Distribution of Soil Nutrients in Loess Hilly and Gully Area

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Abstract. To understand the spatial distribution characteristics of soil nutrients after reclaiming the land in the loess hilly and gully region. We collected the soil profile data of 2m soil layer from the end of the ditch to the head of the ditch. The results showed that: (1) The average available phosphorus, available potassium and organic matter content of the soil in the gully area of the loess hilly and gully region were at a low level. The content of average available phosphorus and organic matter decreased first and then increased with the increase of soil depth. The content of average available potassium decreased with the depth deepening. The gully soil was alkaline and the pH value along with the soil depth. The increase is gradually increasing. (2) The content of available phosphorus gradually decreased, and the content of available potassium and pH value gradually increased. The spatial distribution characteristics of organic matter are similar to the spatial distribution of available phosphorus, and the content of available phosphorus is enriched below the trough end to the middle of the gully.

1. Introduction

The hilly and gully region of the loess plateau has complex terrain, heavy rains and strong intensity, and serious natural disasters such as soil erosion and landslides [1], lack of land resources and poor soil quality. Although the construction of the silt dam at the bottom of the ditch can intercept the sediment, maintain the water and soil and build the land, but the flood discharge design standard is low due to the limited technical level and economic capacity [2], the construction investment is low, most of the silt dam gradually collapses. The output of one acre trench dam is equivalent to the yield of five acres of Liangzhu slope [2], so the remediation of gully land can effectively increase the area of cultivated land and increase production.

Affected by rainfall, the gully loess is easy to grow in the middle of the soil, and the rich soil flow will cause the loss of nutrients such as nitrogen and phosphorus in the soil, promote soil erosion, cause water accumulation in the plot, and form salinization of the wetland or plot. The topography affects the distribution of soil water resources and the material circulation of soil ecosystems, and also makes
the spatial distribution characteristics of regionalized soil nutrients more complicated [3]. The soil nutrient is affected by the movement of water flow and the obstruction of soil particles. It does not orient the movement in the space, and the nutrient content distribution of different soil layers in different gully locations is different [4]. Wei Xiaorong and other studies have shown that soil organic matter, total nitrogen, total phosphorus, and available phosphorus gradually decrease with soil depth as the soil depth increases [5]. Li Linhai studies show that the soil layer of the gully is thinner and the soil organic carbon profile is unevenly distributed [6], Nie Chun and other studies have shown that the higher the content of soil organic matter, total nitrogen and total phosphorus near the Mizoguchi soil [7].

Previous studies on soil nutrients were mostly carried out in specific areas. There are many limitations in the application of loess hilly gully areas, and there are few reports on the distribution of soil properties after land reclamation in the loess hilly gully area. Therefore, this paper studies the spatial structure characteristics of soil nutrients after land remediation in the loess hilly gully area, reveals the spatial distribution of soil nutrients in the gully area, and provides for the optimization of soil nutrient research, scientific management of water and soil and gully land remediation projects in the loess gully area. In accordance with.

2. Materials and methods

2.1. Study area

The study was carried out in the Yangwangou gully of Nanniwan Town, Yan'an City, Shaanxi Province, 109°34′E, 36°19′N, and the Yangwangou Land Remediation Project Area is 4km wide from north to south and 10 km from east to west. The river elevation is 1095m to 1190m, with an average ratio of 0.95%. The project area is hilly and gully area, the soil is mainly loessial soil, paddy soil, and the soil is loose. The underground aquifer has a depth of 0.5-2.5m and is rich in soil. The main crops are corn and wheat. It belongs to the plateau continental monsoon climate, with an average annual frost-free period of 170 days, an average annual temperature of 9.2°C, an annual average evaporation of 1 527.10mm, and an average annual precipitation of 576m. The precipitation is unevenly distributed during the year, mostly concentrated in July-September.

2.2. Sample collection preparation and analysis

After the renovation of the Yangwangou gully, 8 sampling points were set up from the end of the ditch to the head of the ditch. The soil was drilled and collected as a sample point every 400 meters along the ditch to the head. The sampling depth of the soil samples is 0-200 cm, one sample is taken every 10 cm from 0 to 100 cm, and one sample is collected every 20 cm from 100 to 200 cm. The total number of samples collected is 120, 1.5 kg per layer, and brought back to the laboratory. Analysis. The soil was air-dried and ground, and the effective phosphorus, available potassium, organic matter, total nitrogen and pH were determined by four-point method with 2mm, 1mm, 0.149mm sieves. The pH value was determined by the glass electrode method, the effective phosphorus amount was determined by the platinum iridium anti-colorimetric method, the available potassium amount was determined by flame photometry, and the organic quality was determined by the potassium dichromate volumetric method.

Experimental data processing was performed using SPSS 22 for statistical analysis, and Excel was used to map nutrient distribution.

3. Results and analysis

3.1. Distribution characteristics of soil nutrient in profile

The descriptive statistics of soil nutrient contents at different sampling points in the 8 sampling points of the Yangwangou gully area are shown in Table 1.
Table 1. Distribution characteristics of soil nutrient in profile.

| Soil layer (cm) | pH  | Organic matter (g·kg⁻¹) | Effective phosphorus (mg·kg⁻¹) | Available potassium (mg·kg⁻¹) |
|----------------|-----|-------------------------|-------------------------------|-------------------------------|
| 0-10           | 8.12| 9.80                    | 9.60                          | 57.7                          |
| 10-20          | 8.21| 9.01                    | 9.36                          | 55.8                          |
| 20-30          | 8.30| 7.80                    | 8.19                          | 53.2                          |
| 30-40          | 8.35| 8.22                    | 8.50                          | 53.4                          |
| 40-50          | 8.30| 8.81                    | 7.17                          | 56.6                          |
| 50-60          | 8.35| 8.96                    | 8.06                          | 52.2                          |
| 60-70          | 8.24| 8.22                    | 8.97                          | 53.5                          |
| 70-80          | 8.34| 8.44                    | 8.62                          | 53.0                          |
| 80-90          | 8.28| 8.77                    | 8.91                          | 55.2                          |
| 90-100         | 8.27| 8.97                    | 9.10                          | 53.1                          |
| 100-120        | 8.27| 10.78                   | 9.46                          | 52.1                          |
| 120-140        | 8.33| 9.65                    | 9.11                          | 50.2                          |
| 140-160        | 8.33| 10.93                   | 9.44                          | 50.3                          |
| 160-180        | 8.35| 11.14                   | 8.19                          | 50.3                          |
| 1280-200       | 8.29| 10.80                   | 7.79                          | 52.2                          |

The soluble salts in the gully are easy to accumulate in the surface layer of the soil. In this study, the soil is alkaline, and the pH value is between 7.86 and 8.68, which has not reached the standard of saline-alkaline soil. The pH value of 0~20cm soil layer is small. As the depth of soil layer increases, the pH value increases gradually and the alkalinity becomes stronger. This is because soluble salt ions such as sodium ions, carbonates and bicarbonates in the soil are in the soil. During the rainy season, the leaching from the surface layer to the deep layer of the soil is gradually carried out under the action of irrigation.

The soil organic matter in the study area is 4.5~18.5g/kg. According to the second national soil census grading standard, the soil organic matter content is in a lack of level. As the depth of the soil increases, the organic matter first decreases and then increases. The surface organic matter is greatly affected by the change of land use type and the growth process of the plant. The key technology of the comprehensive improvement project of the land for the treatment of the ditch is to cut the steps on both sides of the gully and fill the gully to form the cultivated land. Tiankan side built ditches for flood discharge, that is, grassland and woodland were converted into cultivated land, and the organic matter consumption of crop layer was more, but affected by the return of straw in the first season after remediation, the organic matter content of 0-20cm soil layer was still relatively large. The soil below 100cm is basically the gully in situ soil, and its organic matter is the result of long-term action of soil ecological process, and has little effect with manual intervention.

The soil available potassium in the study area was 38.3~71.5mg/kg. According to the second national soil census grading standard, the soil potassium content was at the lowest to low level of potassium supply. The available potassium content in the soil surface layer (0~15cm) is relatively high, which has a great relationship with the fertilization and cultivation after land remediation. The available potassium is enriched in 40~50cm soil layer, which is 56.6mg/kg. The amount of available potassium in the soil below 60cm is relatively uniform and decreases with depth.

The available phosphorus in soil is 5.29~12.79mg/kg. According to the second national soil grading standard, it belongs to the low phosphorus level. This is because the loess in the gully area is easy to produce short slopes and field gullies when rainfall is slightly large. In the middle of the soil, on the one hand, the soil is poorly ventilated, the biological effect is weak, and the mineralization of phosphorus is poor. On the other hand, the soil nutrient is taken away by the soil flow, which further increases the soil available phosphorus content. The soil available phosphorus content decreased first
and then increased and then decreased with the increase of soil depth. The available phosphorus content was enriched in 0~10 cm soil layer.

3.2. Distribution characteristics of soil nutrients along the gully

In the gully range of the loess hilly and gully region, rainfall, runoff, infiltration and nutrient migration are different under different gully locations, so the soil properties are different in surface and profile distribution. The spatial distribution characteristics of soil available phosphorus, available potassium, organic matter and pH along the direction of the end to the head are shown in Fig. 1- Fig. 4.

![Figure 1. PH distribution in the gully soil.](image1)

![Figure 2. Organic matter distribution in the gully soil.](image2)
Available phosphorus is a highly variable soil property. Effective phosphorus degrades from end to head and concentrates from the end to the middle of the gully. This is related to the vertical penetration of end rain. Soluble phosphorus is under the action of water. Move to a deeper layer of soil. The soil moisture content of the end is more suitable, the soil is rich in microorganisms, and the organic phosphorus mineralization is strong, which accelerates the release of phosphorus.

The available potassium from the end to the head of the ditch showed a trend of increasing gradually. The content of available potassium in the ditch end and the gully was similar, and the soil in the ditch was gradually increasing along the depth. The potassium in the gully was enriched in the 80~140cm soil of the ditch.

The distribution of soil organic matter in the gully is similar to that of soil available phosphorus. The 0~40cm soil layer in the gully has less organic matter and is unevenly distributed. Strengthening gully drainage treatment can increase the frequency of soil dry and wet alternation, so that soil permeability is excellent and organic matter decomposition is accelerated.

The pH value is the soil property of small variation. The pH value distribution of the soil in the gully shows a water flow. The pH value of the groove end gradually increases toward the ditch, and
the surface layer to the bottom layer have an increasing trend, but the change range is small. The soluble salt leaches along the gully from the ditch end to the gully with precipitation and runoff under the action of gravity. After the excess water from the gully is discharged along the drainage ditch, the remaining salt segregant is finally deposited at the ditch. The high pH value of the soil also has an effect on the available phosphorus content in the soil. The water-soluble phosphate is easily converted into other forms under alkaline conditions, and the effectiveness is reduced. Therefore, the pH distribution map and the effective phosphorus distribution map show opposite trends.

4. Conclusion

The average available phosphorus, available potassium and organic matter of the soil in the gully area of the loess hilly and gully region were lower. The available phosphorus content decreased first and then increased with the increase of soil depth. The available potassium decreased with the depth. The average organic matter decreased with the increase of soil depth and increased by the increase of soil depth. The gully soil is alkaline, and as the depth of the soil layer increases, the pH value gradually increases and the alkalinity becomes stronger.

From the distribution characteristics of soil properties in the whole gully, the effective phosphorus decreased gradually from the end to the head, and the spatial distribution of organic matter was similar to the spatial distribution of available phosphorus. The available phosphorus is enriched below the tillage layer in the middle of the gully end. The land remediation technology makes the effective phosphorus content in the 0–60 cm soil layer from the end to the head of the trench. The amount of available potassium increased gradually from the end to the head, and the pH value of the end gradually increased toward the head, which was consistent with the flow direction.

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