Study on Soil Properties of an Erosion Gully in Yanghe Basin in China

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Abstract. Controlling erosion gully caused by soil and water erosion is an important content of ecological restoration. In order to better allocate soil and water loss control measures, the total nitrogen content and water content in the surface soil of gully were analyzed by taking typical erosion gully in Yanghe basin as the research area. The results show that the erosion gully surface soil total nitrogen content was 0.215-1.459 g/kg, saturated moisture content ranged in 35-44%, and the permeability was between 0.0975-0.2925 mm/min. Combined with actual investigation and the experimental results, we conclude that the total nitrogen content and water content of the surface soil in the erosion gully are greatly affected by climate and vegetation conditions.

Keywords. Erosion gully, surface soil, total nitrogen, soil moisture.

1. Introduction

Soil and water erosion are one of the world’s ecological and environmental problems [1]. Serious soil and water erosion will cause erosion gully in soil erosion geomorphology, loss of nitrogen, phosphorus and other nutrients, degradation of soil quality, resulting in ecological imbalance, frequent occurrence of drought and flooding disasters, and has posed a serious threat to the sustainable development of agricultural production [2, 3]. Sediment, especially fine sediment, is the main carrier of nitrogen, phosphorus, heavy metals and toxic substances, and the input of excessive nutrient salts is the main cause of eutrophication in aquatic ecosystems [4, 5] and it is also an important source of agricultural non-point source pollution [6]. Therefore, the study on how to develop appropriate ecological measures to reduce nutrient migration to the environment caused by soil erosion in erosion gully is of great significance to guarantee the quality of water environment, ensure the safety of drinking water sources and maintain the sustainable development of agricultural production.

At present, domestic and foreign scholars have carried out a large number of studies on the loss patterns and patterns of non-point source pollutants in small watershed [7], but there are few studies on specific soil conditions in erosion gullies in typical soil erosion areas. In this paper, typical erosion gully selected from serious soil erosion areas in Yanghe basin was taken as an example. By analyzing the total nitrogen content and water content in surface soil of several sample points in gully, the purpose of this study is to explore the difference of soil condition along erosion gully. It provides basic data reference for controlling soil erosion in erosion gully, formulating reasonable vegetation ecological restoration and soil and water conservation measures.
2. Materials and Methods

2.1. Study Area Overview
This study erosion gully is located in Yanghe basin in Xuanhua district, Zhangjiakou, covers an area of about 0.39 km$^2$, with a north and south to about 1 km long main channel and several branch lander, the height of the gully head to tail gap of about 100 m. According to the field investigation, the terrain of this area is mostly hilly and the soil is sandy loam with coarse soil particles, general water retention capacity and easy erosion. The climate in erosion gully area is arid, with less rainfall but more rainfall and heavy rain, which is concentrated in July, August and September. Local bare land accounts for a large proportion, vegetation coverage and root depth are small, and slope vegetation structure and function degrade. When confronted with heavy precipitation, soil erosion is very easy to occur. For many years, large areas of land reclamation planting, coupled with excess of grazing human activities, such as increased erosion gully land surrounding the bare area, severely damaged the local ecological balance, serious soil erosion problem, and the trend of channel is outspread.

2.2. Sample Collection
According to the field survey, five representative sampling points, mainly in the gully, were selected and numbered GG1-5. In September 2018, topsoil samples were collected on the erosion gully and slope according to the design sampling points (figure 1) for the determination of total nitrogen content, saturated moisture content and permeability of soil. Soil sampling method is shown in Ref. [8].

![Figure 1. Location of sampling sites.](image)

2.3. Test Methods
The test indexes of this study were the contents of total nitrogen, saturated water content and soil permeability of surface 0-20 seabed. The total nitrogen was determined by Semi-micro Kjeldahl method. The saturated moisture content was determined by drying method and the permeability was determined by double loop method.

3. Results and Discussions

3.1. Variation of Total Nitrogen Content
The maximum value of total nitrogen content in topsoil was 1.459g/kg at GG5 and the minimum value was 0.215g/kg at GG3. The distribution of total nitrogen content along the trend of erosion gully inside the gully showed a jump, which may also be related to the growth of vegetation. The sampling
point like GG1 or GG3 where vegetation coverage is low in the gully, the total nitrogen content is lower. Soil erosion is severe due to bare ground and less vegetation coverage. Thus, nitrogen content decreases with soil erosion. According to figure 2, it is easy to find that the total nitrogen content of GG2 is high as well as GG4. This is because the two sampling sites GG2, GG4 have small slopes and more herbs, relatively gentle terrain and little soil and water loss, resulting in a high total nitrogen content in the topsoil. The total nitrogen content of GG5 in eroded gully slope is the highest, which may be related to the original use of surrounding land as arable land.

![Figure 2. Total nitrogen content of surface soil.](image)

3.2. Variation of Saturated Moisture Content
According to the measured data, the saturated moisture content of surface soil in the erosion gully varies from 35 to 44% (figure 3). Among them, the saturated moisture content at the sampling site GG5 is the largest. This is because the site has a higher vegetation coverage and the root system of vegetation is more developed than other sampling sites, which leads to a large void in the soil, and water can enter and fill it well. The variation trend of saturated water content in the gully was close to that of total nitrogen content, indicating that the water status of surface soil was related to vegetation, especially to the role of root system of herbaceous plants.

![Figure 3. Saturated moisture content of surface soil.](image)
3.3. Variation of Permeability
As shown in figure 4, the permeability was between 0.0975-0.2925 mm/min. The change trend of surface soil permeability in the channel of erosion gully is basically consistent with the change trend of saturated water content. And the infiltration of sampling site GG5 is the best while GG3 is worst. This is because soil permeability is related to soil type, soil particle size, pore structure, saturation and other factors. Moreover, soil permeability of forest land is also higher than that of grass land because vegetation coverage, microorganisms and animals of the former one are more abundant than the latter one, soil particles and the porosity of forest land is also higher than that of grassland land. Similarly, exposed slope areas have poor permeability compared with herbaceous areas. Compared with other sampling sites such as GG4 and GG5, sampling site numbered GG3 has lower vegetation coverage.

There are many factors affecting the distribution of nitrogen and phosphorus in soil and water content, including climate, soil type, vegetation cover, crop fertilization, etc. [9]. The effects of climate conditions and vegetation cover on the physical and chemical properties of soil in erosion gully region can be confirmed by studying the nitrogen and water content of surface soil along erosion gully. Heavy rainfall is concentrated in the erosion gully area, and the surface roughness changes under a certain rainfall intensity. Rainfall erosion and erosion lead to changes in microtopography and surface roughness, which in turn affect the infiltration rate of surface soil [10]. Meanwhile, runoff generated will carry sediment particles of surface soil, leading to changes in nitrogen and phosphorus content of surface soil. Increasing vegetation cover is an important measure to control soil erosion. Increasing vegetation coverage can effectively reduce the erosion effect of raindrops [11]. Meanwhile, using vegetation roots to improve soil permeability and agglomeration effect plays an important role in maintaining surface soil nutrients and improving soil moisture.

4. Conclusions
According to the study on the nitrogen content and water content along the course of typical erosion gully in the area with serious soil erosion in Yanghe basin, the total nitrogen content of the surface soil along the erosion gully was 0.215-1.459 g/kg, the saturated water content varied in the range of 35-44%, and the surface soil permeability was between 0.0975-0.2925 mm/min. The distribution of nitrogen content in the gully is roughly consistent with the trend of gully strike. The difference of nitrogen content was related to vegetation types and vegetation coverage. The nutrient content and water content of eroded gully slope are related to the slope gradient. The two factors affect the physical and chemical properties of eroded gully slope surface soil by affecting vegetation cover, vegetation growth and rainfall runoff erosion intensity.
Based on the basic investigation of soil properties in erosion gully area, the serious soil and water loss in this area is further understood, which can provide reference for rational allocation of water conservation measures and carrying out ecological restoration according to local conditions.

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References
[1] Pimentel D, et al. 1995 Science 267 1117
[2] Van Oost K, et al. 2007 Science 318 626
[3] Pimentel D and Kounang N 1998 Ecosystems 1 416
[4] Smith V H, Tilman G D and Nekola J C 1999 Environ. Pollut. 100 179-196
[5] Zhanyu Zhang, Lili Kong, Lei Zhu, Jihong Xia and Patricia X 2012 Environ. Earth Sci. 66
[6] Zhiliang Chen, Jiong Cheng, Ping Liu, Xiaochun Peng, Zhencheng Xu, Zhifeng Wu 2008 An Experiment on influence of storm on nitrogen loss and phosphorus loss under different land use in river basin J. Soil. Water Conserv. 22 30-33. (in Chinese with English abstract)
[7] Sharpley A N and Withers P J A 1994 Fert. Res. 39 133-146
[8] Bo Sun, Jianping Shi and Linzhang Yang 2007 Protocols for standard soil observation and measurement in terrestrial ecosystems vol 2 (Beijing:Chinese Environment Science Press) chapter 5 p 93
[9] Bangroo S A, Najar G R and Rasool A 2017 Catena 158 63-68
[10] Ribolzi O, Patin J, Bresson L M and Latsachack K O 2011 Geomorphology 127 53
[11] Le Bissonnais Y, Cerdan O, Lecomte V, Benkhadra H, Souchère V and Martin P 2005 Catena 62 111