Soil Particle Size Composition and Differences of Different Grassland Types in the Southern Slope of Qilian Mountain

Min Yu\textsuperscript{1,2}, Guangchao Cao\textsuperscript{1}, Shengkui Cao\textsuperscript{1,2}, Jie Yuan\textsuperscript{1,2}, Congcong Qu\textsuperscript{1,2}, Zhirong Chen\textsuperscript{1,2}, Erlong Diao\textsuperscript{1,2} and Zhen Chen\textsuperscript{1,2}

1 Key Laboratory of Physical Geography and Environmental Process in Qinghai Province, Xining, 810008, China;
2 College of Geographical Science, Qinghai Normal University, Xining, 810008, China;

The corresponding author’s e-mail: caoguangchao@qhnu.edu.cn

Abstract. In this paper, we collected soil samples of different grassland types in the southern slope of Qilian Mountain in Qinghai province and analyzed the soil particle size composition and differences. The research result shows that: The soil particle size composition of different grassland types is obviously different, and the soil texture is in silt-sandy soil level. The soil texture from fine to coarse of each grassland is: temperate steppe > alpine meadow > alpine steppe > degenerated grassland > swamp meadow; the overall coefficient of variation (CV) of soil particle size content in different grassland types shows a large difference, the variation of soil silt content in each grassland type was small, while the content of soil sand and clay content fluctuate greatly; the variation degree of soil sand content in each grassland type is moderately variable, but the content of silt and clay is moderately weak, the change rule is sand > clay > silt.

1. Introduction

The Qilian Mountain, which is located in the northeast of the Qinghai-Tibet Plateau and spans two provinces of Gansu and Qinghai in China, is the birthplace of the three main inland rivers, the Heihe river, Shiyang river and Shule river. It is one of the most important water sources in the arid region of northwest China, and its ecological status is very important\cite{1-2}. In recent decades, with the global climate warming and disorderly disturbance of human activities, the water conservation function of the Qilian Mountain has weakened and the natural ecosystem is deteriorating. The grassland ecosystem is a terrestrial ecosystem which is the main producer of perennial herbaceous plants, and it is also the largest ecosystem on land in China. It is an important part of natural ecosystems and plays an important role in maintaining water, soil and ecological balance\cite{3}. Soil particle size is one of the basic physical indicators for describing soil particles. As a basic natural property of soil, soil particle size is one of the most important attribute features that determine the physical and chemical properties of soil, affecting soil texture, nutrients, water holding capacity, water and heat transfer speed and so on\cite{4-5}. At present, there are many researches on the characteristics of soil particle size. Yan et al.\cite{6} studied the soil particle size of typical grasslands in Inner Mongolia; Xie et al.\cite{7} studied the characteristics of soil particle under different coverage grassland of the area with high-frequency debris flow; Ding and others\cite{8} studied the particle size characteristics of the desert steppe in Xilamuren; Zhang et al.\cite{9} studied the grain size characteristics of surface soil on sandy grasslands in Hulun Buir; Qie et al.\cite{10} studied the particle size characteristics of grasslands under different management models in the southern foot area of the Altay
Mountains in Xinjiang Province. However, there are few studies on the soil particle size characteristics of different grassland types in the southern slope of Qilian Mountain in Qinghai province. Therefore, this study takes different grassland types in the southern slope of Qilian Mountain as the research object, and combines field sampling and indoor analysis to research the soil particle size of five types of grassland including temperate steppe, alpine steppe, alpine meadow, swamp meadow, and degenerated grassland. The analysis is carried out to provide a scientific basis for the protection and management of the grassland ecosystem in the southern slope of Qilian Mountain and the sustainable use of grassland resources.

2. Overview of Research Area
The southern slope of Qilian Mountain in the research area is located in the hinterland of the central Qilian Mountains in the northeast of Qinghai province. It is located at the confluence of the Qinghai-Tibet and the Loess Plateaus and the Mengxin Desert [11] with a geographical position of 98°08′13″E~102°38′16″E, 37°03′17″N~39°05′56″N (Figure 1), and the total area is about 24,000 km². The study area is dominated by mountain landforms, and the elevation range is 2257m to 5235m. This region has strong solar radiation, strong evaporation, and a large extent of temperature drop. The annual temperature is relatively poor and the daily difference is relatively large. The average annual temperature is -5.9°C, and the average annual precipitation is about 400m. Most of the rivers in the area originate from the Qilian Mountain glaciers, which are melt-water and snow-melting rivers with rich surface runoff. It is mainly distributed in the rivers such as Heihe River, Datong River, Tuole River, Babao River and Buha River. The mountainous landscape, plateau climate and complex geological formations of Qilian Mountain have led to the diversity of soil and vegetation, with the most complete cold temperate dark coniferous forests-grassland ecosystems, dense forests and vast grasslands. The main soil types are alpine cold desert soil, alpine meadow soil, alpine grassland soil, mountain meadow soil, chernozem and swamp soil; The main types of forest include Picea crassifolia, Sabina przewalskii, Populus davidiana, and Betula platyphylla, which are the main virgin forest distribution areas in Qinghai province and have important ecological significance[12]. The main shrub types are Salix oritrepha, Caragana jubata, Potentilla fruticosa, and Potentilla glabra. The area of grassland in the study area is the largest, and a large area of natural grassland is mainly distributed on the plateau at an altitude of 3000 to 4200 meters. The main types of grassland are temperate steppe, alpine steppe, alpine meadow, swamp meadow, etc. It is an important production base for agriculture and animal husbandry, and it also has the functions of conserving water sources, preventing wind and sand, and maintaining water and soil.
3. Research Method

3.1. Sample Plot Selection and Sample Collection
During August and September in the year of 2015, based on the comprehensive survey of the study area, we selected five typical types of grassland: temperate steppe, alpine steppe, alpine meadow, swamp meadow, and degenerated grassland, and soil samples were collected in a standard plot with an area of 20 m \times 20 m. We selected 3 quadrats in each plot randomly and used a drill with a diameter of 5 cm to collected soil samples with a depth of 50 cm and 5 layers with a distance of 10 cm between the layers. We numbered the soil samples and there are 160 sample points collected. After taking the collected soil samples back to the laboratory, the three random samples of each type of grassland were mixed layer by layer (every 10 cm), dried naturally, and decontaminated to be tested. The total number of mixed soil samples is 800.

3.2. Determination of Soil Particle Size
Weigh 0.4 g soil sample accurately into the 50 mL beaker after passing soil sample over 2 mm sieve, add 10 mL of 10% hydrogen peroxide solution, boil until the reaction calms to remove soil organic matter and easily oxidized salts. After the beaker cools, add 10 mL of 10% hydrochloric acid, shake well and boil it to fully react to remove carbonate; Add distilled water to the sample and allow it to stand for more than 12 hours; Add 10% sodium hexametaphosphate 10 mL and put it in the ultrasonic oscillator to be tested. The instrument used for the particle size analysis was a Mastersizer2000 laser particle sizer manufactured by Malvern, UK. The shading degree is to be distributed between 17% and 20% during measurement. Repeat the measurement three times and take the mean value as the final result[13].

4. Results and Discussion

4.1. Soil Particle Size Composition of Different Grassland Types
The soil particle size composition of different grassland types is shown in Table 1, the temperate
grassland soil sand content ranges from 17.53% to 22.21%, the average value is 19.88%; the soil silt content is between 17.53% and 63.69%, and the average value is 61.34%; the clay content is between 16.75% and 18.81% with an average of 17.65%. The content of soil sand in the alpine steppe ranges from 22.28% to 27.17% with an average of 25.68%, and the soil silt content ranges from 57.25% to 60.75% with an average of 58.26%. The soil clay content ranges from 15.02% to 16.96%, and the average value is 16.07%. The alpine meadow soil sand content ranges from 18.44% to 24.72% with an average of 21.96%, and the soil silt content is between 59.21% and 63.85% with an average of 61%, the soil clay content ranges from 15.42% to 17.87% with an average of 16.87%. The swamp meadow soil sand content ranges from 31.05% to 37.24% with an average of 35.19%; the soil silt content ranges from 51.44% to 57.27% with an average of 52.98%; the soil clay content ranges from 11.32% to 12.72% with an average of 12.04%. The degenerated grassland soil sand content is between 28.35% and 38.48% with an average of 31.75%, the soil silt content ranges from 50.13% to 59.22% with average of 56.20% and the soil clay content ranges from 11.39% to 12.92% with an average of 12.04%.

Table 1. Soil Particle Size Composition of Different Grassland Types.

| Grassland Type   | Depth (cm) | sand (%)  | silt (%)  | clay (%) |
|------------------|------------|-----------|-----------|----------|
|                  |            | av | std | cv (%) | av | std | cv (%) | av | std | cv (%) |
| Temperate Steppe | 0-10       | 17.53 | 10.51 | 59.94 | 63.39 | 9.46 | 14.92 | 17.92 | 4.24 | 23.69 |
|                  | 10-20      | 18.45 | 10.99 | 59.56 | 61.69 | 11.21 | 18.17 | 18.81 | 6.00 | 31.92 |
|                  | 20-30      | 20.40 | 13.89 | 68.12 | 60.66 | 12.12 | 19.98 | 17.71 | 4.86 | 27.45 |
|                  | 30-40      | 20.79 | 14.68 | 70.61 | 61.01 | 13.02 | 21.33 | 17.05 | 4.98 | 29.20 |
|                  | 40-50      | 22.21 | 15.14 | 68.19 | 59.96 | 13.52 | 22.55 | 16.75 | 4.61 | 27.54 |
| Alpine Steppe    | 0-10       | 22.28 | 10.71 | 48.06 | 60.75 | 8.73 | 14.37 | 16.96 | 3.90 | 23.00 |
|                  | 10-20      | 25.06 | 16.00 | 63.83 | 58.51 | 12.99 | 22.20 | 16.43 | 4.11 | 25.01 |
|                  | 20-30      | 27.07 | 17.27 | 63.81 | 57.25 | 14.18 | 24.77 | 15.69 | 4.39 | 27.98 |
|                  | 30-40      | 26.79 | 15.95 | 59.51 | 57.37 | 13.68 | 23.85 | 15.84 | 3.58 | 22.62 |
|                  | 40-50      | 27.17 | 15.69 | 57.76 | 57.41 | 12.79 | 22.28 | 15.42 | 3.84 | 24.90 |
| Alpine Meadow    | 0-10       | 18.44 | 12.91 | 70.01 | 63.85 | 10.10 | 15.83 | 17.71 | 4.48 | 25.28 |
|                  | 10-20      | 20.67 | 14.88 | 71.97 | 61.45 | 11.27 | 18.35 | 17.87 | 6.39 | 35.76 |
|                  | 20-30      | 22.52 | 16.27 | 72.26 | 61.07 | 12.63 | 20.69 | 16.42 | 5.00 | 30.48 |
|                  | 30-40      | 24.72 | 16.54 | 66.91 | 59.21 | 13.38 | 22.60 | 16.06 | 4.37 | 27.20 |
|                  | 40-50      | 23.45 | 17.18 | 73.25 | 59.43 | 13.97 | 23.51 | 16.29 | 5.88 | 36.07 |
| Swamp Meadow     | 0-10       | 31.05 | 16.81 | 54.14 | 57.27 | 11.70 | 20.43 | 12.72 | 6.07 | 47.71 |
|                  | 10-20      | 37.24 | 20.33 | 54.60 | 51.44 | 14.95 | 29.07 | 11.32 | 5.92 | 52.31 |
|                  | 20-30      | 35.29 | 19.90 | 56.38 | 52.13 | 14.07 | 26.99 | 12.58 | 7.79 | 61.95 |
|                  | 30-40      | 37.08 | 18.49 | 49.85 | 51.44 | 14.03 | 27.27 | 11.47 | 5.96 | 51.94 |
|                  | 40-50      | 35.28 | 20.84 | 59.07 | 52.60 | 14.94 | 28.41 | 12.12 | 6.77 | 55.84 |
| Degenerated Grassland | 0-10 | 31.02 | 16.37 | 52.80 | 57.05 | 12.53 | 21.96 | 11.93 | 4.06 | 34.06 |
|                  | 10-20      | 28.52 | 12.94 | 45.37 | 59.22 | 8.09 | 13.67 | 12.26 | 5.36 | 43.69 |
|                  | 20-30      | 32.38 | 16.01 | 49.44 | 55.90 | 11.97 | 21.41 | 11.72 | 4.76 | 40.60 |
|                  | 30-40      | 38.48 | 12.33 | 32.04 | 50.13 | 10.23 | 20.41 | 11.39 | 4.08 | 35.81 |
|                  | 40-50      | 28.35 | 11.45 | 40.39 | 58.72 | 11.49 | 19.56 | 12.92 | 2.99 | 23.14 |

From the above analysis of the soil particle size composition of different grassland types, the swamp meadow has the largest soil sand content with an average of 35.19%, the temperate steppe soil sand content is the smallest, the average value is 19.88%. The content of soil silt in the temperate steppe is the largest with an average of 61.34% and the soil silt content in the swamp meadow is the smallest with
an average of 52.98%. The soil clay content is the highest in temperate steppe with an average of 17.65% and both of the soil clay content in swamp meadow and degenerated grassland are the smallest with an average of 12.04%. Thus it can be seen that the soil texture of the temperate steppe in different grassland types is fine, followed by the alpine meadow, and the soil texture of the swamp meadow is the thickest.

4.2. Change of Soil Particle Size in Different Grassland Types

Through the triangular diagram of soil particle size distribution in different grassland types (Figure 2) and the changes in the soil particle size of each grassland (Figure 3), it can be known that the five different types of grassland soils are all in silt-sandy soil level. Among them, the proportion of silt soil is the highest, and the distribution range is from the silty soil (60%~80%) to the sandy soil (40%~60%). From the change of the soil particle size of each grassland, the soil silt content in each layer of temperate steppe, alpine steppe and alpine meadow does not change substantially, but the soil sand and clay content fluctuate with the change of sampling depth. The content of soil sand in temperate steppe gradually increases from the surface layer to below, while the clay content shows a trend of increasing first and then gradually decreasing. The content of soil sand in alpine steppe and alpine meadow increases with the increase of soil depth, while the clay content shows a decreasing trend. The content of clay in each layer of swamp meadow soil is significantly less than that of sand and silt, and the change is not significant. However, the sand content suddenly increases and reaches the maximum at 10-20 cm, and the variation of sand content below 20 cm is not obvious. On the whole, it shows a trend of decreasing with the increase of soil depth. The maximum content of silt appears in 0-10 cm, and the change is not obvious after 10 cm, and it also shows a tendency to decrease with increasing soil depth. The change of soil sand content in degenerated grassland decreases first, then it increases and decreases at last. The content of soil silt and clay increases at first and then decreases, finally, it begins to increase in the soil depth of 40-50 cm.
4.3. Analysis of Soil Variability of Different Types of Grassland

Further analysis shows that the overall coefficient of variation (CV) of soil particle content in different grassland types is larger (Table 1). The CV value of soil sand content in alpine meadow is the largest and ranges from 66.91% to 73.25%, and the average value is 70.88%; the CV of soil sand content in degenerated grassland is the smallest, it ranges from 32.04% to 52.80%, and the average value is 44.01%; the CV values of soil silt content and clay content in swamp meadow are larger than those in other grassland types, the CV of silt content is between 20.43% and 29.07%, the average is 26.43%, and the clay content CV ranges from 47.71% to 61.95%, with an average of 53.95%; the CV value of soil silt content in temperate steppe is the smallest compared with other grassland types, which is 14.92% to 22.55%, with an average of 19.39%; while the CV value of soil clay content in alpine steppe is the smallest, which ranges from 22.62% to 27.98%, with an average of 24.70%. The size of the CV value reflects the degree of spatial variability of the characteristic parameters. It is generally believed that CV < 10% is weak variability, 10% < CV < 100% is moderate variability, and CV > 100% is strong variability. From the above analysis results, the degree of variation of soil sand content in each grassland type is moderately variable, while the content of silt and clay is moderately weak, and the variation rule is sand > clay > silt.

5. Conclusion

Although the percentages of soil particle size in the five different grassland types are different, the soil textures are all in silt-sandy soil level. Compared with other grassland types, the temperate steppe has the smallest soil sand content, the largest clay content, and fine soil texture. While the soil sand content of swamp meadow and degenerated grassland is more than that of other grassland types, and the clay content is less, and the soil texture is coarser than other grassland types. The soil texture from fine to coarse of each grassland is: temperate steppe > alpine meadow > alpine steppe > degenerated grassland > swamp meadow. From the range of 0-50 cm soil depth, we find that the overall coefficient of variation (CV) of soil particle size content in different grassland types shows a large difference, the variation of soil silt content in each grassland type was small, while the content of soil sand and clay content fluctuate greatly; the degree of variation of soil sand content in each grassland type is moderately variable, while the content of silt and clay is moderately weak, and the variation rule is sand > clay >
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Acknowledgments
This article is funded by the National Key Research and Development Program (2017YFC0404304); National Natural Science Foundation of China (41361005) and Special Funded Project of Key Laboratory of Physical Geography and Environmental Process of Qinghai Province.

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