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Research Progress on Ecological Security Technology of Slope Treatment on Loess Plateau

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Abstract

The Loess Plateau is an important source of Eastern civilization, but also the most serious soil erosion in our country and in the world. Controlling soil erosion and improving the ecological environment are not only the needs of local social and economic development, but also the needs of long-term peace and stability of the country. Since the 1950s, large-scale soil and water conservation work has been carried out on the Loess Plateau. It has played a significant role in improving ecological environment, changing agricultural production conditions and developing rural economy. It is a very effective measure to take small watershed as a unit to conduct comprehensive management. There are 45,000 small watersheds of 6-10 km2 in the Loess Plateau, which are not only the basic units of soil and water loss, but also the units of comprehensive management. Slope is the source of runoff and sediment in small watershed, and slope treatment is an important part of comprehensive management of small watershed. Therefore, it is an urgent task to deepen the study of slope management.

Keywords

Slope Treatment; Ecological Safety; Security; Slope Protection; Loess Plateau.

1. Introduction

Domestic and foreign experts and scholars have made a lot of relevant studies on slope management. Scholars have conducted soil erosion monitoring for pilot projects in the northeast black soil area, analyzed the soil conservation and sediment reduction benefits of 6 kinds of slope management measures, and obtained the average soil conservation and sediment reduction benefits of barren mountain and slope management measures. The average annual erosion modulus of effective rainfall was 161.5 t/(km2·a), and the soil loss was reduced by 95.2%. The average annual erosion modulus of effective rainfall was 699 t/(km2·a), and the soil loss was reduced by 80.2%. The average annual erosion modulus of effective rainfall was 1738 t/(km2·a), and soil loss was reduced by 49.9%[1]. The average soil conservation and sediment reduction benefits of slope farmland management measures were the best, and the average annual erosion modulus of effective rainfall was 16 t/(km2·a), reducing soil loss by 99.5%. The average annual erosion modulus of effective rainfall was 130 t/(km2·a), and the soil loss was reduced by 95.2%. The average annual erosion modulus of effective rainfall was 1298 t/(km2·a), and the soil loss was reduced by 64.6%. On the slope of 18° granite red soil in Hetian Town, three kinds of slope engineering measures, horizontal ditch, horizontal step and Yurian pit, were studied for soil and water conservation effect. The results show that the three slope

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engineering measures can effectively reduce the runoff, and the runoff of Yudiancheng district, horizontal terrace district and horizontal ditch district is reduced by 23.53%, 34.06% and 38.14%, respectively. The flow reduction effect of horizontal ditch is the best, and the measure effect is stable[2].

The engineering measures of slope planting can have great influence on the physical properties of slope soil. Under the treatment of the measures, the bulk density was in the order of control plot > horizontal ditch plot > horizontal level plot > Yudiakeng plot. Meanwhile, the implementation of the measures resulted in the increase of sand content on the slope of granite red soil, while the content of silt and clay decreased [3]. The distribution order of sand content on the surface of the three measures was Yudiakeng > horizontal level ditch. Planting measures to improve slope water and nutrient status. The three measures reduced the loss of nutrients on the slope, among which the fish scale pit measure had a good effect on fertilizer preservation, and the contents of total phosphorus, total nitrogen, alkali-hydrolyzed nitrogen, available phosphorus and organic matter were 43.36%, 38.99%, 7.55%, 336.52% and 23.23% higher than the control[4]. The measures of horizontal gully and horizontal step can significantly increase the available nutrients in all parts of soil, and the increase range is above.

The soil hardness and thickness changes at the construction site of slope treatment project were investigated by using soil profile method and simple percussion test method. The survey results obtained by using Nagagawa simple percussion machine showed that the changes of slope soil hardness after the construction of slope treatment project were very complicated. There is no obvious relationship with soil depth. The thickness of soil layer A tends to increase with the increase of the number of years of slope treatment engineering. However, the change of surface soil thickness with the impact value of more than 1.5 cm/time obtained by simple percussion test has no relationship with the number of years of slope treatment engineering, but may be affected by the digging and filling conditions during construction. WEPP model was used to simulate and predict the slope runoff and sediment of different erosion control measures, and their eco-hydrological effects on sediment reduction were compared and analyzed. The results show that: The runoff and erosion amount of the WEPP simulated no-measure (bare land) plot were 0.7223 and 0.7025, the ME was 0.6160 and 0.6167, and the R2 of the WEPP simulated measure (grassland) plot were 0.7116 and 0.8447, respectively[5,6]. The model effect of the measured plot is better than that of the non-measured plot, and the effect of the shrub forest on sediment reduction under different rainfall types is the best.

In the northern mountainous area of Hebei Province, according to the current vegetation coverage, the heavily weathering rock slope was divided into three types: bare slope, low cover slope and high cover slope. Two preferred species of sea-buckthorn and Pinus tabulaeformis were planted for comprehensive treatment by using horizontal ditch hedge weaving technology, slope separation biological hedge technology and small Yudiao pit land preparation technology, which realized the greening of the heavily weathering rock slope with intense and severe erosion. With satellite remote sensing images of Nijiahe River Basin in Xiji County as the information source and combined with ground survey, scholars obtained the status map of land use and used GIS to guide the land use situation on the slope of the river basin, and finally formed an effective comprehensive protection system for soil and water loss, so as to protect, improve and rationally utilize soil and water resources [7,8].

2. Function and Means of Slope Treatment

The function of slope treatment project is to prevent soil and water loss on the slope by changing the topographic method, to trap rainwater and snow water on the spot, so that it can penetrate into the agricultural land, grassland or forest land, to reduce or prevent the formation of slope runoff, and to increase the soil water available for crops, grasses and trees. At the same

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time, the slope runoff that cannot be stored in situ is introduced into small water storage projects. On slopes where there is a risk of gravity erosion, drainage works or supporting structures can be constructed to prevent landslides. The purpose of slope treatment project is to eliminate runoff on slope, store seepage in situ, use water and soil resources in situ, and increase the cold resistance of agricultural, forestry and animal husbandry land. According to the topography, soil quality and land type, certain engineering measures should be reasonably arranged on the slope, and farmland, forest and grass land and water storage projects should be organically combined with channels, roads and forest belts to form a complete protection system combining storage, seepage, diversion, drainage, irrigation and drainage. The afforestation and grass planting on barren hills and slopes, gentle slope strip fields, twisting fields, horizontal terraces, horizontal precipitation steps on steep slopes, horizontal gullies, and various water storage and soil conservation and afforestation land preparation projects on slopes shall be integrated with each other. Slope treatment engineering generally includes biological engineering, agricultural engineering and water storage engineering several parts, mainly earth ridge, terrace, cut ditch, cut pit, water dustpan, water cellar, reservoir, level ditch, level step and fish scale pit.

3. Development Process of Horizontal Terrace

In the loess hilly and gully region, slope terrace, horizontal terrace, soil and water conservation tillage method pit field, trench field, ridge field, ridge planting, contour tillage, pot planting and other grass field rotation and plant cover are mainly applied to control soil and water conservation technology. In addition, water dustpan, early well, reservoir cellar, water interception pit, Kankan ditch and other measures are also adopted in the treatment of slope.

Horizontal terrace is the most important measure of slope management in Loess Plateau. In the early 1940s, water conservation technicians began to experiment and popularize the construction of slope terrace in Tianshui, Gansu Province, Mizi, northern Shaanxi Province and other places, which increased the yield per mu of sloping land. In the middle period, we should start to build horizontal terraces, and study the planning, design, construction technology and construction method of horizontal terraces, as well as the effect of soil and water conservation on increasing production and improving soil; In the 1950s, the horizontal terrace technology was fully promoted. From 1955 to 1957, Northwest Institute of Biological Soil Research, Chinese Academy of Sciences systematically investigated the design and construction of horizontal terraces and slope terraces on the Loess Plateau, and obtained the formula for calculating the height of the ridge and the width of the field surface. In 1981, Yin Chuanxun et al., Institute of Soil and Water Conservation in Yan 'an Area, conducted an experimental study on terraced fields with separate slopes in the loess hilly area. According to different slope grades and soil thickness and characteristics, the section forms of terraced fields with different specifications were planned and their application scope was popularized. Liu Wanshu, Shi Ding et al. discussed the optimal section and suitable width of terrace. In 1972, Liu Wanshu and others from the Northwest Institute of Water Conservation of Chinese Academy of Sciences in Ansai County, northern Shaanxi Province, used the Dongfang-red tractor to pull the plow to dig the flat land to build terraces, and adopted the "up and down combination of soil turning method" to build terraces with wide fields and high fields, which doubled the yield that year. In the late 1990s, Hengshan and other places in Wudinghe River basin in northern Shaanxi vigorously promoted human-machine combination terracing technology.

4. Allocation Model of Comprehensive Slope Management Measures

In different types of areas in the Loess Plateau, a number of very effective comprehensive slope management models have been formed in the practice of management and production.

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4.1. Slope Management Measures for in Hilly and Gully Region

Duocha small watershed in Mizhi County, northern Shaanxi Province is a secondary tributary of Wudinghe River, belonging to the first sub-district of the Loess Plateau hilly and gully region. The allocation of slope comprehensive management measures in Chha small watershed is based on the principle of adapting to local conditions and comprehensive management, with the aim of protecting and rationally exploiting soil and water resources, improving ecological environment and developing small watershed economy. According to the natural conditions of the small watershed, the slope is divided into beam decoration slope and gully slope. On the gentle slope of Liangruo slope, horizontal terraces are mainly built, supplemented by orchards, forest and grass planting, water cellar and rain collection field, and shrub belts are laid on the screen edge. A small amount of cultivated land is planted on the relatively smooth and complete gully slope with grass field rotation and horizontal and ridge gully planting. Using horizontal gully, horizontal terrace, reverse slope terrace and fish scale pit and other engineering land preparation measures, to create economic forest and timber forest, on the broken gully steep slope, plant shrubs mainly with caragana.

4.2. Slope Management Measures for in Plateau Gully Region

Jiaoergou small watershed in Changwu County, Shaanxi Province is a typical plateau gully area. It has been comprehensively controlled since the 1970s, and has gradually improved various measures and carried out comprehensive control of soil and water conservation. By 1985, a total of 2150.33 hm2 of horizontal ground lay was repaired, 117 source surface protection forest net blocks were constructed, totalling 585 km, 40.4 km of ditch edge ridge was built, 16 ditch head protection projects were placed, source border protection belt was 20 km, and 549.13 hm2 of horizontal terrace on source slope was repaired. A total of 1059.87 hm2 of protection forest based on robinia acacia was constructed. Two small reservoirs, 55 silting DAMS, 17 willow valleys were built, and a certain number of gully bottom anti-erosion forests were built. Before and after treatment, erosion was reduced by 73.7% and runoff by 49.93%, which played a role in water storage and retention.

5. Conclusion

By summarizing the current development status of slope treatment technology at home and abroad and combining with the characteristics of soil and water loss in small watershed of the Loess Plateau, it is necessary not only to conduct comprehensive research on slope treatment planning of the Loess Plateau, but also to conduct in-depth research on the allocation of treatment measures in order to establish a scientific control system and improve the benefits of slope treatment of the Loess Plateau. Slope control on the Loess Plateau is also an important way and means to ensure the ecological security of the Loess Plateau. In-depth study on slope control has certain guiding role and practical significance for solving the problem of soil and water loss in the small watershed of the Loess Plateau, improving the ecological construction of the Loess Plateau, and promoting the sustainable economic and social development of this region.

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