ISSN: 2688-8645

Study on Ecological Restoration Technology of Mine Wasteland

Na Wang[1, 2, 3, 4], Yuhu Luo[1, 2, 3, 4]

[1]Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China

[2]Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China

[3]Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, Xi'an 710075, China

[4]Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an 710075, China

Abstract

Mining destroys the environment and occupies arable land, causing serious social problems. In recent decades, land reclamation and ecological restoration of mine wasteland have become a hot topic of interdisciplinary research. However, compared with developed countries in Europe and America, China's mine wasteland work has the characteristics of low land reclamation rate and poor reclamation quality. This paper discusses the soil reconstruction technology, physical and chemical improvement technology and vegetation restoration technology of land reclamation. At the same time, it is believed that the research on the ecological environment impact mechanism of mine wasteland should be strengthened. In the later stage, modern advanced technologies, such as 3S technology and information system technology, should be used to assess and supervise the reclamation work, and strive to achieve the technical breakthrough in the environmental damage mitigation of mine wasteland, and establish the theoretical system and technical specifications for the reclamation and ecological restoration of mine wasteland.

Keywords

Land Reclamation and Ecological Restoration of Mine Wasteland; 3S Technology; Information System Technology.

1. Introduction

Mineral resources are the material basis of industrial and agricultural production, and the intensity of mining has also increased rapidly with population explosion and social development. Mining is currently the largest organized human activity that changes land use patterns and damages terrestrial ecosystems [1]. More than 93% of China's primary energy, more than 80% of industrial raw materials, and more than 70% of agricultural means of production use mineral products as raw materials [2]. There are more than 8000 state-owned large and medium-sized mining enterprises and 230000 small mines in China. The mining of large and large-scale mines has caused serious damage to the land and ecological environment [3]. According to the report [4-6], by the end of 2005, the area of land damaged by mining activities in China had reached 4 million hm^2, including 1.06 million hm^2 of forest and 2.63 million hm^2 of grassland. Since the 1980s, great progress has been made in mine management in China, and the reclamation coefficient of abandoned land has increased from 5% to 12% at present; However, this figure is far lower than that of developed countries, and still increases at the rate of 33000~47000 hm^2 per year [7].

ISSN: 2688-8645

In response to the call of the national "green mine" construction, while drawing on foreign experience in mine mining, adhering to the concept of ecological environment protection, low-impact development, and sustainable land use, most mines have adopted a new mining mountain construction mode of "mining, treatment, and recovery at the same time", gradually developing towards the integration of "stripping mining, ore discharge and recovery". For open-pit mines, the process of combining pre-mining prevention and mining loss reduction has gradually been widely valued and reasonably applied in mine construction, which makes the entire mining process and post-mining landform reconstruction can be organically combined, and at the same time, it also creates favorable conditions for subsequent soil and vegetation restoration. The pH value of the soil in the mining area is low, the solubility of heavy metal ions is increased, and the rainfall overflow further pollutes the surrounding soil. Heavy metals enter the food chain and cause serious direct harm to human health. Mining causes the destruction of landform and landscape fragmentation, changes the original local water circulation process, and destroys the infiltration process of surface runoff and the flow direction of groundwater. Mining activities lead to the disappearance of biological habitat and the reduction of species diversity. The destruction of the surface vegetation and the disorder of the water system in the mining area can easily induce secondary environmental disasters such as debris flow, flash floods, sandstorms and desertification. Mining not only destroys and occupies a large number of land resources, but also has a lasting and serious negative impact on the ecological environment, directly endangering human health and the sustainable development of mining industry. In almost all cases, mining activities have exceeded the resilience tolerance limit of the ecosystem, and it takes 100 to 1000 years to rely on the restoration of mine waste land by its own succession; Therefore, the artificial intervention of land reclamation and ecological reconstruction of mine wasteland has become a very necessary means of environmental protection [1]. At present, the reclamation and ecological restoration of mining wasteland has become a topic of common concern and interdisciplinary research focus of all countries in the world, and has increasingly received widespread attention.

2. Land Reclamation and Restoration Technology of Mine Waste Land

The mine wasteland is seriously degraded, extremely barren, with excessive content of harmful elements and poor physical properties. Based on this, the natural succession of the ecosystem is carried out. The improvement of soil, vegetation and water system conditions by artificial means is the prerequisite for further bioremediation, water treatment and agricultural and forestry utilization.

2.1. Soil Reconstruction

The key problem of ecological restoration of mine wasteland is the reconstruction of soil matrix. Bioremediation can only be carried out if the soil aggregate structure, pH and water and fertilizer holding capacity are properly repaired. The purpose of soil reconstruction is to rehabilitate and reconstruct the damaged land in the industrial and mining areas, and comprehensively use engineering measures and physical, chemical, biological and ecological measures to reconstruct appropriate soil profiles and physical and chemical properties.

2.2. Physical Improvement

The physical improvement measures of mine waste land include soil dumping, soil replacement, topsoil removal, guest soil and deep ploughing. Different methods can be selected according to the specific conditions, funds and restoration objectives of the mining area. Before surface disturbance, the soil shall be removed and stored in layers, so that the physical structure, nutrient elements, plant seed bank, soil microorganism and soil animal in the soil will be least affected. After the completion of the project, the soil will be transported back to the original

ISSN: 2688-8645

place in layers for use. This method has become the standard procedure for mine environmental protection at present. Soil structure refers to the arrangement and combination of soil particles and the size of soil particles in different depths of soil layers. Loose soil structure is very important for the growth of plant roots. Plants can make their roots fully penetrate in the vertical and horizontal directions in the frit soil matrix, so as to obtain sufficient water and nutrients. The looseness and compactness of the soil structure can be achieved by replacing the topsoil. The soil in the mine wasteland is relatively compact. Before bioremediation, the soil density and aggregate structure should be changed by deep ploughing, and then the soil chemical properties and fertility can be improved by stripping, crushing, fixing and irrigation. If the waste land is seriously polluted, the soil layer is too thin, or even some of the waste land has no soil layer at all, it is necessary to cover the waste land with guest soil. The key of the guest soil method is to find the soil source and determine the thickness and mode of the cover.

2.3. Chemical Modification

Most of the mine wasteland has acid-alkali tendency. For alkaline waste land, $FeSO_4$ and bisulfate should be used to improve it. $CaSO_4 \bullet H_2O$ can replace the sodium ions in the soil into calcium ions to reduce the degree of soil salinization, thus enhancing the permeability of water in the soil and improving the soil matrix. For acid waste land, quicklime or carbonate can be put into the soil for neutralization. The solubility of heavy metal hydroxide is second only to sulfide. Adding lime to the soil can make heavy metal form hydroxide. At the same time, the increase of pH value will lead to the co-precipitation of calcium and heavy metal ions, effectively reducing the mobility of heavy metals in the soil and their enrichment in plants. Organic substances such as sawdust, compost, green garbage, manure and organic sludge can increase the pH value of soil, and can improve soil structure, water holding capacity and cation exchange capacity [8]. Laying 20 cm thick garbage and 20 kg/m^2 lime on the waste land can effectively prevent the acidification of tailings, and the presence of Ca^{2+}can alleviate the toxicity of heavy metal cations.

Most of the mine wasteland lacks nutrients such as N, P, K and organic matter, which is one of the main limiting factors for plant growth. Land reclamation areas used for agriculture or other intensive use generally need to maintain the soil fertility. Relevant research [9] shows that sawdust can improve the survival rate of trees, non-grass herbs and shrubs. The role of soil fertilizers such as N, P, K or lime is increased by applying wood chips containing nitrogen. Most of the nitrogen needed by plant or soil biological communities comes from biological nitrogen fixation and subsequent mineralization of organic nitrogen. Urban sludge is the solid waste produced in the process of sewage treatment by urban sewage treatment plants. In addition to rich N, P, K and organic matter, urban sludge has strong physical properties such as viscosity, water retention and water retention, so it is a good filler for soil reclamation in mining areas.

Organic carbon provides an energy source for metabolism of soil microorganisms. Microorganisms obtain organic carbon through symbiosis with host plants or through decomposition and decay of animals and plants in soil. Supplementing bark or ryegrass (Lolium perenne L) to the soil can provide sufficient organic carbon for soil bacteria to promote its metabolism. For example, Dalbergia sissoo can increase soil water and organic carbon as well as N, P, K content [10]. The increased level of organic carbon is related to the intensity of accumulation and decomposition of deciduous layer into humus.

2.4. Vegetation Restoration Technology

Vegetation restoration technology is based on the basic principles of restoration ecology, environmental ecology, landscape ecology, ecological engineering, botany, soil and fertilizer science and other disciplines. Through the construction of pioneer plant communities, relying on the natural succession of the community to gradually improve its resistance to external interference and resilience, finally establish a stable and healthy plant community, give full play to its ecological functions, and achieve slope stability The purpose of maintaining biodiversity

ISSN: 2688-8645

and improving the environmental quality of the restoration area. The key of vegetation restoration technology is to first solve the problem of "no standing place" for plants, build a stable site condition suitable for the growth of ecological restoration vegetation, and change the unfavorable factors such as no soil or less soil on the slope, poor water and heat safety, plants can not take root, and large temperature change. The reconstruction of these human-controlled environmental factors is described as the reconstruction of plant habitat.

According to the extreme environmental conditions of the wasteland, the selection of plant species should follow the following principles. 1) Priority should be given to the species with easy seeding, high seed germination rate, good resistance to stress, poor resistance, acid and alkali resistance, heavy metal resistance, good adaptability, developed root system, rapid growth and high survival rate. 2) Priority should be given to tree species that can improve soil organic matter and soil physical and chemical properties. 3) Local species are preferred, and excellent indigenous species and pioneer plants are selected as far as possible. 4) When considering economic benefits, we should also consider the various properties of plants, including drought resistance, flood resistance, wind and sand resistance, and disease and pest resistance. 5) Herbaceous plants can be used as protective plants in the initial stage of vegetation restoration process, especially C4 herbaceous plants have strong adaptability to drought, low soil nutrients and climate pressure [11]. Gramineae and Solanaceae have strong tolerance to lead-zinc slag, and Imperata cylindrica (Linn.) Beauv., Polygonum hydropiper, Pennisetum centratiatum Tzvel, Adiantum capillaris, etc. can be selected as pioneer plants.

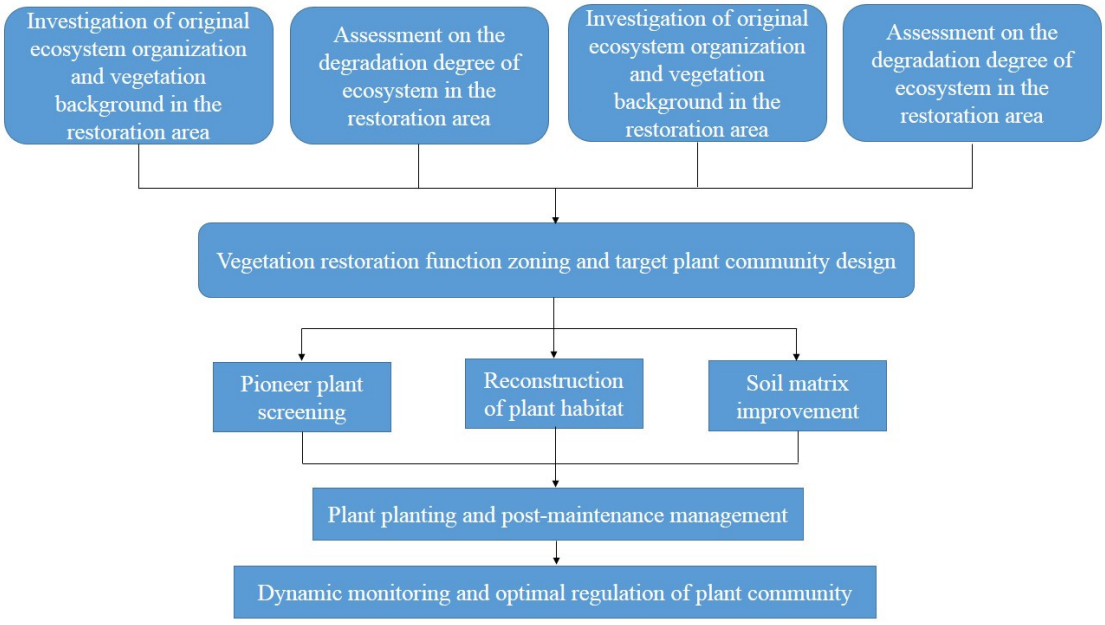

Figure 1. Technical system of slope vegetation restoration in mine wasteland

3. Suggestions

China's land reclamation work started late. Although it has made great progress in recent years, the reclamation rate is still low, and there is a large gap between China and developed countries. Promoting the reclamation of abandoned land in mines is not only one of the effective ways to ensure the realization of the goal of 120 million hm^2 cultivated land protection, but also of great significance to improve the ecological environment of China and improve people's living standards. Land reclamation and ecological restoration of mine wasteland involves multi-disciplinary and multi-sectoral work, and is a complex system project, which requires scientific

ISSN: 2688-8645

and reasonable institutional arrangements and financial and technical support. On the whole, China's land reclamation of mine wasteland lacks macro-management planning and coordination institutions, and there is no clear source of reclamation funds, and there is no specific measures to ensure the scientific and technological innovation of land reclamation. Strengthen the research on the ecological and environmental impact mechanism of mine wasteland, adopt 3S technology and information system technology to monitor, evaluate and supervise the reclamation work, strive to achieve the technical breakthrough of environmental damage mitigation of mine wasteland, and establish the theoretical system and technical specifications of mine wasteland reclamation and ecological restoration.

Acknowledgments

The project was supported by the projects of Land Engineering Construction Group of Shaanxi Provincial (DJNY2022-20).

References

[1] Li Mingshun, Tang Shaoqing, Zhang Xinghui, et al. Practice and countermeasures of ecological restoration of metal mine wasteland [J]. Mining safety and environmental protection, 2005,32 (4): 16-18.

[2] Sun Jun. Main problems and countermeasures of mine environment restoration and treatment in China [J]. China's geology and mineral economy, 2003(10):30-32.

[3] Wang Yinghui, Chen Xuejun. Ecological restoration technology of metal mine wasteland [J]. Metal mine, 2007(6):4-12.

[4] Li Haiying, Gu Shangyi, Wu Zhiqiang. Research progress in reclamation technology of mine waste land [J]. Mineral engineering, 2007,5(2):43-45.

[5] Wang Jingjing. Study on ecological restoration and sustainable development of metal mine wasteland [J]. Anhui Agricultural Science, 2010, 38(15):8082-8084.

[6] Qin Gaoyuan, Zhou Yue, Guo Guangjun, et al. Research progress of mine ecological restoration [J]. Yunnan Environmental Science, 2006, 26(4):19-21.

[7] Shi Shujing, Li Huizhuo. Study on the current situation of land reclamation in coal mining areas in china [J]. Anhui Agricultural Science, 2010(10):5262-5263.

[8] Tordoff G M, Baker A J M, Willis A J. Current approaches to the revegetation and reclamation of metalliferous mine wastes [J]. Chemosp Here, 2000,41(1-2) : 219-228.

[9] Sheoran V, Sheoran A S, Poonia. Phytomining: A review [J]. Minerals Engineering, 2009,22(12) : 1007-1019.

[10] Maiti S K, Ghose M K. Ecological restoration of acidic coal mine overburden dumps: an Indian case study [J]. Land Contamination and Reclamation, 2005,13 (4) :361-369

[11] Liu Yingqin. Study on vegetation restoration technology of mine wasteland [J]. Hunan nonferrous metals, 2010,26(4):50-53.