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Loess Degradation and Improvement Measures

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Abstract

Loess is a special soil type, widely distributed in our country. However, due to the influence of natural factors and human activities, loess has degraded, which has a negative impact on ecological environment, agricultural production and many other aspects. This paper elaborated the manifestations of loess degradation, such as soil erosion, fertility decline, soil structure destruction, etc., deeply analyzed the natural factors (including precipitation, wind power, terrain, etc.) and human factors (such as unreasonable land use, over-reclamation, overgrazing, etc.) leading to loess degradation, and proposed a series of improvement measures to address these problems. It includes engineering measures, biological measures and agricultural technology measures, aiming at providing theoretical basis and practical guidance for ecological protection and sustainable development of loess area.

Keywords

Loess; Degradation; Drought; Fertility Decline; Soil Erosion.

1. Introduction

Loess is a continental yellow silty soil deposit formed in the quaternary period. It is porous yellow silty soil with columnar joints formed under dry climate conditions. Collapsible loess will produce large subsidence after being soaked by water. Loess is widely distributed in arid and semi-arid regions in the middle latitudes of the Northern Hemisphere [1-2]. The total area of loess distribution in the world is about 13 million km^2. The mineral composition of loess is divided into three categories: detrital minerals, clay minerals and authentogenic minerals. The clastic minerals are mainly quartz, feldspar and mica, accounting for 80% of the clastic minerals, followed by pyroxene, hornblende, epidote, chlorite, magnetite and so on. In addition, there are more carbonate minerals in loess, mainly calcite. The main clay minerals are illite, montmorillonite, kaolinite, goethite, hydrous hematite and so on. The chemical composition of loess is dominated by SiO_2, followed by Al_2O_3, CaO, and then Fe_2O_3, MgO, K_2O, Na_2O, FeO,TiO_2 and MnO [3-5]. The physical properties of loess are loose, porous, vertical joints developed, easy to permeate water, and there are many soluble substances, which are easy to be eroded by running water to form gullies, and easy to cause subsidence and collapse. The combination between loess particles is not tight, and the porosity is generally 40% ~ 50%[6].

Paleosoil distribution is common in late Cenozoic earth like deposits in northern China, especially in loess Plateau. The white calcareous deposit layer in the lower part of the loess

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ancient soil layer is often manifested in the form of nodules. The shape of calcium nodules is long columnar, regular dendritic and spherical, generally 15~25 cm long, 5~10 cm wide. Loess in China is distributed at 34~45° north latitude, in an east-west zonal pattern, and is located in the southeast of the desert-loess belt in the middle latitude of the northern hemisphere. The distribution of loess in China includes more than 220 counties (cities) in five provinces, including Shaanxi, Shanxi, Ningxia, Gansu and Qinghai, with an area of 540,000 km^2[7-8], accounting for 6% of the country's land area. Loess is distributed in all continents in the northern hemisphere, especially in northern China, which forms the world-famous Loess Plateau in the middle reaches of the Yellow River. The Loess area once gave birth to the ancient Chinese civilization and is one of the important agricultural producing areas in China [5-6]. However, with the passage of time, loess has been degraded to different degrees, which not only affects the local ecological environment, but also restricts the regional economic development and social stability. Therefore, it is of great practical significance to study loess degradation and its improvement measures.

2. The Degradation of Loess

2.1. Soil Erosion

The precipitation in loess area is concentrated and there is heavy rain. The splash of raindrops will destroy the surface structure of the soil and disperse the soil particles. Under the action of slope runoff, scattered soil particles are washed away, forming erosion landforms such as rill, shallow ditch and even cut ditch. For example, in some mountainous areas of the Loess Plateau, after a rainstorm, numerous new erosion trenches appear on the slopes, and large amounts of fertile topsoil are washed away. With the continuous development of water erosion, gullies are deepened and widened, and slope fragmentation is intensified. This not only leads to a huge amount of soil loss, but also reduces the available land area, and the land becomes fragmented, which is not conducive to agricultural production and rational use of land.

The Loess Plateau has strong winds in winter and spring. Because of the fine grain and loose texture of loess, it is easy to be blown up under the action of wind. Wind erosion can blow away fine particles from the surface of the soil, resulting in a decrease in soil fertility. Long-term wind erosion will also form wind erosion depression, wind erosion and other landforms. In some areas with frequent wind-sand activities, the soil in the farmland is blown away, and the crop roots are exposed, which seriously affects the growth of crops.

2.2. Fertility Decline

In the process of soil erosion, nitrogen, phosphorus, potassium and other nutrients in the soil are taken away along with soil particles. For example, in the process of water erosion, the organic nitrogen in the soil will flow into the river with the sediment, resulting in the lack of nitrogen in the soil. At the same time, due to the low vegetation coverage in loess area, the decomposition rate of organic matter in soil is fast and the amount of supplement is small. For a long time, the content of organic matter in soil has been decreasing continuously, which affects the soil's fertilizer holding capacity and the stability of soil structure.

In some loess areas, unreasonable fertilization, such as excessive application of nitrogen fertilizer, leads to soil acidification. Soil acidification will affect the activity of microorganisms in the soil and reduce the availability of some nutrients in the soil. For example, in acidic soil, phosphorus is easily fixed and difficult to be absorbed by plants.

2.3. Soil Structure Failure

Due to the frequent use of agricultural machinery and human trampling, the soil structure of the loess is compacted. After compaction, the porosity of the soil decreases, and the air permeability and water permeability become worse. The decrease of soil porosity will affect

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the living environment of microorganisms in the soil, inhibit the activities of microorganisms, and then affect the transformation and circulation of nutrients in the soil. For example, aerophilic microorganisms in soils are limited in their activities in poorly ventilated soils and cannot properly decompose organic materials.

Aggregate structure in loess has an important effect on soil fertility and physical properties. However, due to factors such as unreasonable farming practices and soil erosion, soil aggregates are destroyed. After the aggregate is destroyed, the soil's corrosion resistance is reduced, and it is more easily eroded by water and wind, forming a vicious circle.

3. The Causes of Loess Degradation

3.1. Natural Factors

The spatial and temporal distribution of precipitation in loess region is uneven, with most precipitation concentrated in summer and heavy rain. The raindrop kinetic energy of rainstorm is large, and the erosion effect of splash on soil is strong. The inter-annual variation of precipitation is also large, and the soil moisture is insufficient in dry years, the vegetation growth is poor, and the soil corrosion resistance is weakened; In wet years, too much precipitation is likely to cause serious soil erosion.

The Loess Plateau is located in the north of China, affected by the monsoon climate, strong wind in winter and spring. The northwest wind carries a lot of sand and dust and erodes the loess area. Changes in wind strength and direction also affect the intensity and extent of wind erosion. For example, when the wind increases, the extent of wind erosion will increase, and the depth of wind erosion will also increase.

The Loess Plateau has undulating terrain and ravines. The slope topography is conducive to runoff accumulation and soil erosion development. The presence of gully landforms accelerates erosion and transport of soil, and at the bottom of the gully, erosion is more intense due to fast water flow.

3.2. Human Factors

For a long time, there has been irrational land use in the loess area. For example, the clearing of steep slopes for cultivation destroys the original vegetation and leads to increased soil erosion. In the process of some urban construction and industrial development, a large number of high-quality arable land is occupied, which makes the land use structure unbalanced, and also destroys the ecological function of land.

In order to meet the demand for food from the growing population, large-scale reclamation was carried out in the loess region. Overcultivation makes the land not recuperate, and the soil fertility continues to decline. In the process of reclamation, vegetation is destroyed, the ability of soil to retain water and soil is reduced, and soil erosion is intensified.

Overgrazing is a serious problem in some grassland areas of the Loess Plateau. Overgrazing by livestock has reduced grass cover and exposed soil. Livestock trampling also damages the soil structure, making the soil compacted and less ventilated and water-permeable, leading to soil degradation.

Some farmers have unreasonable fertilization in agricultural production, such as insufficient fertilization or excessive fertilization. Insufficient fertilizer application can not meet the nutrient demand of crop growth, resulting in a decline in soil fertility.

Excessive fertilization not only causes waste of resources, but also causes soil acidification, soil compaction and other problems, affecting the quality of soil.

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4. Improvement Measures of Loess Degradation

4.1. Engineering Measures

Terracing is one of the effective engineering measures to control soil erosion in loess areas. By building terraces on the slope, the topography of the slope can be changed, the runoff rate can be slowed down, and the soil infiltration can be increased.The types of terraces include horizontal terraces, slope terraces and slope terraces. Horizontal terraces are suitable for gentle slopes, which can maximize rainwater retention and reduce soil erosion. Slope terrace is a kind of simple terrace built along the contour line on the slope surface, which has a certain effect of water storage and soil preservation. Slope terrace is a terrace built between two adjacent slopes, which can use the water harvesting effect of slope to provide irrigation water for the terrace.

A silting dam is a kind of engineering facility built in a gully to contain mud and silt. When the flood carries sediment through the dam, the sediment is intercepted and deposited in the dam, gradually forming a fertile dam land. Silting dam can not only reduce the amount of soil erosion in gully, but also increase the area of cultivated land and improve the productivity of the land. At the same time, the silting dam can also regulate the runoff of the channel and reduce the harm of the flood to the downstream area.

Gufang is a small water and sand holding structure built in the gully. The valley square can trap runoff and sediment, reduce the flow speed of the gully, and prevent the gully from further cutting and expanding. There are earth Valley, stone Valley and plant valley. Earth valley mill has low cost and is suitable for small gully; Shigufang is strong and durable, suitable for the gully with rapid water flow and large sediment content; Plant valley has good ecological benefits, it can use the roots of plants to consolidate soil, but also can beautify the environment.

4.2. Biological Measures

Afforestation is an important biological measure to improve the ecological environment and prevent soil degradation in loess areas. The roots of trees help to consolidate soil and reduce soil erosion. At the same time, the branches and leaves of trees can trap rainfall, reduce the kinetic energy of raindrops, and reduce the impact of raindrops on the soil. When selecting tree species for afforestation, reasonable selection should be made according to local climate and soil conditions. For example, in the arid areas of the Loess Plateau, drought-tolerant tree species such as platycypress and Pinus tabulaeformis can be selected. In areas with better water conditions, poplar, willow and other fast-growing trees can be selected.

Planting grass is also an effective biological measure. Herbaceous plants grow quickly and have developed roots, which can cover the surface of the soil in a short time and prevent soil erosion. Some perennial herbs such as alfalfa, cladonia, etc., not only have good soil consolidation, but also can improve soil fertility. For example, the roots of alfalfa fix nitrogen and increase nitrogen content in the soil.

For areas with degraded vegetation, vegetation restoration measures should be taken. This includes banning forest cultivation and grass cultivation, and replanting and replanting. Banning forest cultivation allows vegetation to be restored under natural conditions and reduces human interference. Supplementary planting can increase vegetation coverage in areas with sparse vegetation.

4.3. Agricultural Technical Measures

Reasonable fertilization is an important measure to improve soil fertility and prevent soil degradation in loess area. Scientific fertilization should be carried out according to the nutrient status of the soil and the needs of crops. The use of soil testing and formula fertilization technology can accurately determine the content of various nutrients in the soil, and reasonably

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match the proportion of nitrogen, phosphorus, potassium and other fertilizers according to the law of crop fertilizer demand, improve the utilization rate of fertilizers, and reduce the waste of fertilizers and adverse effects on the soil.

Soil amendments can improve the soil structure and fertility of loess. For example, some organic soil amendments such as humic acids can increase the organic matter content of the soil and improve the aggregate structure of the soil. There are also inorganic soil amendments such as gypsum, which can regulate the pH of the soil and improve the availability of nutrients in the soil.

Crop rotation refers to the rotation of different crops in a certain order on the same land. Crop rotation can improve soil fertility and reduce the occurrence of pests and diseases. For example, legumes rotate with gramineous crops, and the nitrogen fixation of legumes can increase the nitrogen content of the soil and provide nutrients for gramineous crops. Inter-cropping is the simultaneous cultivation of two or more crops on the same piece of land. Inter-cropping can make full use of land resources and environmental conditions such as light and water, and improve land productivity. For example, corn and soybeans inter-crop, corn can provide a certain shade for soybeans, soybeans can provide nitrogen for corn.

5. Conclusion

Loess degradation is a complicated process, which is influenced by both natural and human factors. Soil erosion, fertility decline and soil structure destruction are the main forms of loess degradation. In order to improve the degradation of loess, engineering measures, biological measures and agricultural technical measures should be combined.

Engineering measures such as terracing construction, silting dam construction and valley dam construction can effectively control soil erosion. Biological measures such as afforestation, grass planting and vegetation restoration can improve the ecological environment and soil corrosion resistance. Agricultural technical measures such as rational fertilization, application of soil amendments and crop rotation and intercropping can improve soil fertility and soil structure. Only by comprehensive use of these improvement measures can ecological protection and sustainable development be realized in the loess area, so that the loess area can regain vitality and lay a good foundation for regional economic development and social stability.

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