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Distribution Characteristics of Soil Organic Carbon in Degraded Forest Land in the Sandstorm Area of Jingbian County, Shaanxi Province

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Abstract [**Objectives**] To explore the distribution characteristics of soil organic carbon in degraded forest land in the sandstorm area of Jingbian County, Shaanxi Province. [**Methods**] The distribution characteristics and abundance of 0 -20 cm shallow soil organic carbon in 5 towns in the sandstorm area in the north of Jingbian County were studied by field sampling and indoor detection. [**Results**] The average soil organic carbon contents in Hongdunjie Town, Haizetan Town, Huanghaojie Town, Ningtiaoliang Town and Dongkeng Town were 2.93, 3.21, 2.53, 2.54 and 4.08 g/kg, respectively, which were all lower than the national background value (31.00 g/kg). The coefficients of variation of soil organic carbon content in Hongdunjie Town, Huanghaojie Town and Dongkeng Town were 59.04%, 35.97% and 47.55%, respectively, with higher coefficients of variation and larger differences in spatial distribution. The organic carbon content of Haizetan Town and Dongkeng Town was above the abundance, accounting for 70% and 50%, which were relatively rich, while the soil organic carbon content of Hongdunjie was relatively scarce. The average content of soil organic carbon in the sandstorm area was 3.03 g/kg, which was also lower than the national background value. The coefficient of variation was 46.53%, showing high coefficient of variation and large difference in spatial distribution. In addition, 20.41% of the average content of soil organic carbon in the sandstorm area was in the deficient level, and 79.59% were in the medium or above level. [**Conclusions**] The study of distribution characteristics of soil organic carbon in degraded forest land in the sandstorm area of Jingbian County will better serve the precise management of soil resources.

Key words Sandstorm area of Jingbian County, Low-efficiency forest land, Soil organic carbon, Abundance

1 Introduction

The sandstorm area in Jingbian County is located in the transition zone of agriculture and animal husbandry, and it is a transitional area from the sandy area to the loess area[1]. For a long time, problems such as improper reclamation and wind and sand hazards have seriously damaged the ecological environment in this area, and it has become an area with the most serious land desertification in northern China[2-3]. In recent years, ecological restoration measures based on artificial vegetation construction have effectively alleviated environmental problems such as sandstorm hazards and soil erosion, and improved the local ecological environment[4-5]. However, with the change of time, successive years of drought, single tree species, excessive density, unreasonable felling, failure to keep up with tending, and human interference and damage have made some protective forests ruined, caused structural imbalance, low canopy density and vegetation coverage, low economic value and ecological function, serious soil erosion, accordingly leading to forest land degradation and formed a large area of low-efficiency forest land.

The sandstorm area in the north of Jingbian County is located at the southern end of the Mu Us Desert. The climate is dry, the precipitation is low, the sandstorm is severe, the soil quality is low, the forest land is seriously degraded, and the area of defective forest land is large. Therefore, there is an urgent real demand for accurate control of soil resources in this area[6]. During the evolution of degraded forest ecosystems, vegetation, as an important covering part of terrestrial ecosystems, plays an extremely important role in water and soil conservation, land conservation, and ecosystem carbon sequestration[7]. Zhou Lilei *et al.*[8] and An Shaoshan *et al.*[9] found that soil bulk density increases with the aggravation of grassland degradation and decreases with vegetation recovery. Findings of Su Yongzhong *et al.*[10] showed that in the artificial sand-fixation forest of *Caragana microphylla* Lam. in the Horqin sandy land, improved soil conditions can in turn increase the vegetation coverage in the area. Soil organic carbon (SOC) is an important indicator to measure ecosystem stability, soil health and fertility. Its content, composition, structure and stability directly drive the evolution direction of the ecosystem[11], and can be used as evaluation indicators for the evolution of degraded forest land ecosystems. The total amount and distribution of SOC are affected by land use, precipitation, temperature, geology, vegetation type, and soil depth[12-13].

In order to grasp the distribution status of soil organic carbon

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in low-efficiency forestlands in the sandstorm area of northern Shaanxi, we took the low-efficiency forestlands in northern Jingbian County as the research object to conduct research on the distribution characteristics of soil organic carbon in order to better serve the precise management of soil resources.

2 Materials and methods

2.1 Overview of the study area The study area (36°58′45″ – 38°03′15″ N, and 108°17′15″ – 109°20′15″ E) is located in the sandstorm area in the north of Jingbian County, Shaanxi Province. It is located on the southern edge of the Mu Us Desert, the terrain is high in the south and low in the north, high in the west and low in the east. This area belongs to temperate zone semi-arid continental monsoon climate, with large temperature difference between day and night, short frost-free period, little rain and frequent sandstorms. The annual average temperature is 7.8 ℃, the average temperature of the hottest month (July) is 22.2 ℃, and the average temperature of the coldest month (January) is 8.5 ℃. The annual precipitation is 395.4 mm and most of the precipitation is concentrated in July to September, accounting for 62% of the annual precipitation. The annual average evaporation is 1 930 mm, and the distribution of precipitation and evaporation is uneven within the year. The soil type is mainly aeolian sandy soil. The total area of the study area is 27.991 ha, including 2.010 1 ha of arbor forest land, 10.702 7 ha of shrub land and 3.158 7 ha of other land.

2.2 Soil sample collection and processing Based on the previous research and exploration, we selected five towns, Hongdunjie Town, Haizetan Town, Huanghaojie Town, Ningtiaoliang Town and Dongkeng Town, in Fengshatan District in the north of Jingbian County of Shaanxi Province as sampling areas. Common vegetation types in each town include *Caragana intermedia*, *Hippophae rhamnoides*, and *Salix cheilophila*. According to the size of each area, 14, 10, 11, 6 and 8 sampling points were separately set up in Hongdunjie Town, Haizetan Town, Huanghaojie Town, Ningtiaoliang Town and Dongkeng Town. A 40 mm diameter earth drill was used for manual sampling, and the sampling depth was 0 – 20 cm. The collected soil samples were picked out of plant roots and gravel, put into ziplock bags, and brought back to the laboratory for later use. The soil samples brought back to the laboratory were naturally air-dried and passed through a 1 mm sieve for the determination of soil organic carbon. The soil organic carbon was measured by the potassium dichromate volumetric method[14].

2.3 Data processing and analysis The data were processed and analyzed with the aid of Excel 2010 and SPSS 22.0 software.

3 Results and analysis

3.1 Statistical analysis of soil organic carbon distribution From Table 1, the results of descriptive statistical analysis of soil organic carbon in the sandstorm area in the north of Jingbian County show that the average soil organic carbon contents in Hongdunjie Town, Haizetan Town, Huanghaojie Town, Ningtiaoliang Town and Dongkeng Town were 2.93, 3.21, 2.53, 2.54 and 4.08 g/kg, respectively. The soil organic carbon content of Haizetan Town and Dongkeng Town was higher than that of other towns, mainly due to the difference in vegetation types and planting densities. The average soil organic carbon content in the sandstorm area is 3.03 g/kg, which is lower than the national background value like other towns[15]. The coefficients of variation of soil organic carbon in the five towns and sandstorm areas were all greater than 10%, which belonged to medium variation. The coefficients of variation of soil organic carbon in Hongdunjie Town, Huanghaojie Town, Dongkeng Town and the sandstorm area were 59.04%, 35.97%, 47.55% and 46.53%, respectively, showing high coefficient of variation and large spatial distribution.

3.2 Analysis of soil organic carbon abundance The abundance and deficiency of soil organic carbon referred to the nutrient classification standard of the second national soil census[16]. From Table 2, it can be known that the proportions of the abundance and deficiency of soil organic carbon in Hongdunjie Town, Haizetan Town, Huanghaojie Town, Ningtiaoliang Town and Dongkeng Town were 35.71%, 10%, 27.28% and 0, respectively. Therefore, relatively speaking, the soil organic carbon content in Hongdunjie Town was relatively scarce. The organic carbon content of Haizetan Town and Dongkeng Town separately accounted for 70% and 50% above the abundance level, indicating that the soil organic carbon content of the two towns was relatively abundant. The proportion of soil organic carbon content in the sandstorm area was 20.41% in the deficient level, and 79.59% in the above medium level. For the degraded low-efficiency forestland in the Jingbian County of Shaanxi Province, the level of soil organic carbon content was generally considerable.

Table 1 Descriptive statistics of soil organic carbon content in five towns in the sandstorm area of Jingbian County g/kg

Area	Max.	Min.	Average	Median	Standard deviation	Coefficient of variation//%	National background value
Hongdunjie	7.96	1.01	2.93	2.36	1.73	59.04	31.00
Haizetan	4.76	1.32	3.21	3.32	0.88	27.41	
Huanghaojie	4.33	1.30	2.53	2.34	0.91	35.97	
Ningtiaoliang	3.47	1.94	2.54	2.46	0.54	21.26	
Dongkeng	7.41	2.16	4.08	3.51	1.94	47.55	
Sandstorm area	7.96	1.01	3.03	2.76	1.41	46.53	

Table 2 Abundance of soil organic carbon in five towns in the sandstorm area of Jingbian County %

Area	Level 1 (very rich > 4.0)	Level 2 (rich 3.0 – 4.0)	Level 3 (medium 2.0 – 3.0)	Level 4 (scarce 1.0 – 2.0)	Level 5 (very scarce < 1.0)
Hongdunjie	14.29	21.43	28.57	35.71	0
Haizetan	10.00	60.00	20.00	10.00	0
Huanghaojie	9.10	9.10	54.55	27.28	0
Ningtiaoliang	0	16.67	66.67	16.67	0
Dongkeng	50.00	0	50.00	0	0
Sandstorm area	16.33	22.45	40.82	20.41	0

4 Conclusions

(i) The average soil organic carbon contents in Hongdunjie Town, Haizetan Town, Huanghaojie Town, Ningtiaoliang Town and Dongkeng Town were 2.93, 3.21, 2.53, 2.54 and 4.08 g/kg, respectively, which were all lower than the national background value (31.00 g/kg). The soil organic carbon content of Haizetan Town and Dongkeng Town was higher than other towns.

(ii) The coefficients of variation of soil organic carbon content in the five towns were all greater than 10%, which belonged to medium variation. The coefficients of variation in Hongdunjie Town, Huanghaojie Town and Dongkeng Town were 59.04%, 35.97% and 47.55%, respectively. The coefficient of variation was relatively high, and the spatial distribution varied greatly.

(iii) The proportion of soil organic carbon content above abundance in Haizetan Town and Dongkeng Town was 70% and 50%, respectively, indicating that the soil organic carbon content of the two towns was relatively rich, but the soil organic carbon content of Hongdunjie was relatively scarce.

(iv) The average soil organic carbon content in the sandstorm area was 3.03g/kg, which was lower than the national background value. The proportion of soil organic carbon content in the scarce level was 20.41%, and the proportion of above-medium level was 79.59%.

The study of distribution characteristics of soil organic carbon in degraded forest land in the sandstorm area of Jingbian County will better serve the precise management of soil resources.

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