Stocks of organic carbon and nitrogen in dark serozems of the Chirchik river basin in Tashkent region of Uzbekistan

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Abstract. The reserves of SOC and TN were investigated in the profile of dark serozems of the river basin Chirchik, Tashkent region of Uzbekistan, in connection with the exposure of slopes and use in agriculture. The highest stocks of SOC and TN (79.2 and 10.3 t/ha) are noted in the 1-meter layer of natural soil on the northern slope that is more abundant in moisture, relatively low temperature and thicker vegetation cover. And in a meter layer of a similar soil on the southern slope, the SOC and TN reserves were significantly lower and amounted to 75.5 and 9.7 t/ha. The use of these soils in agriculture led to significant losses of SOC and TN in the meter layer and in the soil profile as a whole. In the soil of the northern slope of agricultural use, the SOC and TN reserves were 76.7 t/ha and 10.3 t/ha, which is significantly lower compared to natural soil. Also, in the soil of agricultural use on the southern slope, the value of SOC and TN reserves in the meter layer of soil was 68 and 9 t/ha that is significantly lower than that in the natural soil of the slope developed in the same exposure. Thus, slope exposure and agricultural land use were the main factors affecting SOC and TN stocks in the profile of the studied soils.

1. Introduction

Information on the stocks of organic carbon (SOC) and nitrogen (TN) in the profile of natural and agricultural soils and the factors affecting these indicators will help to assess the potential for carbon sequestration in dark serozems in the Chirchik river basin of Tashkent region of Uzbekistan.

Tashkent region is located in the northeastern part of Uzbekistan, occupies the mountains and foothills of the western Tien Shan, in the basin of the middle reaches of the river Sirdarya as an independent Chirchik-Angren basin [8]. Dark serozems of low mountains and foothills developed in a subarid climate within the Chirchik-Angren district are distributed at altitudes from 700 to 1200-1300 m above the sea level [19].

The content of organic matter and nitrogen in the soils of the river Chirchik and Tashkent region have been studied by many researchers [2; 4; 5; 10; 11; 12; 14]. However, changes in organic carbon and total nitrogen stocks in soil profiles have not fully elucidated in terms of climate change mitigation.

Soil carbon sequestration and preservation of existing carbon stocks have given its many benefits, such as, improved food production is an important mitigation pathway for achieving the global Paris Climate Agreement target below 2 °C [22]. SOC sequestration mitigates the effects of climate change, improves the environment, and promotes food and food safety [16].

The study of changes in soil organic carbon in space and time is important for understanding the soil system and its role in the carbon cycle [13]. Studying the influence of altitude and related factors (climate, vegetation) on the physical and chemical properties of the soil can help predict changes in response to future climatic impacts on afforestation [3].

The degree of stratification of soil organic pools C and N with soil depth, expressed as a ratio, may indicate soil quality or the functioning of the soil ecosystem, since surface organic matter is important for erosion control,
water infiltration and nutrient conservation [1]. The interaction between terrestrial nitrogen (N) and carbon (C) cycles is shaping the response of ecosystems to global change. However, the global distribution of nitrogen availability and its significance for global biogeochemistry and biogeochemical interactions with the climate system remain uncertain [21]. Vegetation types, altitude and pH may be the main factors controlling the spatial distribution of SOC and TN in mountainous regions [22].

A significant portion of the depleted SOC pool can be restored through the conversion of marginal lands to regenerative lands, the introduction of conservative tillage using cover crops and mulch from crop residues, nutrient cycling, including the use of compost and manure, and other sustainable soil and water management systems [15].

Estimates of soil organic carbon (SOC) stocks and sequestration potential in 20 regions of the world have shown that with best management practices, 4 ppm (4 ppm Soil for Food Security and Climate Project) or even higher sequestration rates can be achieved [1]. Studies have been done in Yunnan province in south-western China under different types of vegetation and at different heights with three soil depths (0–20 cm, 20–40 cm, and 40–60 cm), SOC and TN stocks were positively correlated with average annual temperatures and average annual rainfall.

2. Materials and methods

Soil pits were laid on dark serozems: natural soil and vineyards of the northern and southern slopes. Soil samples were taken from the soil horizons, dried in air and crushed and passed through sieves 0.25 mm and 1 mm. The total SOC content was estimated by oxidation with K-dichromate in sulfuric acid while heating the suspension at 180 °C for 30 min, the total N content - according to Keldahl; soil texture with a hydrometer - according to Kachinsky. The bulk density was determined using 500 cc steel cylinders (height: 8 cm; diameter: 8.7 cm). Samples collected in cylinders were dried at 105 °C until constant weight, pH water; the soil (1 mm) was determined on a PH 3000 pH meter.

3. Results and Discussions

According to the profile of the studied dark serozems, the content of sand ranges from 54-68%, clay - 25-31%, silt - 9-15%, pH-water in the range of 7.3 - 7.8, the content of water-soluble salts - 0.115-0.195%. The bulk density of soils in the sod and arable horizons is much lighter than that in the lower horizons. When these soils are used in agriculture, a plow horizon with a lower bulk density and a subsurface horizon with a higher bulk density are formed in comparison with the underlying horizons. In natural soils, the bulk of SOC and TN are contained in the soddy (Ah) and under the soddy (Ah) horizons; in the lower horizons, their content and reserves sharply decrease. The C / N ratio fluctuates among 7.5-8.2 gradually expanding down the soil profile (Table 1).

The content and reserves of SOC and TN in the profile of natural soils differed greatly according to the exposures of the slopes. On the northern slope, a more favorable moisture regime, a relatively low temperature and a greater density of vegetation cover, the content of SOC and TN were significantly higher compared to the similar soil of the southern slope, which was characterized by lower moisture content due to strong evaporation of moisture under the action of direct sunlight and a sparse vegetation cover. In the soddy (Ah) and under the soddy (Ah) horizons of the natural soil of the northern slope, the SOC content was 1.87 and 0.82%, respectively, and TN 0.25 - 0.11%. And the stocks of SOC and TN were, respectively, 96.8 and 12.5 t / ha, and in the meter layer - 79.2 and 10.3 t / ha.

In a similar soil on the southern slope, the SOC content in the soddy (Ah) and under the soddy (Ah) horizons was 1.81 and 0.81%, respectively, and TN 0.23 - 0.10%. And the stocks of SOC and TN were significantly lower than the soil of the northern slope and amounted to 90.7 and 11.7 t / ha in the whole profile, and 75.5 and 9.7 t / ha - in the meter layer, respectively. The same pattern was observed in the underlying horizons of both soils.

The use of dark serozem in agriculture was accompanied by a significant decrease in the content and reserves of SOC and TN in the soil (Table 2). In the soil of the northern slope in the arable (Ap) and under arable (B1) horizons, the SOC content was 0.76 and 0.70%, and TN was 0.10 and 0.09%, respectively. The SOC and TN stocks were 88.1 and 11.3 t / ha in the soil profile as a whole, and in the meter layer, respectively, 76.7 and 10.3 t / ha, which is significantly lower compared to natural soil (tab. 2), but at the same time much more than in the similar soil of the southern slope.
Table 1. Bulk density, content and reserves of organic carbon and total nitrogen in the profile of natural dark serozems

| Horizon | Soil layer (cm) | Bulk density (gr/cm$^3$) | SOC (%) | Stocks SOC (t/ha) | TN (%) | Stocks TN (t/ha) | C/N |
|---------|----------------|--------------------------|---------|------------------|--------|-----------------|-----|
| North slope | | | | | | | |
| A$_h$ | 0-5 | 1.27 | 1.87 | 11.87 | 0.25 | 1.56 | 7.6 |
| A$_1$ | 6-29 | 1.33 | 0.82 | 26.12 | 0.11 | 3.38 | 7.7 |
| AB | 30-58 | 1.34 | 0.48 | 18.53 | 0.06 | 2.42 | 7.7 |
| B$_1$ | 59-80 | 1.34 | 0.42 | 12.33 | 0.05 | 1.57 | 7.8 |
| B$_2$ | 81-111 | 1.33 | 0.39 | 16.02 | 0.05 | 2.06 | 7.8 |
| C | 112-144 | 1.34 | 0.27 | 11.93 | 0.03 | 1.50 | 8.0 |
| Total | | | | | | | |
| 0-100 | | | 96.79 | 12.50 |
| South slope | | | 79.18 | 10.26 |
| A$_h$ | 0-3 | 1.29 | 1.81 | 7.00 | 0.23 | 0.90 | 7.8 |
| A$_1$ | 4-22 | 1.33 | 0.82 | 20.67 | 0.10 | 2.73 | 7.6 |
| AB | 23-55 | 1.34 | 0.53 | 23.60 | 0.07 | 3.10 | 7.6 |
| B$_1$ | 56-78 | 1.34 | 0.42 | 12.89 | 0.05 | 1.66 | 7.7 |
| B$_2$ | 79-100 | 1.33 | 0.39 | 11.37 | 0.05 | 1.43 | 7.9 |
| C | 101-142 | 1.34 | 0.27 | 15.18 | 0.03 | 1.86 | 8.2 |
| Total | | | | | | | |
| 0-100 | | | 90.70 | 11.68 |

Table 2. Bulk density, content and reserves of organic carbon and total nitrogen in the profile of dark serozems used in agriculture

| Horizon | Soil layer (cm) | Bulk density (gr/cm$^3$) | SOC (%) | Stocks SOC (t/ha) | TN (%) | Stocks TN (t/ha) | C/N |
|---------|----------------|--------------------------|---------|------------------|--------|-----------------|-----|
| North slope | | | | | | | |
| Ap | 0-24 | 1.28 | 0.76 | 23.39 | 0.10 | 2.96 | 7.9 |
| B$_1$ | 25-48 | 1.38 | 0.70 | 23.28 | 0.09 | 2.94 | 7.9 |
| B$_2$ | 49-70 | 1.34 | 0.41 | 12.00 | 0.05 | 1.54 | 7.8 |
| B$_3$ | 71-98 | 1.33 | 0.38 | 14.04 | 0.05 | 1.79 | 7.9 |
| C | 99-142 | 1.34 | 0.26 | 15.42 | 0.03 | 2.02 | 7.6 |
| Total | | | | | | | |
| 0-100 | | | 88.14 | 11.25 |
| South slope | | | | | | | |
| Ap | 0-26 | 1.30 | 0.76 | 25.64 | 0.10 | 3.42 | 7.5 |
| B$_1$ | 27-51 | 1.37 | 0.47 | 16.23 | 0.06 | 2.15 | 7.5 |
| B$_2$ | 52-81 | 1.36 | 0.41 | 16.85 | 0.05 | 2.19 | 7.7 |
| B$_3$ | 81-102 | 1.34 | 0.36 | 10.05 | 0.05 | 1.30 | 7.8 |
| C | 103-131 | 1.34 | 0.26 | 10.07 | 0.03 | 1.26 | 8.0 |
| Total | | | | | | | |
| 0-100 | | | 79.05 | 10.35 |
In the soil of the southern slope for agricultural use, the value of SOC and TN reserves as a whole in the soil profile was 79.1 and 10.4 t/ha, and in the meter layer - 68 and 94 t/ha, which is significantly lower than that in the natural soil of a slope developed in the same exposure.

4. Conclusions
It has been established that the exposure of the slope and agricultural land use are the main factors affecting the SOC and TN stocks in the profile of dark serozems of the river basin in Chirchik, Tashkent region. The content and reserves of SOC and TN in the dark serozems of the northern slope are significantly higher than that in similar soils of the southern slope. The involvement of dark serozems in agriculture leads to a significant decrease in the content and reserves of SOC and TN both in the northern slopes and in the southern slopes.

References
[1] Agrochemical characteristics of soils of the USSR Republics of Central Asia1967(Moscow:Publishing HouseNAUKA)
[2] Badía D, Ruiz A, Girona Aet al.2016 The influence of elevation on soil properties and forest litter in the Siliceous Moncayo Massif, SW Europe J. Mt. Sci.132155–2169
[3] Bairov A J, Nuriddinova Kh T, Zhurayev Sh A2017 The current state of brown soils of the western spurs of the Chatkal ridgeBulletin of Kyrgyz National Agrarian University named after K. I. Scriabin2(43) 131-135.
[4] Bairov A J, Nuridinova Kh T, Juraev Sh A 2015About the current state of virgin and rain-fed typical serozems. Bulletin of the National University of Uzbekistan3227-29.
[5] Minasny B, Malone B P, McBratney A B, Angers D A, Arrouays D, Chaplot V, Zueng-Sang C, Kun C, Bhabani S D, Damen JF, Alessandro G, Carolyn B H, Suk Y H, Biswapati M, Ben P M, Manuel M, Brian GM, Leigh W 2017 Soil carbon 4 per mille Geoderma29259-86
[6] Franzluebbers AJ 2005 Soil organic matter stratification ratio as an indicator of soil quality Soil and Tillage Research 66(2)95-106
[7] Gafurova LA, Mahsudov HM 2005 Features of mountain-brown soils of the western spurs of the Chatkal ridge and their susceptibility to erosion Materials of the IV Congress of the Society of Soil Scientists and Agrochemists of Uzbekistan, Tashkent, pp. 38-46
[8] Genusov A Z, Gorbunov N V, Kimberg N V 1960 Soil and climatic zoning of Uzbekistan for agricultural purposes (Tashkent).
[9] Genusov A Z, Kuziev R K 1987 Aspects of fertility of irrigated soils in Uzbekistan Cotton growing 7716-19
[10] Khanazarov A, Tursunov L, Fakhrutinova M, Kamilova D 2009 Soils of Uzbekistan (Tashkent).
[11] Kuziev R K, Sektimenko V E Soils of Uzbekistan (Tashkent: Publishing House EXTREMUM PRESS)
[12] Lazarev S F 1957 Khlopchatnik Microbiological characteristics of serozems 2(Tashkent: Publishing House of the Academy of Sciences of the Uzbek SSR)
[13] Parras-Alcántara L, Lozano-Garcia B, Galán-Espejo A 2015 Soil organic carbon along an altitudinal gradient in the Despeñaperros Natural Park, southern Spain Solid Earth 6125–134
[14] Rabochev I S, Imamaliev A I 1985 Melioration and fertility of irrigated soils of Central Asia. Reports of the symposia of the VII Delegate Congress of the All-Union Society of Soil Scientists (Tashkent) pp. 2-19.
[15] Rattan L 2004 Soil carbon sequestration to mitigate climate change Geoderma 123(1–2) 1-22
[16] Rattan L 2017 Soil organic carbon sequestration: importance and state of science. Proceedings of the global symposium on soil organic carbon Global symposium on soil organic carbon(Rome, Italy), pp. 6-11
[17] Rozanov A N 1953 Soils of nut-fruit forests of the Ferghana ridge Proceedings of the Soil Institute Dokuchaeva39 Moscow
[18] Yongqiang Zh, Juanjuan A, Qiwu S, Zhichao L, Lingyu H, Ligu S, Guoyong T, Li L, Guodong Sh 2021 Soil organic carbon and total nitrogen stocks as affected by vegetation types and altitude across the mountainous regions in the Yunnan Province, southwestern China CATENA 196,04872
[19] Zaehle S 2013 Terrestrial nitrogen–carbon cycle interactions at the global scale Philos Trans R Soc B-Biol Sci. 368:9
[20] Zomer R J, Bossio DA, Sommer Ret et al. 2017 Global Sequestration Potential of Increased Organic Carbon
in Cropland Soils. Sci Rep 7, 15554 https://doi.org/10.1038/s41598-017-15794-8