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A Review of Saline-alkali Land Resources and Improvement Measures

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Abstract

Saline-alkali land is an important reserve cultivated land resource in my country. The improvement and utilization of saline-alkali land is of great practical significance to meet the food demand of our population and the sustainable development of agriculture. Soil salinization is a land resource problem facing the world. China's saline-alkali land is huge, widely distributed and of various types. Timely treatment and rational management of saline-alkali land resources can improve its ecological environment. This paper reviews the resource status of saline-alkali land, analyzes the influence of natural and human factors, and reveals the distribution of saline-alkali land. The research progress of saline-alkali land improvement was carried out from the aspects of straw returning improvement measures, chemical measures, plant measures and engineering measures. Finally, an outlook is put forward for the optimization of the improvement measures of the saline-alkali land in the future.

Keywords

Saline-alkali Land; Type; Cause of Formation; Distribution; Control Measures.

1. Introduction

Saline-alkali soil is a general term for saline soil, alkaline soil and various saline soils and alkaline soils, which restricts the development of regional social economy [1]. The problem of soil salinization has brought great harm to the agricultural ecological environment and production, and then caused serious consequences such as the serious decline of soil quality and the degradation of large tracts of grassland. Currently, 75 countries worldwide are affected by soil salinity. The area of salinized land is about 9.5×10^7 hm^2, and 7.7×10^7 hm^2 of soil is in a state of secondary salinization, which limits crop yields around the world [2]. As an important reserve cultivated land resource, the improvement and utilization of saline-alkali land is of great practical significance to meet the food demand of our population and the sustainable development of agriculture [3]. The core of the improvement and utilization of saline-alkali land is to rely on various technical means to reduce the harm of soil salinization, improve and improve soil fertility, and improve the soil to a state suitable for the normal growth and development of crops, so as to realize the rational utilization of saline-alkali land resources [4]. Based on the characteristics of saline-alkali land, and on the basis of summarizing relevant scientific research achievements, this paper summarizes the research progress of desalination

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restoration and fertilization and conservation of saline-alkali land from the perspective of saline-alkali land treatment and transformation measures, aiming to provide reference for the improvement of saline-alkali land. The improvement of saline-alkali land can effectively improve soil physical and chemical properties, increase biodiversity, improve ecosystem stability, and enhance environmental carrying capacity, laying the foundation for further development and utilization of saline-alkali land. It can enrich vegetation types, improve landscape effects, purify air, adjust microclimate, etc., and improve the living and investment environment in saline-alkali areas. Therefore, the improvement of saline-alkali land has important ecological, economic and social significance.

2. Resources of Saline-alkali Land

2.1. Causes of Saline-alkali Land

2.1.1. Natural Factors

The formation of soil salinization is divided into natural and man-made factors. Most soil salinization is formed under natural conditions. The essence of soil salinization is to dissolve various soluble salts and store them in the soil surface. In general, groundwater and soil water maintain a certain dynamic balance, and the ion content in the surface soil is relatively stable. Once the balance is destroyed, it will easily lead to the formation of saline-alkali land. When demonstrating the relationship between groundwater and soil salinization, Kovda pointed out that the movement and function of groundwater are the most important in the process of saline-alkali soil formation [5]. In a hot and dry climate with strong evaporation, if the groundwater is buried below 10 m, the evaporation of soil moisture will not exceed the total amount of precipitation, and the soil will not be salinized. If the groundwater is buried at a depth of 1-3 m, it is prone to strong evaporation, and the soil accumulates and returns to salt, resulting in salinization of the soil. Special geographical location can also lead to the formation of saline-alkali land [6]. For example, in coastal areas, due to the strong evaporation of soil water and the production of salt in surrounding lakes, the groundwater level and soil salinity are high, coupled with the lack of freshwater resources, the natural soil desalination rate is low, and it is easy to form saline-alkali land. In addition, the soil-forming parent material also has an important impact on the formation of saline-alkali soil. It contains abundant base ions. After long-term accumulation, coupled with the influence of climate and hydrological conditions, the salt is not easily eluted, and the saline-alkali soil is formed over time.

2.1.2. Human Factors

Soil salinization caused by human factors is called secondary salinization, which is caused by unreasonable artificial irrigation, blind reclamation, excessive logging, overgrazing, unreasonable construction and other activities. Excessive water injection into the soil and insufficient drainage will lead to groundwater damage, the groundwater level will rise, and the salt will remain on the surface due to evaporation of water, resulting in the accumulation of salt in the soil. Secondary salinization reduces soil fertility, and the destruction of the ecological environment causes plants to lose their good growth environment and nutrient conditions, which eventually leads to crop yield reduction.

2.2. Saline Distribution

The existing saline-alkali land area in China is about 27 million hm^2, of which the area that can be used as arable land is 0.6 million hm^2, and the saline-alkali wasteland is 21 million hm^2. The saline-alkali land is mainly distributed in the northeast plain, northwest arid area, semi-arid area, eastern coastal area and Huanghuaihai plain area [7]. Among them, the land with agricultural production development potential accounts for more than 10% of the total cultivated land in my country. If the saline-alkali wasteland can be treated in time, the local

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ecological environment can be improved, the land utilization rate can be improved, and the development of the local ecological economy can be promoted [8]. The inland saline-alkali soils are mainly distributed in most of Xinjiang, Qaidam Basin in Qinghai, Hexi Corridor in Gansu, and western Inner Mongolia. Such saline-alkali soils are mostly sulfate-alkali soils, and some are chloride saline-alkali soils, with a salinity content of 1% to 4%, and the surface soil can be as high as 20%. Alluvial plain saline-alkali soils are mainly distributed in the Huanghuaihai Plain, Songliao Plain and Sanjiang Plain, and are distributed in bands in the Yellow River alluvial plain and Loess Plateau, mainly carbonate-alkaline soils. The coastal saline-alkali soils are mainly distributed in Jiangsu, Shandong, Hebei and other places to the north of the Yangtze River estuary, and less distributed in Zhejiang and Fujian and other places to the south of the Yangtze River estuary [9]. The salt composition of soil is mostly chloride, and its salt composition and source are closely related to the strata of the sea and seawater.

3. Improvement Measures for Saline-alkali Land

3.1. Straw Improvement

The principle of straw returning to the field to improve soil salinization can be divided into two aspects from the perspective of the method of straw returning to the field [4]. On the one hand, the straw is directly crushed and returned to the field. After the straw is crushed, it is combined with tillage, rotary tillage and subsoiling. Some intermediate products, such as polysaccharides, can aggregate soil mineral particles into aggregates, increase the number of soil aggregates, improve soil structure, enhance soil water-holding capacity, reduce soil evaporation, and inhibit the accumulation of deep salt in the cultivated layer [10]. At the same time, returning straw can reduce the pH value and exchangeable Na^+ content of saline-alkali soil through adsorption, acid-base neutralization, etc., thereby improving the physical and chemical properties of the soil, increasing the organic matter content and nutrient content in the soil, and achieving the purpose of improving saline-alkali soil. On the other hand, straw mulching is returned to the field. This method can greatly reduce soil water evapotranspiration and inhibit the accumulation of salt on the surface. The straw mulching effect is similar to plastic film mulching, which prevents the direct communication of water and the atmosphere, and blocks the upward movement of soil surface water. At the same time, it also increases light reflectivity and heat transfer, reduces soil surface temperature and evaporation water consumption, and accelerates salt washing and alkali discharge, thereby reducing the damage to crop roots caused by salt, which is conducive to improving root soil layers and increasing the productivity of saline-alkali land [11].

3.2. Plant Improvement

Plant improvement has the advantages of low cost, large scale, quick effect and high economic benefit. The use of plant life activities can improve soil structure, reduce soil bulk density, increase soil porosity, facilitate water permeability and ventilation, and increase soil organic matter and nutrient content. Studies have shown that the content of soil total nitrogen, total potassium, available phosphorus and organic matter increases with the increase of the planting years of salt-tolerant plants [12]. The use of salt-tolerant plants to improve saline-alkali soil is the key to plant improvement. Salt-tolerant plants can grow under conditions of high osmotic pressure, and organic acids secreted by plant roots can improve soil pH, reduce soil pH, and improve soil structure. Salt-tolerant plants can also absorb the salt in the soil and store the salt in the vacuoles, which not only avoids being poisoned by themselves, but also reduces the salt content of the soil [13]. Ding et al. [14] found that the planting of puccinellia tenuiflora had a significant effect on the improvement of coastal saline soil, and elaborated the mechanism of the improvement of saline-alkali soil from the morphological structure, biological characteristics and physiological characteristics of salt tolerance.

3.3. Chemical Measures

Chemical measures to improve saline-alkali land are mainly by adding modifiers to the soil, adjusting the pH of the soil, changing the reaction of the soil solution, improving the nutritional status of the soil and the composition of the adsorbed cations of the soil colloid, such as replacing Na^{+} with Ca^{2+}, changing the hydrophilic colloid to hydrophobic colloid, promotes the formation of aggregate structure, further improves soil structure, increases soil permeability, accelerates soil desalination, and prevents salt accumulation and salt return. At present, the chemical modifiers that are more researched are gypsum, humic acid, polyacrylamide, superphosphate, citric acid, etc. Some of these modifiers improve the growth of plants through the properties of the modifiers themselves, and use the life activities of plants to play a role in The role of soil improvement, some directly improve the basic physical and chemical properties of soil [15]. For example, gypsum can dissolve to produce Ca^{2+}, and Ca^{2+} has the function of increasing plant stress resistance. Plants absorb soluble Ca^{2+} in the soil to enhance their salt resistance; increasing the application of calcium-containing fertilizers can improve the viability and disease resistance of plants in a saline environment.

3.4. Engineering Measures

The engineering measures include leveling the land, establishing a perfect drainage and irrigation system, replacing the soil, deep ploughing and improving the soil, leaching the soil layer and silting, etc., and using engineering methods to control the saline-alkali land. In the coastal area, the allowable depth theory is selected as the guiding basis for laying salt discharge pipes, and traditional engineering is used to improve the saline-alkali soil. Establish buried deep and shallow pipelines and shallow-dense salt drainage systems in saline-alkali areas, form hidden pipes to achieve horizontal drainage, and improve saline-alkali land in coastal areas. The soil salinity content in the shaft drainage area showed a downward trend, with a decline rate of 52%. In the area without shaft drainage, the soil surface returned to salt, and the soil salinity content increased by 41%, which has a positive effect on alleviating salinity. Shi [16] combined well irrigation and well drainage with channel drainage, extracting salt water from the soil to supplement fresh water in the rainy season, increasing the space occupied by groundwater, increasing the soil infiltration rate during the flood season, and accelerating soil desalination.

4. Summary and Prospect

With the development of modern production technology, there have been a variety of improvement methods for saline-alkali land, such as water conservancy improvement, biological improvement, agricultural improvement, and chemical improvement, and each has its own advantages and disadvantages. Although chemical improvement measures can quickly change soil structure, they may also bring about secondary pollution; plant and biological improvement measures are slow to take effect and have a long cycle. Due to the different regional distribution of saline-alkali land, different geological conditions, climate differences and other factors. Due to the different geochemical characteristics of saline-alkali soils, it is necessary to take improvement measures of adjusting measures to local conditions and comprehensive prevention and control for saline-alkali land with different soil qualities and regions.

With the advancement of saline-alkali land improvement technology and the promotion of new methods at home and abroad, the sustainable development of saline-alkali land has been gradually realized. In the utilization of saline-alkali land resources, one should not be blind, but should have a comprehensive new understanding of saline-alkali land resources, consider from the perspectives of halophyte resources, saline soil resources, brackish and fresh water resources, etc., and apply relevant water conservancy and hydrology knowledge to practice operate. In the future, various methods should be used for joint improvement, such as the combination of plants and microorganisms, the combination of chemical amendments and agricultural measures, the combination of chemical improvement and engineering measures, and the combination of plant improvement and chemical amendments.

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