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Analysis of Soil Layer Thickness and Its Influencing Factors in Gully of the Loess Plateau

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Abstract. Soil thickness is an important basic characteristic of soil, which can directly reflect the degree of soil development, is closely related to soil fertility, and is an important index for identifying soil fertility in the field. It is not only a supplementary source of soil nutrients, but also a primitive storage of soil minerals, and a main indicator for judging the degree of soil erosion. Soil thickness and properties are important indicators of soil quality and an important material basis for plant growth. Soil thickness can affect vegetation growth and surface hydrology, and also has a decisive effect on landslides, soil erosion, and soil fertility and productivity. In view of this, this paper studies the soil thickness and its influencing factors, and provides a theoretical basis for improving the soil quality in different regions and protecting the regional ecological environment.

Key word: Soil thickness; natural factors; human factors; gully; Loess Plateau.

1. Introduction

Since the publication of "Russian Chernozem" by Dakuchayev in 1883, soil science was born. Until the soil science field investigation and research method is formed, the soil thickness has become the basic soil characteristics through field investigation of soil formation factors and profile morphology, and comprehensive analysis of the surrounding natural geographic environment and soil utilization. A basic element must be taken into account in the research process of soil development, which also marks the beginning of a systematic study of soil thickness. With the continuous development of soil science, soil thickness, as an important index of soil parameters, has received more and more attention, and has been considered as an index factor in the research of many fields.

From the perspective of soil genesisand topography evolution, the change of soil thickness over time in a particular location depends on the balance between the rate of weathering bedrock and the chemical leaching and soil physical erosion transport. The soil formation process depends on the weathering process of the underlying parent material under various physical, chemical, and biological effects. It is generally believed that the rate of these weathering processes will exponentially decrease as the thickness of the overlying soil increases [1]. Studies have shown that in addition to the time of soil formation, soil thickness is also closely related to many environmental factors such as topography and geomorphic conditions (slope, aspect, altitude), land use patterns, biological communities, surface vegetation cover, climatic conditions, etc.[2-3]. Recent studies believe that long-term human activities can also significantly change the soil thickness in a plot, such as agricultural farming activities and planting hedgerows on slopes. When there is a balance between the erosion process and the weathering process at a certain point, the soil at this point will reach a relatively stable thickness. Under stable topographical environmental conditions without significant soil erosion, the soil will gradually develop into a thick layer of soil with a hierarchical profile. The gully stratum of the loess small watershed is complex and the soil thickness is uneven. In order to improve the benefits of comprehensive management in the area and ensure the productivity and stability of the farmland soil after remediation, it is necessary to conduct a systematic study of the soil structure before land remediation and precision detection

2. Overview of soil thickness

The thickness of the soil layer is generally defined as the vertical distance from the surface to the consolidation layer material (soil parent material, bedrock, hard rock, etc.). Soil layer thickness is a key property of soil, which can affect plant growth and hydrological runoff processes

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at various scales [4]. The thickness of the soil layer directly affects the amount of water and nutrient stocks. If the soil layer is too shallow, it affects the depth and breadth of the plant root system to the soil layer, and it also affects the support of some plants above the ground. Under the condition that the nutrient content is basically the same, the total amount of plants produced by the deep soil layer is much larger than that on the shallow soil layer [5]. The thickness of the soil layer is not only a supplementary source of soil nutrients, but also a storage reservoir of soil mineral elements. It is closely related to land productivity and is also an important indicator to determine the degree of soil erosion. In addition, the thickness of the soil layer is also an important index for soil classification. In various hydrological models and surface environmental process models, the thickness of the soil layer is one of the important input parameters.

The topography of the basin is the result of the long-term interaction between internal and external forces. After erosion, it presents a landscape of ridges and ridges crisscrossing, and ravines are vertical and horizontal. The watershed is covered by loess and the soil layer is deep. Generally, the thickness of the soil layer can reach tens of meters to hundreds of meters. The land improvement planning project considers more of increasing the amount of cultivated land, while ignoring the quality of cultivated land, including ignoring the thickness of the newly added cultivated land. The general survey of soil thickness is of great significance in land engineering. The determination of soil thickness through exploration can guide the design and construction of land engineering. On the one hand, it can ensure the source of soil and the balance of the earthwork in the project, and on the other hand, it can avoid excessive earthwork. Excavation caused problems such as thin soil layer, difficult to use, and land desertification caused by the exposure of the parent material of the land.

The thickness of the soil varies from place to place. In plain areas, the loess layer is thicker. In high mountain areas, there is no loess layer. It is only a rock layer. Generally speaking, the loess layer of the Loess Plateau is the thickest, estimated to be thousands of meters, and the cultivated soil layer does not exceed 0.5 meters. In the small watersheds of Jiulongquangou and Yangwangou in Nanniwan, a typical area of the Loess Plateau gully, the soil on the slope is relatively thick, usually about tens of meters, and some of the slope has thin soil and exposed rock layers. The thickness of the soil layer is only less than 5 m; in the drainage channel of the watershed, the thickness of the soil layer decreases from the head of the ditch to the mouth of the ditch, from about 5 m at the head of the ditch to less than 1 m at the mouth of the ditch.

3. Factors affecting soil thickness

3.1 Natural factors

3.1.1 Climate factors

Climate directly affects the water and heat status of the soil through the continuous exchange of water and heat between the soil and the atmosphere; indirectly affects the formation and development of the soil through the transformation, migration, leaching and deposition of minerals, organic matter and their products in the soil process. Different climatic zones have different water and heat conditions and their ratios, which determine that the soil has different physical, chemical and biological processes and changes. In the process of soil formation, different parent rocks have different resistance to weathering, and the thickness of the formed soil layer is also different. Under the same soil formation time, generally mud shale and mudstone are easy to form thick layers of soil. Limestone, quartz sandstone, and silica-gelled sandstone are difficult to form thick soils. Climate can also indirectly affect the formation and development of soil by affecting the weathering process of rocks and the type of vegetation, which in turn affects the thickness of the soil layer. From dry desert areas or low-temperature tundra areas to hot and rainy tropical rainforest areas, with changes in temperature, precipitation, evaporation, and the productivity of different vegetations, the return of organic debris gradually increases, chemical and biological weathering gradually increases, and weathering crusts gradually increase. Thicker, the soil layer is correspondingly thicker.

Nanniwan Town, Yan'an City is the second sub-region of the loess hilly and gully region. It has a semi-arid continental monsoon climate. The annual average precipitation is 573 mm, and it decreases from south to north. The precipitation is unevenly distributed throughout the year and has large inter-annual variability. From September to September, due to the influence of the westward subtropical high pressure, the convergence of middle and low-level medium and small systems, and the uplifting effect of topography on the airflow, local rainstorms often formed with short duration, high intensity, and small coverage area. The precipitation accounted for about a year. About 75% of the precipitation, the loess covering depth of the slope in this area is 50~150 m. Due to the influence of water erosion in the channel, the thickness of the soil layer is 0.4~5 m.

3.1.2 Biological factors

Among biological factors, plants play the most important role. Green plants selectively absorb nutrient elements from parent material, water bodies and the atmosphere, and produce organic matter through photosynthesis, and then return the organic nutrients to the surface in the form of litter and debris. Most plant organic matter is concentrated in the soil surface, but there is also a considerable amount of biological organic matter concentrated in the 30-50 cm of the soil. The difference in the nutrient return amount and return form of different vegetation types is the root cause of the soil organic matter content. For example, the organic matter content of forest soil is generally lower than that of grassland. This is because grass roots are dense and concentrated in the near-surface soil. The root system is very deep, and there is not much organic matter directly provided to the surface of the soil, and the organic matter is returned to the surface in the form of fallen leaves.

When studying the relationship between soil thickness and surface vegetation, vegetation coverage has always been an important indicator factor. This is mainly because the higher the vegetation coverage, the greater the effect of vegetation on rainfall interception, thus avoiding the impact of raindrops. The direct scouring and impact of the ground surface reduces the amount of soil erosion. The study found that when the vegetation coverage is less than 20%, there is no obvious correlation between the soil thickness and the vegetation coverage. After the vegetation coverage reaches 20%, there is a clear positive relationship between the soil thickness and the vegetation coverage. Correlation, that is, without considering the influence of other factors, the soil thickness will become thicker as the vegetation coverage increases. However, after the vegetation coverage reaches 70%[6], this correlation becomes no longer obvious and disappears.

There are many types and numbers of soil animals. The organic residues of animals are also the source of soil organic matter and participate in the formation of soil humus. In addition, some animals such as earthworms and termites can also change the soil structure, porosity, and arrangement of soil layers by stirring the soil, which also has a great effect on the composition and morphological characteristics of the soil. For example, the number of earthworms per hectare of soil can be more than 250,000 to 1 million, and the average soil is turned by about 20 t/hm^2 in a year, and through their digestive system, some complex organic matter in the soil is transformed into simple and effective nutrients. , And then excreted into the soil, improving the soil structure and improving fertility. The excavation of animals in the soil creates many holes of different sizes, which enhance the water permeability, air permeability and tightness of the soil. The presence of these animals in the soil accelerates the soil-forming process of the parent material and is conducive to the accumulation of organic matter. At the same time, it also increases the soil porosity, reduces the soil bulk density, and makes the soil more loose. Therefore, the thickness of the soil layer is often larger in areas with active animal behavior and a wide variety of species. Microorganisms can fully decompose the organisms of animals and plants, synthesize soil humus, and then decompose it, which is an important part of the biological cycle of soil material, which transforms the parent material and promotes the soil formation process. The main function of microorganisms in the process of soil formation is the decomposition and transformation of organic residues and the synthesis of humus. Similarly, in a soil with a wide variety of microorganisms, its organic matter content is high, and the thickness of the soil layer is generally large.

3.1.3 Terrain factors

The influence of topography on soil thickness mainly acts on the soil indirectly by causing the redistribution of material and energy. The parent material is the material basis for the formation of soil. Under the influence of climate and organisms, the soil is gradually formed from the surface of the parent material. Different topographical parts can have different types of soil-forming parent material, such as the upper part of the mountain or on the platform, the parent material is mainly the residue; the parent material of the slope and foothills is mostly slope deposits; the alluvial cone or alluvial fan of the piedmont plain, forming soil The parent material is alluvial deposits; in river terraces, floodplains, alluvial plains, lakes and areas near the seashore, the corresponding parent materials are alluvial deposits, lake deposits and marine deposits. The terrain affects the water and heat conditions and the redistribution of materials. In mountainous areas with steep slopes, most of the precipitation becomes surface runoff, which flows from a high place to a low place, and the soil is eroded; in flat or low-lying places, precipitation infiltrates the soil and material accumulation often occurs. Different terrain parts have different absorption of solar radiation and different ground radiation, which affects the difference in surface temperature.

Elevation is one of the important topographical factors, and changes in altitude will cause spatial variation of natural elements such as landforms, vegetation, soil, and hydrology. In mountainous areas, due to the vertical changes of temperature, precipitation and humidity along with the altitude of the terrain, different climate and vegetation zones are formed, resulting in significant vertical zone differentiation in the composition and physical and chemical properties of the soil. It can be seen from the survey area survey that the project area has a steep land slope and is a typical loess gully small watershed, with an altitude between 992 and 1525 m. Studies have shown that there is a positive correlation between the thickness of the soil layer and the altitude, but the correlation is not obvious. Only when the mountain has sufficient altitude and relative height, a vertical climate zone will be formed, which will lead to other physical geography[7].

3.1.4 Time factor

The period from when the soil was first formed to the present is the age of the soil. For this period of time, it is called the absolute age of the soil in soil science. The beginning of the absolute age of the soil means that the ground is exposed after glaciers melt and retreat, or the sediments of rivers and lakes are basically stably exposed to the surface, or the beaches become land after the coast rises and the sea retreats. Generally speaking, in high-altitude mountain areas and high-latitude northern areas, the effect of detachment from glaciers is later, and the absolute soil age is younger; in low-altitude areas and southern regions at low latitudes, the absolute age of soil is older. It can also be said that the soil formed on the in situ residual weathering material is generally older, while the soil on the alluvial material is younger. It is generally believed that the oldest existing soil appeared in the Tertiary Period, with an absolute age of tens of millions of years, but it is rare. The age of most modern soils is thousands of years. From the perspective of the concept of absolute soil age alone, it seems that the greater the absolute age of the soil, the deeper its development and the thicker the soil layer, but in fact this is not completely the case. Therefore, the concept of relative soil age is proposed.

The relative age of soil does not refer to the duration of the existence of the soil, but refers to the speed of soil formation under the combined action of various soil-forming factors, that is, the depth of soil development. The soil profile has obvious layers, complete profile configuration and large layer thickness, and its development degree is higher. However, the profile differentiation is not obvious, and the thin soil layer with simple profile configuration is relatively short in age. Generally speaking, the absolute age of the soil is large, and the relative age is also large. However, although some soil has experienced a long time, for some reason, its development degree still stays at a relatively low stage.

3.2 Human factors

3.2.1 Farming measures

The impact of humans on the soil is bidirectional. Man is both a soil improver and not a destroyer, because it requires farming. The development direction of the soil can be controlled by changing a certain soil-forming factor or the relative relationship between the factors and the soil-forming process can be strengthened or inhibited. For example, irrigation and drainage can change the hydrothermal conditions of the natural soil, thereby changing the movement process of substances in the soil. In addition, agricultural measures such as farming, fertilization (including the application of organic fertilizers, inorganic fertilizers and various pesticides), and irrigation can directly affect the changes in soil development, composition and characteristics. Reasonable use and management of soil can maintain and improve soil fertility; otherwise, it will lead to soil degradation, fertility decline, and even desertification, secondary salinization or swampization.

These are all examples of man-made soil development in a direction that is conducive to improving soil productivity and making the soil properties more suitable for crop growth. However, if the land use is unreasonable, then the impact of production activities on the soil will be bad and destructive. For example, deforestation, land reclamation on steep slopes, overgrazing, etc., will cause soil erosion or wind erosion. As a result of soil erosion, not only the fertility of the soil is reduced, but even the soil is completely destroyed, and the eroded sediment will also block ditches and rivers, bury farmland, and cause adverse consequences that are difficult to remedy. This requires a high degree of vigilance.

3.2.2 Land use method

The soil erosion control measures implemented in the Yangjuangou small watershed, a typical area of the Loess Plateau gully, adjusted the land use structure and increased the proportion of arbor forest land and shrub forest land in the watershed, spreading throughout the small watershed. Due to tree planting and afforestation, there is a greater tendency for terraces to be converted into arbor forests and shrub forests, especially in the east and west of the watershed. Most of the waste grassland is also converted to arbor forests, shrub forests and sloping farmlands, and grassland is the largest transferer , Arbor woodland and shrub woodland are the largest transferees. These human factors, while changing the way of land use, also led to the redistribution of the thickness of the soil in the watershed[8]. Studies have shown that in karst areas, the soil thickness data under different land use types are barren hills and bare land, barren grassland, woodland, arable land, and paddy field in descending order of different land use types (Table 1).

Table 1. Correlation analysis results of soil layer thickness and land use mode

Numbering	Land use type	Interference method	Interference intensity	Average soil thickness (cm)
1	Barren Mountain and Bare Land	Grazing	Severe	8.075
2	Wild grassland	Grazing	Severe	12.473
3	Woodland	Land preparation	Moderate	18.275
4	arable land	Farming	Mild	21.731
5	Paddy field	Farming	No interference	31.869

Superimposing and analyzing the soil thickness data of the above several different land use types found that the average soil thickness in the analysis results is relatively thick for paddy fields and cultivated land. Farming is the main interference method of the two, and the degree of interference is relatively compared. light. Such research results also fully prove that the cultivation of arable land in karst areas will aggravate local soil erosion. This conclusion is basically the same as that obtained in other areas. In addition, the average soil thickness of woodland, barren grassland and barren hills are 18.275 cm, 12.473 cm and 8.075 cm, respectively. The main interference method in these areas is grazing, and the destruction of the ecological environment is mainly caused by the transitional grazing of cattle, sheep and other livestock. In particular, most of the project areas for gully control and land reclamation are located in loess hilly and gully areas, and their ecosystems are extremely fragile, and this kind of destruction is undoubtedly a fatal blow.

4. Conclusion

(1) The thickness of the soil layer is affected by natural factors such as climate, topography, organisms and time, as well as human factors such as farming measures and land use methods. In people's research on soil erosion and other aspects, the interference of human activities has been listed as one of the important influencing factors.

(2) In the study of regional soil thickness, land use is one of the most important factors. This is mainly because the vegetation coverage and micro-topography of the ground surface will be largely affected by land use. Once the land use pattern changes, the amount of soil erosion and the intensity of soil erosion will be directly affected and thus change, and the soil thickness will gradually become thinner as the amount of soil erosion increases and the intensity of soil erosion increases.

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