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Editorial: Climate change and soil microbial control of carbon sequestration

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Editorial on the Research Topic
Climate change and soil microbial control of carbon sequestration

Soil microorganisms, as a major regulator in the dynamics of soil organic carbon (SOC) and nutrient availability, partake in a variety of biochemical reactions. Because of the large soil carbon pool, even small changes in the balance between inputs and outputs from the soil carbon pool can exert a significant impact on atmospheric CO_2 levels. Over the past few decades, the influence of climate change on soil carbon cycling has been intensively analyzed. The focus on investigating the global carbon cycle due to its connection with climate change has led to an increasing number of studies on microbial control of SOC. It has been extensively recognized that the extent of SOC reservoir is determined by microbial involvement since soil carbon dynamics ultimately stem from microbial activity and growth. However, the mechanisms by which these microbe-regulated processes cause soil carbon stabilization under climate change is still unclear. Therefore, the Research Topic "*Climate Change and Soil Microbial Control of Carbon Sequestration*" were organized.

The interest for this Research Topic were mainly included 1) novel insights into the interplay in soil microbial community function; 2) recent advancements in soil carbon dynamics under the influence of global climate change; 3) biogeochemical mechanisms connecting soil microbes and SOC; 4) the role of soil microbes in the SOC conversion process; 5) the new high-throughput sequencing for soil microbes, including metagenome, transcriptomics, metabonomics methods, etc.; 6) Response of soil microbes to climate change and their impacts on SOC transformation and fixation; 7) Addressing uncertainty in estimating SOC pool at the local, regional, and global scales. Twelve articles were published in this Research Topic, highlighting key progress in the field:

Smallwood et al. demonstrated that volatile organic compounds (VOCs) can potentially serve as bioindicators of subsurface biogeochemical processes, providing high-resolution data and broad-scale measurements that can be used to characterize biological roles in the thermokarst–permafrost continuum. This study also establishes methods and approaches for effectively capturing VOCs during winter seasons that could allow for more accurate measurements of subsurface microbial rates of carbon conversion.

Zheng et al. discovered that high-affinity CH_4 oxidation induced by high CH_4 concentrations is widespread in paddy soils. In acid-neutral paddy soils capable of oxidizing atmospheric CH_4, type II methanotrophs exhibited higher 16S rRNA: rDNA ratios and, higher potential activity than type I methanotrophs. CH_4 oxidation enhanced biotic interactions between methanotrophs and other prokaryotic taxa. Soil pH and nutrient availability can significantly affect the methanotrophic community and high-affinity CH_4 oxidation activity.

Liu et al. revealed that soil respiration (Rs) decreased with increasing stand age in poplar plantations throughout the growth cycle. The microbial *r*-strategies were the key biotic factors that influenced Rs in different-age poplar plantations. Other abiotic factors such as pH, SOC and NO_3–N, and litter C: N were also important drivers of Rs. Soil properties such as pH and bulk density also significantly affected soil microbial community diversity and composition, and altered the ecological strategies of microbial communities, which in turn altered Rs.

Qiao et al. found that grazer exclosure is effective in increasing soil microbial diversity without affecting the stability of their networks. These benefits may be affected by climate warming, which reduces bacterial diversity and network complexity by increasing nitrate nitrogen contents. The recovery of soil microbial communities in degraded grasslands through grazing exclosure may be slow under future warming scenarios. Land managers need to consider the environmental as well as social and economic implications of degraded grassland restoration measures.

Wu et al. basing on 701 sampling points of topsoil, geostatistics and geodetectors revealed that the average value of effective phosphorus content in the topsoil of the study area was 14.28 mg/kg. Among all theoretical models, the exponential model has the best fitting effect. Elevation is the main controlling factor for the spatial variation of available phosphorus in the topsoil, followed by soil types, planting systems, annual precipitation, and organic matter. The diversity and complexity of spatial heterogeneity could affect available phosphorus content in cultivated soil.

Wang et al. found that higher soil organic matter levels were associated with greater species diversity, and both diversity and soil organic matter decreased with increasing soil depth. The Annelida greatly improved soil quality, fertility, and nutrient availability in karst basins. The major species influencing the soil organic matter distribution were *Agrotis segetum*. Earthworms thrived at relatively high soil humidity and thickness but are negatively impacted by rock outcrops. The spatial distribution of soil animals is positively influenced by interactions between soil thickness, humidity, structure, and bulk density and is negatively influenced by rock outcrops and soil types. Beneficial land use increases soil animal diversity and abundance, promoting SOM accumulation. Microtopography greatly impacts soil organic matter in karst basins by altering its spatial distribution.

Li et al. demonstrated that continuous 6-year conservation tillage (CT) significantly increased maize yields, aggregate stability, and POC (0–30 cm) and MAOC (0–20 cm) contents. Tillage practice and soil depth both influence bacterial, fungal and protistan communities. The connectivity of module 1 was significantly related to POC and MAOC contents CT increased the richness of specific fungal (*Cephalotrichum*) and protistan (*Cercozoa*) species and promoted SOC fraction accumulation through straw degradation, macroaggregate formation and predation effects. Stimulating the function of keystone taxa can drive the function of the module 1 community in SOC accumulation under CT practices, which is beneficial for maintaining soil fertility and productivity in eolian sandy soils on the Northeast China Plain.

Xuemei et al. illustrated that both climate warming and nitrogen deposition significantly increased soil organic carbon component and altered soil bacterial, leading to a positive impact on soil enzyme activity, and enzyme stoichiometry, as well as C: P and N: P ratios. Soil bacterial diversity also showed significant increments. Climate warming led to a decrease in the soil enzyme C: N ratio and C: P ratio, while increasing the soil enzyme N: P ratio. Nitrogen deposition resulted in a significant increase in the soil enzyme C: N ratio and a decrease in the soil enzyme N: P ratio. Soil organic carbon components were directly influenced by the negative impact of climate warming and the positive impact of nitrogen deposition.

Liu et al. found that the heavy metal pollution in the downwind direction of the automobile Parts Co., Ltd. is mainly As, CD, and Zn mixed heavy metal pollution, as well as the distribution is uneven. The coefficient of variation of As was the largest, and the regional variation amplitude was large. The accumulative index of AS and CD was 6, which reached a very serious pollution level. The content of As was 1994.7 mg/kg, exceeding the standard by more than 44 times, and the distribution of As in soil was uneven. The pollution level of Zn belonged to the moderate level. The pollution degree of heavy metals in the soil decreases as the distance from the downwind outlet of plant increases.

Li et al. indicated that arbuscular mycorrhizal fungi (AMF) communities varied through the increase or decrease of dominant *genera* and effectively buffered the impact of the ecosystem on environmental changes, finally improving the overall resilience of the dry environment. No tillage and subsoiling with mulch significantly changed the composition of AMF community at growth stages. Conventional tillage could promote proportions of the *genus Claroideoglomus*, whereas no tillage was good to proportion of *genera Glomus* and *Septoglomus*. No tillage and subsoiling with mulch influenced the composition of key *genera* by changing plant biomass and soil characteristics, result in the AMF community composition changing.

Luo et al. found that photovoltaic shading improved soil microbial biomass with the increasing of 20%–30%. Compared to light intensity, the soil depth had more important impacts on the diversity and relative abundance of soil bacterial communities. The dominant phyla were *Actinobacteria*, *Proteobacteria*, *Acidobacteria*, *Chlorobacteria*, and *Dimonobacteria*. The ecological network was more stable and better adapted to light stress under the photovoltaic. *Euryops pectinatus* is more conducive to maintaining the stability and health of subsurface ecosystems in vulnerable areas. Soil nutrients are the key driving factor in the dominant soil community changes.

Huang et al. investigated seasonal and biogeographic dynamics of soil ciliates community in the Yarlung Zangbo River and found that soil ciliates communities and environmental factors exhibited significant seasonal and geographic variations. The soil ciliate community was more complex in wet season than in dry season, and the stability of soil ciliate community in wet season was higher than that in dry season. The stability of soil ciliate community in wetland was higher than that in forestland, shrubland and grassland, and the anti-interference ability was stronger. Soil temperature, total nitrogen, soil organic matter and soil water content are the important factors affecting the structure of soil ciliate community.

The goal of this Research Topic is to explore how soil microorganisms exert two primary, contradictory impacts on controlling soil carbon dynamics by focusing on climate change and its impact on soil microbial control carbon sequestration. All results above in this Research Topic will provide good insights in understanding microbe-regulated processes cause soil carbon stabilization under climate change. In the future, we should continue to focus on soil carbon sequestration mediated by soil microorganism with the scenarios of climate change.

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