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Analysis of the Causes of Saline Alkali Land in Northern Shaanxi and Case Study

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Abstract

In recent years, research on measures to improve saline alkali land has become a focus in the field of land resource development. A review of such research can help summarize existing achievements, problems, and trends, and can also respond to national scientific and technological guidance, local conditions, and other comprehensive utilization strategies for saline alkali land. Based on the formation reasons of saline alkali land in northern Shaanxi, this article systematically summarizes and analyzes existing improvement technologies and specific cases, and analyzes the causes and improvement cases of saline alkali land, in order to provide reference for the efficient improvement and utilization of saline alkali land in northern Shaanxi and further research on improvement technologies.

Keywords

Saline Alkali Land; Cause Analysis; Improvement Case.

1. The Significance of Saline Alkali Land Management

Saline alkali land is a huge potential reserve resource for arable land and a valuable potential granary. Soil salinization is a bottleneck problem that restricts the utilization of land resources and the high-quality development of agriculture. The area of saline alkali land in China is about 500 million acres, of which 110 million acres are reserve resources for arable land that can be improved. Through engineering salt removal and soil improvement technologies, saline alkali wastelands can be converted into arable land, directly alleviating the problem of scarce arable land resources. The management of saline alkali land also helps to ensure national food security. Against the backdrop of global climate change and increasing population, the pressure on food production is increasing. Improving saline alkali land, increasing arable land area, and improving land utilization efficiency can help provide security for the country's food security. At the same time, the treatment of saline alkali land can effectively improve the ecological environment and restore the ecological function of soil. Saline alkali land usually contains excessive salt and alkaline substances, leading to a decrease in soil biodiversity and vegetation coverage. In recent years, China has successively issued relevant policy documents to improve the comprehensive utilization rate of saline alkali land and carry out systematic improvement and research on saline alkali land. By implementing governance measures, the improved land

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can provide a growing environment for various plants and promote the sustainable development of the natural environment. Based on the characteristics of salinization in different regions, researchers have gradually developed some improvement technologies that are suitable for the local area. Through demonstration projects, they have promoted the promotion and application of advanced improvement experience. In addition, the management of saline alkali land can drive the rise of related industries and promote the diversified development of local economy. The management of saline alkali land involves multiple aspects such as soil improvement, irrigation system construction, crop breeding and planting, which can create a large number of employment opportunities and stimulate regional economic vitality. The mature saline alkali land management industry can also become a highlight for local governments to promote and attract investment, helping to promote the comprehensive development of regional economy.

2. Analysis of the Causes of Saline Alkali Land Formation

2.1. Main Factors Contributing to the Formation of Saline Alkali Land

2.1.1. Natural Factors

The formation of saline alkali land is closely related to natural factors such as climate, soil characteristics, and hydrological conditions. Climate factors play an important role. In arid climate regions such as Xinjiang, Gansu, and Ningxia in northwest China, due to low precipitation and high evaporation, salt gradually accumulates in the soil, forming widely distributed saline alkali land. The differences in soil types affect the movement of water and salt. In some loose soils, water is prone to evaporation, and salt will form a saline alkali layer on the surface of the soil; In sticky and heavy soil, water cannot be effectively drained, leading to the accumulation of salt. Due to poor soil structure and drainage conditions, some areas in Northeast China have experienced salinization. Hydrological conditions also affect the formation of saline alkali land. Due to the high groundwater level in areas such as the Yellow River irrigation area, the Huang Huai Hai plain, and low-lying basins, highly mineralized groundwater rises to the soil surface through capillary action, gradually accumulating salt and forming a saline alkali layer. Meanwhile, basins and low-lying areas have become gathering areas for saline alkali land due to poor drainage. It can be seen that natural factors have a significant impact on the formation process of saline alkali land, and various factors are intertwined, leading to the widespread distribution of saline alkali land in China.

2.1.2. Human Factors

Human factors such as agricultural activities and water resource management can also lead to soil salinization. Agricultural activities are the main human factor in salinization, and inappropriate large-scale irrigation and fertilization often lead to the accumulation of salt in the soil, especially in arid and semi-arid areas. During the irrigation process of farmland, after the evaporation of water, the surface salt of the soil accumulates, forming salinized soil. In addition, unreasonable farming methods such as excessive cultivation and monoculture planting can also reduce the natural recovery capacity of soil and accelerate soil salinization. Improper management of water resources can also lead to soil salinization. In some areas, excessive extraction of groundwater leads to soil moisture imbalance, and underground salt gradually migrates to the surface due to the lack of water dilution, forming saline alkali soil. At the same time, the allocation of water resources is not fair, resulting in a scarcity of water resources in certain regions and a significant regional difference in salinization. Soil salinization is not only a result of natural conditions, but also a direct reflection of human activities.

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2.2. Causes of Saline alkali Land in Northern Shaanxi

2.2.1. Yulin Area

The scarcity of precipitation and the imbalance of evaporation are the main factors. Yulin is located in the northern part of the Loess Plateau, with a temperate semi-arid continental monsoon climate. The average annual precipitation is only about 400 millimeters, while the evaporation rate is over 2000 millimeters. This climate characteristic leads to the dominant upward movement of soil moisture, and dissolved salts accumulate in the surface layer through capillary action, forming salt frost or crust. The seasonal salt accumulation pattern shows that during the summer when precipitation is concentrated, some salt is leached into deeper layers. However, during the spring drought period, there is a significant phenomenon of surface salt return, forming a dynamic cycle of "desalination return salt".

The terrain, geomorphology, and hydrological conditions result in poor drainage in low-lying areas. There are a large number of enclosed or semi enclosed depressions in the Wuding River and Yuxi River basins in Yulin, where salt cannot be discharged after collecting in the lower areas along the surface runoff, forming a core area of salinization. For example, in Zhengjiagou Village, Yuhe Town, due to its low-lying terrain and long-term accumulation of salt, more than 2200 acres of arable land have been abandoned. The lateral seepage of rivers raises the groundwater level. Due to the lateral seepage of river water, the depth of groundwater in riverbank areas is generally less than 1.5 meters, with a mineralization degree of 3-5 g/L. Salt migrates to the surface through capillary action.

Soil texture and groundwater characteristics accelerate salt transport in loamy soils. The soil in Yulin saline alkali area is mainly composed of sandy loam, and the height of capillary water rise can reach 1.2-2 meters, far exceeding that of sandy soil (0.5 meters), which makes it easier for salt to accumulate on the surface. Highly mineralized groundwater recharge, with groundwater salinity exceeding 10 g/L in some areas, far exceeding the crop tolerance threshold (<2 g/L), has become an important source of soil salinity.

The flooding caused secondary salinization. Traditional irrigation methods, such as flood irrigation in rice fields, cause the groundwater level to rapidly rise above the critical depth (1-2 meters), and salt accumulates on the surface with evaporation. According to the investigation, some irrigation areas in Yulin have expanded the area of saline alkali land by 30% due to excessive irrigation. The lack of drainage system led to heavy irrigation and light drainage in early farmland construction, resulting in siltation of drainage ditches in irrigation areas and inability to discharge salt. Due to poor drainage, the soil salinity in Yuhemao Village and other areas in Yuyang District has increased from 0.3% to 1.2%.

The residual salt content of ancient lacustrine sediments is buried in some areas of Yulin (such as the old course of Yuxi River), containing a large amount of soluble salts (NaCl, Na_2SO_4, etc.), which gradually migrate to the surface under the action of groundwater.

The salt pan layer covered by wind blown sand, in the edge area of the Mu Us sandy land, makes it difficult for the lower layer of salt to naturally leach due to wind blown sand cover, forming concealed saline alkali land.

2.2.2. Yan'an Area

Drought and strong evaporation. Yan'an belongs to a semi-arid continental monsoon climate with an average annual precipitation of about 500 millimeters, but the evaporation rate is as high as 1500-2000 millimeters, resulting in residual salt on the surface after soil moisture evaporation. For example, after concentrated summer precipitation in the Nanniwan area, salt content rapidly moves up with capillary action, forming surface salt crystals. Hydrogeological characteristics. Groundwater in the Loess Plateau generally contains carbonates and sulfates, and the water level is relatively shallow (only 1-2 meters in some areas), making it easy for salt to migrate to the surface through capillary action. Low lying terrain accumulates salt, and there

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are a large number of enclosed depressions in the Yan'an gully area. Salt from surface runoff and groundwater gathers here, forming saline alkali patches. For example, the riverbank in the Yanhe River Basin has a salinization rate of 15% -20% due to poor drainage. Soil structural defects. The soil developed from loess parent material has a sticky texture and poor permeability, which hinders salt leaching and exacerbates the accumulation of surface soil salt. Improper irrigation management. In historical reclamation, large-scale flooding was used (such as during the Nanniwan reclamation period), which caused the groundwater level to rise to the critical depth (within 1.5 meters), leading to secondary salinization. Excessive use of chemical fertilizers. The long-term use of chemical fertilizers in facility agriculture areas (with an average annual nitrogen fertilizer application of over 300 kg/ha) has caused soil compaction and increased salt ion concentration.

3. Case Study on Typical Saline Alkali Land Improvement

1) Along the Great Wall, there is a comprehensive development area for agriculture, forestry, animal husbandry, and fishery in the sand dunes and tidal flats. It is located in the southeast of the Maowusu sand area, with a terrain that is higher in the northwest and lower in the southeast, at an altitude of 1000-1500 meters, and belongs to the wind blown beach area. Salt soil is mainly distributed in the west. Due to the high groundwater level and poor drainage, some tidal flats have caused soil salinization and swampification, with a total of more than 150000 acres of saline alkali tidal and saline soil, most of which are saline alkali wasteland. The method to improve saline alkali land is to dig trenches for drainage, lower the groundwater level, and prevent soil salinization; It is also possible to plant rice and wash salt. Local residents have used this method to develop 370000 acres of rice, which not only improves the soil but also increases grain production.

2) Management Model for Mild Salinization of Gully Farmland in Nanniwan Loess Plateau

In response to the high risks of waterlogging and salinization in farmland in the gully region of the Loess Plateau, comprehensive interception ditches, reservoirs, dual-purpose irrigation and drainage channels, flood discharge channels and other interception, storage, irrigation and drainage technical measures have been taken to construct a "drought irrigation, flood drainage" ditch soil flow non dynamic regulation irrigation mode and obstacle elimination technical mode for waterlogging, salt alkali prevention, erosion resistance, etc., achieving non dynamic regulation and utilization of surface water, soil water and groundwater resources in the ditch, regulating soil flow and groundwater levels, improving the efficiency of ditch water resource utilization. The irrigation guarantee rate of ditch farmland has reached over 75%, the water use coefficient of the canal system has been increased from less than 0.5 to 0.7, and the irrigation water use coefficient has reached 0.65. The interception ditch technology intercepts 48% of soil water and 52% of groundwater, causing the groundwater level in the farmland at the ditch mouth to drop by 0.2-0.5 meters, and the oxidation-reduction potential of the soil surface 0-20 cm to increase from -120-40 mV to 15-40 mV. The content of reducing ferrous ions decreased from 17.9-50.5 mg/kg to 3.8-26.3 mg/kg. Improved the redox state of farmland soil in the ditch, reducing the water-soluble salt content of farmland soil to below 1 g/kg, effectively reducing the risk of soil salinization. The quality level of farmland in the ditch has been upgraded to 11, which is one level higher than the quality level of surrounding farmland, turning the former "muddy bay" into a "high-yield and stable farmland". After the completion of the project, the yield of rice per mu will increase from 200 kilograms to 400 kilograms, the yield of corn per mu will increase from 300 kilograms to 500 kilograms, and the yields of soybeans, millet, and potatoes will increase by 60%, 91%, and 130%, respectively. At the same time, integrating the "Nanniwan Spirit" red culture into the utilization of arable land, constructing a "high standard

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farmland red tourism" industrial model, expanding the development space of the agricultural industry, driving local people out of poverty and promoting rural development.

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