Differential characteristics of soil organic carbon and its driving factors in the northeastern Qinghai-Tibet Plateau

Xin Wang[1], Yanbin Wen[1], Weiwei Pei[1], and Yangong Du[2]

[1]Northwest Institute of Plateau Biology Chinese Academy of Sciences
[2]Northwest Institute of Plateau Biology

April 20, 2023

Abstract

Clarifying the spatial distribution of soil organic carbon (SOC) can provide a theoretical basis for mitigating carbon emissions. The characteristics of SOC and soil organic carbon density (SOCD) change in different vegetation and soil types, and the response mechanism of SOC content to environmental factors are unclear. Thus, 131 sites were selected for sampling from the 0-30 cm soil layer to study regional SOC and SOCD spatial distribution. The results showed that the SOCD in the northwestern region was lower than that in the southeastern in the northeast of the Qinghai-Tibet Plateaue. Both SOC and SOCD were affected by the vegetation type. The order of vegetation types was swamp > meadow > steppe > desert. Furthermore, SOC content decreased with increasing soil depth in the 0-30 cm soil layer. The SOC and SOCD contents also differed among the different soil types. The order of SOC from largest to smallest was alpine meadow soil > bog soil > chestnut soil > saline-alkali soil > alpine steppe soil > grey-brown desert. The path analysis showed that TN significantly positively affected SOC (P < 0.001). This study aimed to provide a scientific basis for grassland carbon sink management in the Qinghai-Tibet Plateau.

Differential characteristics of soil organic carbon and its driving factors in the northeastern Qinghai-Tibet Plateau

Xin Wang[1,2], Yanbin Wen[1,2], Weiwei Pei[1,2], Yangong Du[1*]

[1]Northwest Institute of Plateau Biology, Chinese Academy of Sciences, Xining, China, 810008

[2] University of Chinese Academy of Science, Beijing, China, 100049

Correspondence E-mail: ygdu@nwipb.cas.cn, ckl7813@163.com

Abstract: Clarifying the spatial distribution of soil organic carbon (SOC) can provide a theoretical basis for mitigating carbon emissions. The characteristics of SOC and soil organic carbon density (SOCD) change in different vegetation and soil types, and the response mechanism of SOC content to environmental factors are unclear. Thus, 131 sites were selected for sampling from the 0-30 cm soil layer to study regional SOC and SOCD spatial distribution. The results showed that the SOCD in the northwestern region was lower than that in the southeastern in the northeast of the Qinghai-Tibet Plateaue. Both SOC and SOCD were affected by the vegetation type. The order of vegetation types was swamp > meadow > steppe > desert. Furthermore, SOC content decreased with increasing soil depth in the 0-30 cm soil layer. The SOC and SOCD contents also differed among the different soil types. The order of SOC from largest to smallest was alpine meadow soil > bog soil > chestnut soil > saline-alkali soil > alpine steppe soil > grey-brown desert. The path analysis showed that TN significantly positively affected SOC ($P < 0.001$). This study aimed to provide a scientific basis for grassland carbon sink management in the Qinghai-Tibet Plateau.

Keywords: SOC; SOCD; spatial distribution; vegetation types; soil types

Introduction:

As an important part of the carbon pool of terrestrial ecosystems, soil organic carbon affects the productivity of ecosystems and greatly impacts the Earth's carbon cycle and global climate change. It is not only the "source" but also an important "sink" of greenhouse gases (Cheng et al. 2023). The SOC pool is the largest carbon pool in terrestrial ecosystems (Bai. 2018), approximately three times that of vegetation and twice that of atmospheric carbon (Lal. 2004). Global climate change has a robust effect on soil organic carbon (SOC) (Chen et al. 2019; Li 2009). In the context of global change, small changes in soil carbon pools can cause large changes in atmospheric carbon dioxide concentration (Plaza et al. 2019). Changes in SOC dynamics can alter the ecosystem's carbon balance and determine whether soils are carbon sources or sink at regional and global scales (Román et al. 2022). Therefore, research was carried out on the changes in the characteristics of SOC and soil organic carbon density (SOCD) and their response to influencing factors. Understanding the carbon cycle in grassland ecosystems and managing ecosystem carbon sinks is significant (Breulmann et al. 2016).

China's total grassland carbon pool was 79.24 ± 2.42 Pg C, of which 82.9% was stored in the soil, 16.5% in biomass, and 0.60% in litter (Fang et al. 2010). The SOC content of China's coastline ranges from 0.63 to 36.7 g/kg (Fang et al. 2010). The SOC content in the alpine meadow is the largest, which is 51.54 g/kg, and the desert grassland ecosystem is the smallest, with a value of 4.96 g/kg (Chen et al. 2019). A study of different swamp wetland types in an arid area between the Altai Jinshan and Qilian Mountains found seasonal saltwater swamp > inland salt swamp > herb swape (Chen. 2020). The SOCD of *Leymus chinensis* formations in Inner Mongolia is higher than that of *Stipa grandis* and *S. sareptana*formations (Feng et al. 2019). The SOCD of the main soil types in Henan Province is 6.64–7.77 kg*m^{-2}(Yu et al. 2008).

SOC content is controlled by output and input and above- and below-ground biomass. Litter and root exudates are the main sources of SOC input (Wang et al. 2015). Plant roots, microbial respiration (Shi et al. 2012), and the oxidation of carbon-containing minerals (Trumbore 2006) are the main sources of SOC output. The factors that affect these two processes also influence changes in SOC. SOC content is mainly affected by the combined effects of climate, soil, and vegetation on a regional scale (Chen et al. 2019). At the regional scale of the Tibetan Plateau, SOC content mainly depends on total nitrogen and altitude (Dai et al. 2022). Studies have shown that environmental factors have a dimensional effect on SOC(O'Rourke et al. 2015). SOC content is mainly affected by climatic factors on a large scale(Wang et al. 2009). Climate affects SOC by affecting vegetation (Bot et al. 2005). The main factors affecting SOC on a small scale are land-use methods and management (Zhang et al. 2020). There is a negative correlation between soil pH and SOC (Yan et al. 2020). Grazing is the main reason for the increase in SOC in northern Jiangsu (Lu et al. 2020). As a nutrient necessary for vegetation growth, an increase in nitrogen content can promote the accumulation of SOC (Qi 2017). The surface SOC storage of a typical grassland in Inner Mongolia is affected by factors such as the type of community vegetation, aboveground biomass, and average leaf area of the plant community (Feng et al. 2019).

As an important part of the Qinghai-Tibet Plateau, Qinghai Province is one of the most sensitive and vulnerable regions to global climate change. Its warming rate is approximately twice that of the global average. It profoundly impacts the carbon cycle of terrestrial ecosystems and environmental climate change in China (Wang et al. 2012). Therefore, clarifying the distribution characteristics of organic carbon in Qinghai Province is important for determining the role of Qinghai Province and the Qinghai-Tibet Plateau in the carbon cycle of China's terrestrial ecosystem and global environmental changes. Previous studies on SOC in Qinghai Province have been limited to local areas or specific vegetation types (Wang et al. 2019;Liu et al. 2016). Our research was based on 25 county-level regions in Qinghai Province, with 131 sampling sites in the 0-30 cm soil layer, differences in SOC and SOCD changes in different vegetation and soil types, and the adjustment effect of SOC on certain environmental factors. The purpose of this study was to explore the distribution characteristics of SOC and its influencing factors in the northeastern Tibetan Plateau, and to provide a scientific basis for revealing the grassland carbon sink management and ecosystem service optimization on the Tibetan Plateau.

Materials and method

Site description

The study area covers the Qinghai Province area and includes multiple types of natural ecosystems, climatic conditions, soil conditions, and vegetation community composition. There was apparent spatial differentiation. The average annual temperature in the study area ranges from -11.47 to 12.87 . The average annual precipitation is 47.38-551.38 mm. We selected 131 sampling sites in 25 county-level regions of Qinghai Province, including Guinan, Tongde, Zeku, Henan, Maqin, Gande, Dari, Banma, Jiuzhi, Maduo, Tianjun, Dulan, Wulan, Gonghe, Xinghai, Chengduo, Nangqian, Zaduo, Zhiduo, Qumalai, Golmud City, Gangcha, Haiyan, Qilian, and Menyuan. They include steppe, meadow, desert, and swamp vegetation (Fig. 1).

Field sampling and sample testing

A total of 131 samples were collected during the growing season from July to September in 2011 and 2012. Stratified soil samples were collected at depth increments of 0-5, 5-10, 10-20, and 20-30 cm, and sampling from each site was repeated five times. The SOC was determined using the dry burning method (PE2400) and repeated five times.

The aboveground biomass was collected using the standard harvest method (sample area: 50x50 cm) and repeated five times for each plot. Belowground biomass was measured using the root drilling method and collected from 0-5, 5-10, 10-20, and 20-30 cm layers. Sampling from each plot was repeated five times, and the roots were washed using the water-washing method. The samples were dried at 65 to constant weight, weighed, and converted to a standard unit ($g*cm^{-3}$).

The total nitrogen content was measured using an elemental analyser (PE-2400). pH was measured using a pH meter.

The root drilling method was used to collect soil bulk density samples at 0-5, 5-10, 10-20, and 20-30 cm in selected plots, with five replicates for each plot. The samples were baked to a constant weight at 105 degC in a blast drying box to obtain soil bulk density.

The soil organic carbon density (SOCD)was calculated as

$$\mathrm{SOCD} = \sum_{i=1}^{n} (1-\theta_i) \times T_i \times v_i \times C_i/10$$

In the above formula, T_i is the thickness (cm) of layer i,v_i is the bulk density ($g\cdot cm^{-3}$) of layer$i$, C_i is the SOC content (%) in layer i , andθ_i is the volumetric percentage of fragments > 2 mm. The C_i content was converted from the organic matter concentration using a conversion coefficient of 0.58 since the organic matter was determined by wet combustion with $Cr_2O_7^{2-}$(ZHANG et al. 2022).

Data analysis

Data were organised using Excel 2010. The R programme (4.2.1) was used for significance testing and path analysis, and the figure was drawn using Origin 2022. The semi-variance function of the experimental data and ordinary kriging interpolation was calculated using ArcGIS 10.2.

Results

Spatial distribution characteristics of SOCD

The SOCD in the northwest was lower than that in the southeast on a horizontal scale in the Qinghai Province (Fig. 2), and the changing trend was the same on a vertical scale. The SOCD in most areas of the 0-5, 5-10, 10-20, and 20-30 cm soil layers are 0.28–2.31, 0.53–2.61, 1.00–4.20, 0.64–4.60 $kg*m^{-2}$. The highest values of SOCD in the 0-5, 5-10, and 20-30 cm soil layers appeared in Menyuan County, with values of 6.70, 14.96 and 6.05 $kg*m^{-2}$, respectively. The highest SOCD value of 11.603 $kg*m^{-2}$appears in Zhiduo County in the 10-20 cm layer. The lowest values of 0.758, 0.980, 1.237, and 1.632 kg*m^{-2} appear in Golmud City regardless of the soil layer. Generally, the SOCD of the deep soil layer (10-30 cm) was higher than that of the 0-10 cm surface soil layer.

Vertical distribution characteristics of SOC and SOCD of different vegetation types

The SOC and SOCD show the same trend from the perspective of vegetation types and were in the order of swamp > meadow > steppe > desert (Fig. 3). The SOC content decreased vertically in the lower soil layers and was mainly concentrated in the surface soil. The SOCD of the steppe, swamp, and meadow vegetation types showed an upward trend in the 0-20 cm soil layer, reaching a maximum in the 10-20 cm soil layer, and that of the desert reached a maximum in the 20-30 cm soil layer. The SOCD ranges of 0-5, 5-10, 10-20 and 20-30 cm layers are 0.41–11.00, 0.39–18.08, 0.98–33.41, 1.57–41.49 kg*m^{-2}, respectively. The average values were 2.58, 2.77, 5.05 and 4.42 kg*m^{-2}.

Vertical distribution characteristics of SOC and SOCD in different soil types

The SOC and SOCD were the highest in the meadow soil. SOC gradually decreased with the depth of the soil layer, while the SOCD gradually increased. The SOC of the different soil types are in the following order: meadow soil > bog soil > chestnut soil > saline-alkali soil > alpine steppe soil > grey-brown desert soil (Fig. 4). The SOC of bog and chestnut soils was the highest at 5-10 cm. Alpine steppe soil had the highest SOC in the 10-20 cm soil layer. The 20-30 cm soil layer had the lowest SOC. The SOCD values of the different soil types were as follows: meadow soil > bog soil > chestnut soil > saline-alkali soil > grey-brown desert soil > alpine steppe soil. The SOCD value at 10-20 cm was the highest. The order of SOCD was as follows: 10-20 cm > 20-30 cm > 0-5 cm > 5-10 cm in the vertical distribution.

Regulation mechanism of SOC

The structural equation model (SEM) indicated that all predictor variables together accounted for 31% of the variations in SOC at the 0–30 cm depth (R^2 = 0.31, Fig. 5). Total nitrogen (TN) and belowground biomass (BGB) had direct and significant ($P< 0.01$) positive effects on SOC, with values of 0.454 and 0.147, respectively. Above ground biomass (AGB) and Litter directly and negatively impact SOC; the values are -0.043 and -0.050, respectively. BGB also had a positive indirect effect on litter and TN. AGB had a strong indirect negative effect on litter and BGB. pH had a strong indirect impact on TN and BGB.

Discussion

Our research suggests that the SOCD mainly has a lower spatial distribution in the northwest than in the southeast of Qinghai Province. China's average SOCD is 7.97 kg/m^{-2}, with the highest in the northeast, followed by the central region, and the lowest in the dry areas of the northwest (YANG et al. 2023). Compared with other regions in Qinghai Province, Golmud is arid and has less rainfall, with a large temperature difference between day and night (WANG et al. 2019). The ecological environment is fragile, and vegetation development is poor (WANG et al. 2017), which is not conducive to the accumulation of SOC. The replenishment of dead plants, litter, and secretions is mainly concentrated in the surface soil, leading to SOC accumulation (WANG et al. 2021).

In this study, the swamps had the highest SOC and SOCD values. SOCD is determined by SOC and bulk density (BD) (ZHANG et al. 2020), causing the soil litter layer and organic matter input from the soil layer to have corresponding differences in vegetation, quantity, and chemical properties due to vegetation types (YANO et al. 2005). The soil organic carbon content of the alpine meadow in northern Xinjiang was higher than that of the alpine steppe and increased to 161.32 kg/ha/yr (WANG et al. 2022). The average SOC at 1 m depth in the semi-arid grassland in Gansu Province was 7.09 kgm^{-2}(TIAN et al. 2016). The swamps had the highest SOC contents in our study. This is because the stagnant water in the swamp prevents adequate aeration, there are fewer aerobic bacteria, the mineralisation process is weakened, the input of organic matter is far greater than the output, and long-term accumulation increases the total organic carbon content of the soil (DONG et al. 2019). Research on the soil organic carbon storage of different vegetation types on the

Qinghai-Tibet Plateau found that the soil organic carbon storage of alpine meadows is higher than that of alpine grasslands and deserts (CHEN 2016). This finding is consistent with the results of the present study.

Differences in soil type also affect SOC content. The SOCD of different soil types shows a certain distinction and similarity on the vertical change scale. The difference in water and heat conditions on the Qinghai-Tibet Plateau caused by topography and atmospheric circulation, and the influence of fixed factors in the ecosystem, caused the SOCD of the Qinghai-Tibet Plateau to decrease from south to north and east to west (WANG et al. 2019). In this study, the meadow soil had the highest SOC and SOCD, possibly due to the low temperature, high humidity, the slow decomposition rate of humus, and the high accumulation rate of organic matter in the meadow soil (WANG and ZHOU 1999).

In this study, TN and BGB had extremely significant direct and positive effects on SOC, whereas pH, AGB, and litter had negative effects. Soil nitrogen is important for soil life, respiration, and plant photosynthesis (GUO et al. 2016). TN positively affected SOC, whereas pH negatively affected SOC in a *Stipa crustella* grassland of Inner Mongolia (ZHANG et al. 2020). Nitrogen addition can change the soil microbial community structure (WANG et al. 2014), improve microbial carbon use efficiency, weaken microbial respiration, and increase organic carbon accumulation(WANG et al. 2016). Studies have shown that the soil pH in Alxa grasslands significantly reduces SOC (FU et al. 2004). Microbial activities, which play an important role in the mineralisation of SOC, are suppressed when the soil environment is acidic (TANG 2019). High salinity reduces the normal growth of vegetation and the SOC content when the pH value is higher than 10(CHEN et al. 2019). It mainly affects SOC content by affecting the litter decomposition rate (ZHAO et al. 2018).

Conclusion

On the horizontal scale, the soil organic carbon density in the northeastern part of the Qinghai-Tibet Plateau was low in the northwest and high in the southeast. The vertical distribution of soil organic carbon and soil organic carbon density varied significantly among soil and vegetation types. Total nitrogen and belowground biomass were the main factors affecting soil organic carbon content in the northeastern Tibetan Plateau.

Conflicts of interest

All authors declare no conflict of interest.

Data Accessibility Statement

If this manuscript was accepted, the soil organic carbon data would be uploaded to Dryad database.

Acknowledgements

This study was supported by key development projects of Qinghai (2022-NK-135).

References:

BAI S.G. Profile distribution characteristics of soil inorganiccarbon and carbon sequestration potential in-different saline-alkali degree soil. Inner Mongolia Normal University, 2018.

BOT A., BENITES J. The importance of soil organic matter. Journal of Geology, 117, 241, 2005.

BREULMANN M., BOETTGER T., BUSCOT F., GRUENDLING R., SCHULZ E. Carbon storage potential in size-density fractions from semi-natural grassland ecosystems with different productivities over varying soil depths. Science of the Total Environment, 545, 30, 2016.

CHEN S. Spatial distribution characteristics and digital mapping of soil organic carbon in Sejila Mountain. Zhejiang University, 2016.

CHEN T. Distribution characteristics of soil organic carbon and its influencing factors in different swamp wetland types in arid region. Hubei Agricultural Sciences, 59(18), 54, 2020.

CHEN X.T., XU T.L., LI X.J., ZHAO A.H., FENG H.Y., CHEN B.D. Soil organic carbon concentrations and the influencing factors in natural ecosystems of northern China. Chinese Journal of Ecology. 38(04), 1133, 2019.

CHENG J., HUANG W.Q., ZHANG S.C., ZHANG W.Q., HUANG G.B., ZHANG J.Z., WU L.Q. Spatial distribution of and factors influencing topsoil organic carbon density in Fujian province, China. Journal of Agricultural Resources and Environmen, 1, 2023.

DAI L., GE J., WANG L. Influence of soil properties, topography, and land cover on soil organic carbon and total nitrogen concentration: A case study in Qinghai-Tibet plateau based on random forest regression and structural equation modeling. Science of The Total Environment, 821, 1534, 2022.

DONG Y., GENG Y.Q., HUANG G.L., LI N., ZHANG C.Y. Organic carbon content of surface soils in the Marshs and wet meadows of Qinghai Lake Basin and their structural characteristics. Wetland Science, 17(04), 478, 2019.

FANG J.Y., YANG Y.H., MA W.H., ANIVAL M., SHEN H.H. China's grassland ecosystem carbon pool and its changes. Science in China:Life Sciences, 40(07), 566, 2010.

FENG S.J., ZHAO Y.Y., LI Y.H., YAN Y.Z., HAN F. The Differences and Influencing Factors of Topsoil Organic Carbon Storage in Typical Steppe of Inner Mongolia. Chinese Journal of Grassland. Chinese Journal of Grassland, 41(02), 116, 2019.

FU H., CHEN Y.M., WANG Y.R., WAN C.G. Organic carbon content in major grassland types in Alex, Inner Mongolia. Acta Ecologica Sinica, 24(03), 469, 2004.

GUO Y., LI F., LI Y.D., DUAN T.Y. Progress in the elucidation of the mechanisms of arbuscular mycorrhizal in promotion of phosphorus uptake and utilization by plants. Pratacultural Science, 33(12), 2379, 2016.

LAL R. Soil carbon sequestration impacts on global climate change and food security. science, 304(5677), 1623, 2004.

LI Y.S., ZHANG R.H., WANG G.X., ZHAO L., DING Y.J., WANG Y.B. Spatial Variability Characteristics of Soil Organic Carbon and Nitrogen Reveal Typical Alpine Meadow Degradation on Qinghai-Tibetan Plateau. Environmental Science, 30(06), 1826, 2009.

LIU S., DU Y., ZHANG F. Distribution of soil carbon in different grassland types of the Qinghai-Tibetan Plateau. Journal of Mountain Science, 13, 1806, 2016.

LU X.T., LIU S.G., ZHANG L.M., YU D.S., SHI X.Z., XING S.H. Variation characteristics of soil organic carbon content in dry land of northern Jiangsu from 1980 to 2008. Journal of Fujian Agriculture and Forestry University, 49 (1), 132, 2020.

QI J.H. Contents of Soil Organic Carbon and Its Relations with Physicochemical Properties of Secondary Natural Oak Forests in Eastern Mountain Area of Liaoning Province. Journal of Soil and Water Conservation, 31(4), 135, 2017.

O'ROURKE S.M., ANGERS D.A., HOLDEN N.M. Soil organic carbon across scales. Global Change Biology, 21, 3561, 2015.

PLAZA C., PEGORARO E., BRACHO R. Direct observation of permafrost degradation and rapid soil carbon loss in tundra. Nature Geoscience, 12(8), 627, 2019.

ROMAN D. M., WADOUX A. M., MALONE B., MINASNY B., MCBRATNEY A., SEARLE R. Mapping soil organic carbon fractions for Australia, their stocks and uncertainty. Biogeosciences Discussions, 1, 2022.

SHI B.K., JIN G.Z., WANG Z.Y. Temporal and spatial variability in soil respiration in five temperate forest in Xiaoxing'an Mountains, China. Acta Ecol Sin, 32(17), 5416, 2012.

TANG M. Research advances in spatial and temporal distribution of soil organic carbon and its influencing factors in China. Journal of Henan University of Engineering, 31(04), 42, 2019.

TIAN Z., JIAN P., WEI L. Spatial–temporal patterns of water use efficiency and climate controls in China's Loess Plateau during 2000–2010. Science of The Total Environment, 565, 105, 2016.

TRUMBORE S.E. Carbon respired by terrestrial ecosystems: R ecent progress and challenges.Global Change Biology, 12, 141, 2006.

WANG B., ZHOU Y., ZHANG Q.L. The characteristics of soil organic carbon in Larix olgensis forest and its relationship with other soil physical and chemical properties. Journal of Ecology and Rural Environment, 1, 2021.

WANG D.B., CHEN L. Soil organic carbon and its influencing factors. Scientific and Technological Innovation, (27), 126, 2015.

WANG D.D., SHI X.Z., YU D.S., WANG H.J., SUN W.X., REN H.Y., ZHAO Y.C. Main natural factors controlling soil organic carbon density in the uplands of Northeast China. Ecology and Environmental Sciences, 18(3), 1049, 2009.

WANG G., MAO J., FAN L. Effects of climate and grazing on the soil organic carbon dynamics of the grasslands in Northern Xinjiang during the past twenty years. Global Ecology and Conservation, 34, e02039, 2022.

WANG J.B., HUANG Z., LIN X.H. Review on Carbon Budget of the Grassland Ecosystems on the Qinghai-Tibet Plateau. Progress in Geography, 31(01), 123, 2012.

WANG J.S., ZHAO X.H., ZHANG C.Y. Effects of simulated nitrogen deposition on soil organic carbon and total nitrogen content in plantation and natural forests of Pinus tabuliformis. Journal of Beijing Forestry University, 38(10), 88, 2016.

WANG L., ZENG H., ZHANG Y.J., ZHAO G., CHEN N., LI J.X. A review of research on soil carbon storage and its influencing factors in the Tibetan Plateau. Chinese Journal of Ecology, 38(11), 3506, 2019.

WANG Q.K., WANG Y.P., WANG S.L. Fresh carbon and nitrogen inputs alter organic carbon mineralization and microbial community in forest deep soil layers. Soil Biology and Biochemistry, 72, 145, 2014.

WANG S.Q., ZHOU C.H. Estimat ing soil carbon reservoir of terrestrial ecosystem in China. Geographical Research, 18(4), 349, 1999.

WANG S.B., QI Z.X., HE H.S., WANG W.P., WU P. Laws of Temporal-spatial Distribution of Vegetation and an Analysis of the Influencing Factors in the Golmud iver Basin. China Rural Water and Hydropower, (10), 65, 2017.

WANG Y.L., ZI H.B., CHENG R.X., TANG L.T., SUO E.A.Z., LUO X.P., LI J., WANG C.T. Forest soil organic carbon and nitrogen storage and characteristics of vertical distribution in Qinghai Province. Acta Ecologica Sinica, 39(11), 4096, 2019.

XIA S., SONG Z., VAN Z.L. Storage, patterns and influencing factors for soil organic carbon in coastal wetlands of China. Global Change Biology, 28(20), 6065, 2022.

YAN X., LI W.S., LUO X., ZHANG Y.R., HUANG Y.Y., QIN Y.N. Study on the Vertical Distribution Characteristics of Soil Organic Carbon under Different Land Use. Agriculture and Technology, 40(14), 13, 2020.

YANO Y., LAJTHA K., SOLLINS P. Chemistry and Dynamics of Dissolved Organic Matter in a Temperate Coniferous Forest on Andic Soils: Effects of Litter Quality. Ecosystems, 8(3), 286, 2005.

YANG R.M., HUANG L.M., ZHANG X. Mapping the distribution, trends, and drivers of soil organic carbon in China from 1982 to 2019. Geoderma, 429, 116232, 2023.

YU J.J., YANG F., WU K.N., LI L., LV Q.L. Soil organic carbon storage and its spatial distribution in Henan Province. Chinese Journal of Applied Ecology, (05), 1058, 2008.

ZHANG C.Y., ZHAO X., XIN Y.C., TANG W.J., WANG L. Carbon storage and distribution of grassland ecosystems in Qinghai Province. Journal of Beijing Normal University(Natural Science), 58(02), 286, 2022.

ZHANG X.R., ZHANG W.Q., WU R.C.H., LI X.J., SAI S.Y.L.T., CHUN F. Relationship between organic carbon and soil physical and chemical properties in Stipa krylovii grassland. Journal of Arid Land Resources and Environment, 34 (08), 194, 2020.

ZHAO D., QUAN L., TU C.Y. Distribution Characteristics of Soil Organic Carbon in Typical Forestlands in Drainage Basin of Gongba River[J]. Bulletin of Soil and Water Conservation, 38(6), 54, 2018.

Hosted file

`SOC picture(EE).docx` available at https://authorea.com/users/586146/articles/638873-differential-characteristics-of-soil-organic-carbon-and-its-driving-factors-in-the-northeastern-qinghai-tibet-plateau