fixation and leaching of soil inorganic carbon\[11\].

Soil CO2 flux is divided into soil biological flux and soil abiobioc flux. Biological flux refers to the biological processes such as soil respiration through vegetation root system, microbial dynamic respiration (microbial decomposition of soil litter and organic matter) and soil animal respiration. It is also one of the important ways of carbon exchange between terrestrial ecosystem and atmospheric ecosystem, and one of the largest fluxes in the global carbon exchange process. Recent studies have found that in the carbon cycle of the soil-atmosphere system, the soil with sparse vegetation or inactivated soil releases CO2, during the day and absorbs CO2 from the atmosphere at night\[12\-13\]. Xie et al. \[14\] pointed out that the inorganic abiotic absorption process in soil is likely to be a natural process in saline-alkali soil which is widely distributed on the earth. Inorganic carbon sequestration in saline-alkali soil can dominate or temporarily dominate soil carbon sequestration. Wang Zhongyuan, et al. used the method of autoclaving to separate the soil inorganic CO2 flux of 9 saline alkali soil from the soil CO2 flux. The results show that the soil inorganic CO2 flux is mainly controlled by the temperature when the soil type is certain:Low temperature is beneficial for CO2 absorption and high temperature is beneficial to CO2 release\[15\]. According to the soil in the desert area of the United States, high temperature sterilization method is applied to remove biological action in soil.

Saline-alkali soil in arid area is widely distributed, soil conditions are complex and affected by farming. The research work of saline-alkali soil-atmospheric carbon cycle is very challenging. However, the study of soil-atmospheric carbon cycle system is of great significance to explore the principle and mechanism of greenhouse gas change in order to slow down global climate warming and strengthen the management and control of greenhouse gases. Exploring the mechanism of soil-atmospheric carbon cycle is an important problem related to the development of all mankind.

2. Study on Saline-Alkali soil - Atmospheric carbon cycle in Arid area

Soil CO2 flux is the second largest flux in terrestrial ecosystem carbon cycle, and its small change can seriously change the balance of atmospheric CO2 concentration. At the same time, soil CO2 flux is the largest output flux in terrestrial ecosystem carbon budget, is a key ecological process affecting atmospheric CO2 concentration, and plays a very key role in the regulation of regional and global scale carbon cycle \[17\]. Although a lot of research has been done on soil CO2 flux in recent decades, it is still not enough to fully reflect the global characteristics of soil CO2 flux. Some key processes and mechanisms need to be clarified \[18\-20\]. The study of soil CO2 flux process is an important content to explore the global carbon cycle and carbon loss \[21\-22\]. Soil respiration is a process in which CO2 is produced by living and non-living processes in soil and emitted from soil surface to atmosphere \[23\]. The
emission process includes two processes: The production of CO2 in the soil, the diffusion movement in the soil and the emission from the soil surface to the atmosphere [24]. In the saline-alkali soil environment of arid area, vegetation is sparse and the number of microorganisms in soil is lower. Therefore, the study of soil abiotic CO2 flux in arid area is helpful to explain the principle of "Carbon sink". In recent years, the response mechanism of soil abiotic CO2 flux to soil temperature has been systematically studied. Soil abiotic CO2 fluxes were positive during the day and negative at night from May to October 2012 and March to April 2013. In the rest of the month, the diurnal scale did not change much. During the observation period, there was a linear relationship between abiotic CO2 flux and soil temperature change rate, but the determination coefficient was not high [25].

The results indicate that a non-trivial CO2 exchange process between soil and atmosphere can induce carbon sequestration and this exchange process is modified by temperature. Although soil temperature cannot be directly used to explain the effect of temperature on the abiotic soil carbon flux, the rate of change in soil temperature can accurately interpret the role of temperature played in the abiotic CO2 exchange between soil and atmosphere. The mean hourly CO2 fluxes on sterilized and unsterilized soils were -0.09 lmol m\(^{-2}\) s\(^{-1}\) and 0.49 lmol m\(^{-2}\) s\(^{-1}\) [26].

3. Carbon sequestration form and Migration and Transformation of Saline-alkali soil in Arid area

At present, combined with the previous research results, soil temperature, humidity, rainfall, atmospheric turbulence and so on, will have an impact on soil CO2 flux. In recent years, different research teams in the world have found that the process of absorbing CO2 by saline-alkali soil exists in saline-alkali soil with pH greater than 7.0. The researchers began to control experiments, field monitoring experiments, isotopic tracer analysis, absorbed CO2 through absorption and migration. The transformation was stored in saline-alkali soil in arid area. From carbon isotope data of the DIC, it can be seen that the source of carbon dioxide in the carbonate originates from the atmosphere. Thus a net sequestration of atmospheric CO2 occurs when carbonate is precipitated [26]. At present, it is generally agreed that inorganic processes do exist in soil CO2 fluxes, but there is still no unified conclusion on the formation mechanism of soil inorganic CO2 fluxes [28]. The main viewpoints are dissolution/precipitation of carbonate system [29], dissolution chemistry of CO2 [30] and underground hole ventilation [31]. The reversible variation of soil inorganic CO2 flux with temperature, as well as the characteristics strongly regulated by soil pH and affected by EC, verify the above theoretical mechanism from the side. The research on soil inorganic CO2 fluxes in different saline-alkali soils is very representative, which will greatly enrich the global soil CO2 flux database and promote the interpretation of saline-alkali soil carbon cycle in arid areas.

4. Prospect

At present, in view of the lack of more systematic research on the carbon cycle of saline-alkali soil in arid area, in order to further explore the position and role of saline-alkali soil in the global carbon cycle in arid area, it is necessary to grasp the scientific problem of carbon sequestration by saline-alkali soil in arid area, explore the process of carbon cycle in arid area from the mechanism, so as to clarify the mechanism of CO2 sequestration in saline-alkali soil in arid area, establish the theoretical system of carbon cycle in arid area, and put forward a new way of "Carbon loss". It contributes to China's energy conservation and emission reduction planning and international carbon balance negotiations.

In the aspect of CO2 observation of saline-alkali soil in arid area, the observed time can be increased from growth season to annual observation. Combined with local climatic conditions, the observation points can be established, the physical and chemical properties of soil can be explored and laboratory culture experiments are carried out, the culture time is increased, the formation process of carbonate is explored and combined with microbial experiment, and the relationship between the number of mineral crystals formed by colonies and the degree of salt and alkali is observed. The ecosystem itself is diverse, and the carbon cycle itself is an extremely complex biological, chemical and physical process, which requires the integration of knowledge in many fields to determine the carbon cycle process of saline-
alkali soil in arid area and its role in the global carbon cycle, and to find out the global significance of carbon cycle in saline-alkali soil in arid area, which is still full of opportunities and challenges.

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