Soil Nutrient Content Distribution in Gully in Loess Hilly Region

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Abstract. In order to find out the distribution of soil organic matter, total nitrogen and total phosphorus contents in gully in loess hilly region and the difference between gully and slope, 29 and 58 samples were taken from gully and slope in Yuanzegou small watershed respectively. The results showed that the contents of total nitrogen, total phosphorus and organic matter in the 0-60cm soil layer ranged 0.091~0.628g/kg, 0.402~1.388g/kg, and 0.826~6.550g/kg respectively. According to the results of the second national soil census, the total nitrogen and organic matter content in the gully are at the lower level of grade 6, the total phosphorus content is at the higher level of grade 2, and the variation coefficient ranges from 21.6% to 33.4%, which is moderate. Pearson correlation analysis shows that soil total nitrogen, total phosphorus and organic matter contents are positively correlated with slope direction and elevation, negatively correlated with slope, and weakly correlated with soil moisture content, clay content and silt content, and negatively correlated with sand content. 0-20cm, the organic matter contents in the gully was higher than that slope 7.19%; 20-40cm and 40-60cm, the organic matter content in the gully was lower than that slope 4.66% and 12.67% respectively, but there was no significant difference. 0-20cm, 20-40cm, 40-60cm, the content of total nitrogen and total phosphorus in gully were higher than that slope, and the total nitrogen content was higher 24.31%, 13.04% and 8.70% respectively, with significant difference only in 0-20cm (p<0.05); The total phosphorus content was higher 15.68%, 13.56% and 15.11% respectively, with significant differences (p<0.05).

1. Introduction
Soil organic matter, total nitrogen and total phosphorus are essential nutrients for plant growth. Soil nutrient content in loess plateau has changed a lot since farmland was converted to forest. Meng tingting et al. [1] studied the changes of soil nutrient content in different land use in small watershed
of loess hilly region, and the results showed that the soil organic carbon, total nitrogen and total phosphorus contents in grassland were higher than those in farmland and abandoned grassland. Guo man et al. [2] studied the changes of soil nutrients and enzyme activities under different years of vegetation restoration in the loess hilly region, and the results showed that both soil nutrients and enzyme activities increased in a fluctuating trend with the increase of the years of returning farmland. Han fengpeng et al. [3] studied the effect of plant root distribution on soil nutrients in the slope of loess farmland, and the results showed that the contents of organic matter, total nitrogen, total phosphorus, nitrate nitrogen and ammonium nitrogen in the soil surface with roots were higher than those in the slope without roots. The above studies take the slope and sloping farmland as the research area. However, the loess plateau terrain is broken and gullies crisscathe, and the gully area accounts for about 40% of the total area of the loess plateau and 50%~60% in the loess hilly area, so the gully area has a large space for utilization. For example, in the development and utilization of gully in gully cultivation, Hu ya et al. [4] studied the distribution characteristics of soil nutrients after reclamation of gully land in hilly and gully areas of loess plateau, indicating that the average available phosphorus, available potassium and organic quality of soil were at a low level. The ditches that have not been used to treat ditches and make land have been reclaimed by local farmers.

In the small watershed of Yuanzegou, qingjian county, shaanxi province, the slope is of different land use types, such as agricultural land, jujube forest and grassland. There are many studies on soil nutrients and water on the slope of this small watershed [5-6], but few studies on the distribution of soil nutrient content in the gully. The study on the distribution of soil nutrient content in the gully in this region can provide local farmers with references for planting cash crops such as walnut and jujube trees in the gully bottom, as well as for soil fertility when protecting the vegetation slope.

2. Materials and methods

2.1. Study area

The study area is located in Yuanzegou small watershed (37°15' N, 118°18' E) in qingjian county, shaanxi province. The soil in the small watershed is mainly yellow miansoils with strong infiltration capacity. The field water capacity is about 25% and the wilting humidity is about 7%. This area belongs to the temperate continental monsoon climate, with the average annual temperature of 8.6℃, the monthly minimum temperature of -6.5℃ (January), and the monthly maximum temperature of 22.8℃ (July). The average annual rainfall is 505 mm, but it is unevenly distributed throughout the year, with 70% of the annual rainfall concentrated in July to September. The soil bulk density, soil moisture and particle composition of gully soil in the study area are shown in table 1.

| Soil depth (cm) | Soil moisture (%) | Clay (%) | Silt (%) | Sand (%) | Soil texture |
|----------------|------------------|----------|----------|----------|-------------|
| 0–20           | 8.17 ± 3.25      | 13.34 ± 1.46 | 69.10 ± 4.92 | 15.68 ± 3.38 | silty       |
| 20–40          | 10.81 ± 3.26     | 14.56 ± 1.81 | 70.62 ± 3.33 | 14.63 ± 4.47 | silty       |
| 40–60          | 11.99 ± 4.04     | 13.88 ± 1.49 | 68.53 ± 4.07 | 16.28 ± 4.46 | silty       |

2.2. Soil sampling and laboratory analysis

In May 2015, soil samples were taken from the gully head and the gully wall along the length of the gully. Sampling points were taken by random sampling method and portable handheld GPS was used for positioning. Soil samples were drilled with a diameter of 10cm. Randomly take 3 points near each point, a total of 29 soil samples. The soil in the aluminum box was dried for 24 hours in an oven at 105 degrees, and its moisture content was measured [7]. The determination method is based on the third edition of soil agrochemical analysis compiled by bo shidan [8]. In order to compare the difference between the organic matter, total nitrogen and total phosphorus of the soil in the gully and the slope
surface, in June 2015, we adopted 55 sample points on the slope surface of the basin, and the sampling method and the test method were the same as above.

2.3. Statistical analysis
One-way anova was used to represent the effects of different soil layers on soil total nitrogen, total phosphorus and organic matter; LSD method was used to analyze the differences among different soil layers (p<0.05); Excel 2007 was used for data processing; Spss 20 was used for data analysis; and oringe8.0 were used for mapping.

3. Results

3.1. Distribution of total nitrogen, total phosphorus and organic matter contents in gully
As can be seen from table 2, 0-60cm, the contents of total nitrogen, total phosphorus and organic matter in the gully ranged 0.091~0.628g/kg, 0.402~1.388g/kg, and 0.826~6.550g/kg respectively. According to the results of the second national soil survey, the soil total nitrogen and organic matter contents in this gully are at the lower level of grade 6, while the soil total phosphorus content is at the higher level of grade 2. With the increase of soil layer, the content of total nitrogen and organic matter decreased. 0-20cm, the total nitrogen content in the soil was 31.23% and 41.20% higher than that 20-40cm and 40-60cm (p<0.05). The organic matter content of soil was 23.00% and 35.51% higher than that 20~40cm and 40~60cm (p<0.05), while total phosphorus in soil layers showed no significant difference. The variation coefficients of soil total nitrogen, total phosphorus and organic matter ranged from 21.6% to 33.4%, which was considered as moderate variation.

### Table 2. Distribution of total nitrogen, total phosphorus and organic matter in gully soil.

| Soil depth (cm) | Variable (g/kg) | Min   | Max     | Mean ± sd | CV   |
|----------------|-----------------|-------|---------|-----------|------|
|                | STN             | 0.136 | 0.628   | 0.301 ± 0.094a | 31.2%   |
| 0~20           | STP             | 0.402 | 1.239   | 0.925 ± 0.213a | 23.0%   |
|                | SOM             | 2.197 | 6.550   | 4.309 ± 1.260a | 29.2%   |
| 20~40          | STN             | 0.100 | 0.319   | 0.207 ± 0.052b | 25.3%   |
|                | STP             | 0.367 | 1.388   | 0.92 ± 0.248a | 26.9%   |
|                | SOM             | 1.291 | 5.123   | 3.318 ± 0.985b | 29.7%   |
| 40~60          | STN             | 0.091 | 0.288   | 0.177 ± 0.054b | 30.6%   |
|                | STP             | 0.403 | 1.184   | 0.920 ± 0.199a | 21.6%   |
|                | SOM             | 0.826 | 4.803   | 2.779 ± 0.925b | 33.4%   |

3.2. Factors affecting soil total nitrogen, total phosphorus and organic matter content
As shown in table 3, Pearson correlation analysis shows that soil total nitrogen, total phosphorus and organic matter contents are positively correlated with slope direction and elevation, negatively correlated with slope, and weakly correlated, positively correlated with soil water content, clay content and powder content, and negatively correlated with sand content. Organic matter content was positively correlated with total nitrogen content, but not with total phosphorus content.
Table 3. Soil organic matter, total nitrogen and phosphorus and topographic factors (slope, slope direction and elevation) and particle composition Pearson correlation analysis.

| Soil depth (cm) | SOM | STN | STP |
|----------------|-----|-----|-----|
| 0~20           | 0.069 | 0.145 | 0.042 |
| 20~40          | 0.231 | 0.076 | 0.026 |
| 40~60          | 0.178 | 0.065 | 0.034 |

**Significant correlations at the 0.01 probability level (2-tailed).**

3.3. Comparison of organic matter, total nitrogen and total phosphorus contents in gully soil with the slope

In order to find out the differences between the organic matter, total nitrogen and total phosphorus of the soil in the gully of the small watershed with different vegetation cover types, we randomly adopted 59 sample points on the slope, and compared the difference in the distribution of total nitrogen and total phosphorus between the slope of 0-60cm soil and the soil in the gully with anova. As shown in figure 1, the organic matter content in the 0-20cm was higher 7.19% than that in the slope; the organic matter content in the 20-40cm and 40-60cm soil layers was lower than that in the slope, 4.66% and 12.67%, respectively, but there was no significant difference (figure (a)). In the 0~60cm soil layer, the total nitrogen and total phosphorus gully contents in the soil were higher than those in the slope, and the total nitrogen levels were 24.31%, 13.04% and 8.70%, respectively, with only significant differences between 0~20cm (p<0.05) (figure (b)). The total phosphorus levels were 15.68%, 13.56% and 15.11%, respectively, with significant differences (p<0.05) (figure (c)).

Figure 1. Difference in contents of organic matter, total nitrogen and total phosphorus between gully and slope.

4. Discussion

In this study, the total nitrogen and organic matter contents in the gully soil were both at the low level of level 6, which was caused by two reasons: first, the gully soil was silt soil with low nutrient content; second, the gully was exposed in the small watershed without vegetation cover, and the slope was steep with severe erosion and erosion, resulting in low nutrient content in the gully. Fang [9] and
Tesfaye [10] showed that soil nutrients generally accumulate in the surface layer. In this study, with the increase of soil layer, total nitrogen and organic matter contents in the soil showed a decreasing trend, which was consistent with previous studies. At the surface of 0~20cm, the total nitrogen and organic matter contents in the soil were significantly higher than those in the lower layer (p<0.05), which may be related to the arid and semi-arid climate of the loess plateau. The annual precipitation in the study area was only about 505mm. Soil organic matter derived from leaf litter is mainly distributed in the topsoil. Due to the low soil moisture content in this area, the decomposition and water conductivity of soil organic matter are low [11]. Therefore, it is possible that the decomposed soil organic matter seeps into the subsoil with the rain is minimal. The total phosphorus content of the soil is at a high level of level 2, and there is no significant difference among different soil layers. This is because the total phosphorus content is mainly related to the soil parent material [12], while the difference in the gully soil parent material in this basin is small. The study area is small, which is the main reason for the moderate variation of soil total nitrogen, total phosphorus and organic matter content.

Studies have shown [13] that soil nutrient content is closely related to soil clay. The more clay content and dust particles there are, the more soil clumps and colloids there are, and the higher the soil nutrient content. In this study, the contents of soil total nitrogen, total phosphorus and organic matter were positively correlated with the contents of clay and powder, and negatively correlated with the contents of sand, which was consistent with the results of previous studies. The content of soil total nitrogen, total phosphorus and organic matter is weakly correlated with topographic factors, which may be caused by small watershed area and small topographic difference.

5. Conclusion
According to the results of the second national soil survey, the contents of total nitrogen and organic matter in the gully are at the lower level of grade 6, while the contents of total phosphorus in the gully are at the higher level of grade 2. Pearson correlation analysis showed that soil total nitrogen, total phosphorus and organic matter content were positively correlated with slope direction and elevation, negatively correlated with slope, positively correlated with soil water content, clay content and powder content, and negatively correlated with sand content. There was no significant difference in organic matter content between the gully soil and the slope surface, while there was a significant difference in total nitrogen and total phosphorus in 0~20cm and 0~60cm respectively. In general, the soil nutrients in the gully were larger than those in the slope surface.

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