Countermeasures for Ecological Environment Restoration of Pumped Storage Power Stations in Northern Stone Mountain Areas

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Abstract : Due to the lack of analysis of the actual ecological environment of pumped storage power stations, it is difficult to achieve the ideal restoration effect. Therefore, a study on ecological environment restoration strategies for pumped storage power stations in northern rocky mountainous areas is proposed. Starting from the actual situation of slopes in different areas of the pumping and storage power station in the rocky mountainous area, targeted analysis was conducted on specific types and characteristics. With the help of the ecological environment degradation level evaluation system, objective analysis was made on the specific situation. Combining vegetation coverage, soil erosion, stream conditions, and biodiversity, the ecological environment restoration needs of the pumping and storage power station slope in the rocky mountainous area were determined, And it was used as the execution benchmark for plant variety selection, and targeted remediation plans were set up based on different basic environmental conditions. In the test results, the vegetation coverage on the slope of the pumped storage power station has significantly increased. After one year of construction, the Shannon Wiener index of vegetation community biodiversity has increased from 0.446 to 0.535, corresponding to a 20% increase.

Keywords: Northern rocky mountainous areas; pumped storage power station; ecological environment restoration; the degree of ecological environment degradation; repair requirements; variety selection; repair plan;

1 Introduction

For pumped storage power stations, their damage to the ecological environment is inevitable. The specific analysis of them is mainly reflected in the following aspects. Firstly, pumped storage power stations usually require the construction of upper and lower reservoirs, which will change the living environment of existing aquatic and terrestrial organisms and disrupt local ecological balance. At the same time, the decrease in water flow velocity upstream of the reservoir can lead to a series of problems, such as reduced dissolved oxygen, sediment deposition in the reservoir, eutrophication of water bodies, decreased water quality, and changes in local microclimates[1]. Based on the above analysis results, it is crucial to

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minimize the excavation of mountain slopes and take appropriate measures to prevent soil erosion during the ecological environment restoration of pumped storage power stations. On this basis, different governance methods need to be adopted according to the characteristics of different ecological environments, such as zoning governance in the surrounding areas of the reservoir, and repairing different biological species and ecological environments. During the construction process, timely ecological restoration is necessary to minimize damage to the ecological environment [2-3]. Special attention should be paid to the coordination and cooperation with local governments, village committees, environmental protection departments, and other parties in the construction of pumped storage power stations and the restoration of the ecological environment, in order to jointly promote the restoration of the ecological environment. After the completion of ecological environment restoration work, long-term monitoring is required to ensure effective restoration of the ecological environment. In response to this, research on ecological environment restoration based on spatial production theory has received widespread attention [4-5]. It focuses on the restoration of the ecological environment in the Yangtze River Basin, and combines the administrative weakening of ecological environment restoration in the vertical space, as well as the constraints of subordinate attributes and single factor space in the horizontal space. Based on spatial relations and spatial theory, it reconstructs spatialism, The spatial production theory, created with the core of the ternary spatial dialectics, explores the power operation, rights allocation, organizational mechanism, and spatial structure of ecological environment restoration in the Yangtze River Basin, achieving a spatial shift in the concept of ecological environment restoration in the Yangtze River Basin, balancing the spatial balance of subject rights and responsibilities, constructing a standardized and coordinated spatial structure, and constructing an evaluation system. However, it is difficult to achieve in the specific implementation stage. The research on ecological environment restoration and governance based on a cement limestone mine in Henan Province is also one of the typical research achievements in the field. After fully considering the historical legacy issues of mineral resource mining and the optimization of relevant policies and standards, effective measures have been proposed for specific problems, providing effective reference value for similar mine governance. However, from a more macro perspective, Its application has certain limitations.

On this basis, this article proposes a study on ecological environment restoration strategies for pumped storage power stations in northern rocky mountainous areas, and conducts application testing based on the actual geological environment. It is also hoped that the design and research of this article can provide reference and reference for other similar projects.

2 Design of ecological environment restoration measures for pumped storage power stations

2.1 Analysis of the degree of ecological environment degradation in the disturbed area of the slope of the pumped storage power station

Before repairing the ecological environment of the pumped storage power station, it is necessary to objectively evaluate the degree of ecological degradation in the disturbed area of the slope of the basic pumped storage power station. In response to this, this article starts with the actual situation of slopes in different areas of pumped storage power stations in rocky mountainous areas [6-7], and conducts targeted analysis on specific types and characteristics.

In general, the slopes of pumped storage power stations in rocky mountainous areas are usually composed of rocks, soil, and vegetation. Based on geographical location and rock type. On this basis, the corresponding slope types can be divided into the following four types:

(1) Gneiss slope: Gneiss is a common stone slope with obvious bedding and easy peeling characteristics. This type of slope usually requires support and reinforcement to prevent collapse and landslides.

(2) Granite slope: Granite is a hard stone slope with high stability. However, the surface of granite slopes is usually rough and prone to accumulation of dust and dirt, which affects plant growth.

(3) Limestone slope: Limestone is a relatively fragile rock slope that is prone to collapse and fragmentation. In the construction of pumped storage power stations, it is necessary to reinforce and protect the limestone slope to prevent soil erosion and landslides.

(4) Soil slope: Soil slope is one of the most common slope types in pumped storage power stations in rocky mountainous areas. Due to the susceptibility of soil to erosion and landslides, it is necessary to support and reinforce soil slopes.

Based on the above analysis results of slope types and characteristics in different areas of the pumping and storage power station in rocky mountainous areas, this article analyzes the impact pathways and characteristics of slope excavation activities on the original ecological environment according to the vegetation site conditions of different types of slopes [8-9]. The specific analysis results are shown in Table 1.

Table 1. Impact pathways and characteristics of slope excavation activities of pumped storage power stations in rocky mountainous areas on the original ecological environment

Slope type	Vegetation site conditions	Impact t	Impact characteristics
Gneiss slope	Usually poor, with sparse existing vegetation	Destroy existing vegetation, accelerate soil erosion, and affect the balance of the ecosystem	Change the existing microtopography and stream conditions
Granite slope	Relatively good, but with high surface roughness, which is not conducive to vegetation growth		Change the existing microtopography and stream conditions
Limestone slope	Usually poor, prone to disintegration and fragmentation		Change the existing microtopography and stream conditions
Soil slope	Relatively good, but the soil is susceptible to erosion and landslides		Change the existing microtopography and stream conditions

Based on Table 1, it can be seen from the analysis of the impact pathways and characteristics of slope excavation activities on the original ecological environment of the pumping and storage power station in rocky mountainous areas that the vegetation site conditions of different types of slopes vary significantly. However, the impact pathways of the pumping and storage power station in rocky mountainous areas on the original ecological environment are mainly carried out by destroying vegetation and changing the original microtopography and stream conditions.

Therefore, the evaluation system for the degree of ecological environment degradation in the disturbed area of the pumped storage power plant slope constructed in this article aims to comprehensively evaluate the impact of slope excavation activities on the original ecological environment in rocky mountainous areas. A specific evaluation system for the degree of ecological environment degradation is shown in Table 2.

Table 2. Evaluation System for the Degree of Ecological Environment Degradation in the Disturbed Areas of the Slope of the Pumped Storage Power Station

Number	Evaluation Index	Evaluation Content
1	Vegetation coverage	The vegetation coverage on the slope, including species, quantity, and growth status
2	Soil erosion situation	The degree and trend of soil erosion on slopes, including soil erosion, rock erosion, etc
3	Microtopography change	The situation of micro terrain changes on the slope, including terrain height, steep and gentle slopes, etc
4	Stream conditions	The condition of streams near the slope, including flow rate, water quality, etc
5	Biodiversity	Biodiversity around the slope, including species numbers, ecological balance, etc

According to the method shown in Table 1, this article divides the degree of ecological environment degradation on the slopes of pumped storage power stations in rocky mountainous areas into three levels:

(1) No degradation: high vegetation coverage, slight soil erosion, minimal micro terrain changes, good stream conditions, and rich biodiversity.

(2) Mild degradation: vegetation coverage is low, soil erosion has increased, micro terrain changes are significant, stream conditions are average, and biodiversity is affected to some extent.

(3) Moderate degradation: low vegetation coverage, severe soil erosion, and significant micro terrain changes.

According to the above method, objective analysis of the degree of ecological environment degradation of the slope of the pumped storage power station in rocky mountainous areas is achieved, providing a reliable basis for the design of subsequent ecological environment restoration strategies for pumped storage power stations.

2.2 Ecological environment restoration of pumped storage power stations

Based on the above analysis results, targeted design should be carried out in the specific stage of ecological environment restoration for pumped storage power stations, taking into account the specific situation. Therefore, this article is based on the vegetation coverage, soil erosion, stream conditions, and biodiversity of the slope of the pumping and storage power station in rocky mountainous areas [10]. When analyzing the specific ecological environment status of the slope of the pumping and storage power station in rocky mountainous areas, the calculation method can be expressed as follows:

$$P = \frac{\sum s_i m_i * \lambda}{S} \quad (1)$$

Among them, P represents the vegetation coverage parameter of the slope of the pumped storage power station in rocky mountainous areas, s_i represents the coverage area of i-type vegetation on the slope, m_i represents the number of type vegetation on the slope, λ represents the growth status (stage) of vegetation on the slope, and S represents the total area of the pumped storage power station slope in rocky mountainous areas.

$$D = \frac{\sum K e_K}{S} \quad (2)$$

Among them, D represents the degree of soil erosion on the slope of the pumped storage power station in rocky mountainous areas, K represents the current coefficient of soil erosion and rock erosion, and e_K represents the rate of change of soil erosion and rock erosion coefficients. This parameter is the average value of changes in soil erosion and rock erosion coefficients over a certain period of time.

$$E = \frac{\sum H e_H}{S} * \frac{\sum J e_J}{S} \quad (3)$$

Among them, E represents the micro terrain changes of the slope of the pumped storage power station in the rocky mountainous area, H and J represent the current terrain height parameters and slope gradient parameters of the slope, respectively, e_H and e_J represent the terrain height parameter change rate and slope gradient parameter change rate of the slope.

$$X = \frac{\sum L e_L}{S} * \sum Q e_Q \quad (4)$$

Among them, X represents the stream condition of the slope of the pumped storage power station in the rocky mountainous area, L and Q represent the current flow and water quality parameters of the slope, respectively, e_L and e_Q represent the rate of change of the flow and water quality parameters of the slope.

$$T = \frac{\sum n f(s)}{S} \quad (5)$$

Among them, T represents the biodiversity of the slope of the pumped storage power station in rocky mountainous areas, n represents the number of species on the slope, and $f(s)$ represents the ecological balance coefficient of the local slope area.

Based on the calculation methods shown in equations (1) - (5) and the actual situation on site, the selection of plant varieties for ecological restoration stage should be considered.

For the area with poor vegetation site conditions, adopt the method of taking soil nearby according to local conditions, and take the soil with physical and chemical properties similar to mine soil, which should be clean, dry and free of any impurities as the basis for spray seeding. It should be noted that organic substances (such as humus soil, mixed fertilizers, sawdust, husks, etc.) should be applied to increase the nutrient content of the land, improve the permeability of the land, improve the physical and chemical properties of the land, and provide favorable ecological conditions for the normal growth of crops. During the construction process, materials rich in organic matter and clay are used, with the addition of high grade aggregate agents. At the moment of spraying, physical and chemical reactions occur with the air, inducing reactions between the aggregates, forming a high-strength, erosion resistant substrate that can ensure the normal growth of vegetation.

For slopes with unstable structures and mostly potholes on the surface, there are abundant scattered stones. Firstly, fill the potholes and slopes with stones, waste soil, etc., compact them in layers, and lay cohesive soil layers as anti leakage treatment. Then, cover the slope with soil and plant vegetation. Plants such as purple locust and brocade can be planted using artificial slope construction technology. When the stones and waste soil are insufficient, lattice slope protection and greening technology can be used for vegetation construction and slope protection technology.

For slopes with steep slopes and safety hazards, it is necessary to use mortar masonry or steel bars to build frame beams of different shapes on the slope according to a certain shape, and use anchor cables or anchor rods to reinforce them. Then, in the frame, pile up straw bags filled with planting soil, use plastic or metal nets to fix the straw bags, and finally, use dry spraying, The base layer containing straw decomposition agents and the surface layer containing plant seeds can be mixed with grass seeds such as purple locust and shrub seeds such as broccoli.

For steep slopes with unstable overall structure and weak stability, due to weak water and fertilizer retention capacity, there is a risk of landslides and difficulty in vegetation construction. Therefore, first clean the slope surface, remove stones that pose safety risks, then clean the pumice and dangerous rocks on the slope, and then level the area of the site

Greening with soil cover can be achieved by using green barrier blocking technology. Planting trees such as Platycladus orientalis and Pinus tabulaeformis at the foot of the slope, shrubs such as Caragana korshinskii and Amorpha fruticosa at the bottom, and vines such as Parthenocissus on the slope surface to coordinate with the surrounding environment.

3 Application testing

3.1 Overview of testing environment

During the specific testing process, comparative testing was conducted based on an actual water storage power plant. Analyze the basic situation of the water storage power station, and its specific engineering characteristics are shown in Table 3.

Table 3. Engineering Characteristics of Water Storage Power Station

Number	parameter	configuration
1	Control basin area/km^2	1915
2	Check flood level/m	276
3	Flood storage capacity/m^3	6.08*109
4	Normal water storage level/m	256
5	Normal storage capacity/m^3	3.06*109
6	Dam crest height/m	726.3
7	Dam crest length/m	604
8	Maximum dam height/m	105.4

The water storage power station is located in the warm temperate zone and belongs to a typical monsoon climate zone. In winter, it is controlled by the polar continental climate, which is cold with little rain and snow. In spring, it is affected by the variable continental air masses, with little precipitation and the prevalence of northerly or westerly winds. The evaporation is large, often resulting in dry weather; In summer, the position of the Pacific subtropical high ridge shifts northward, and the climate on the southwest and southeast oceans is transported to this basin, becoming the main precipitation season; In autumn, the southeast monsoon weakens, and the continental air masses in the polar regions gradually strengthen, transitioning from rainy weather to a cool and dry autumn season with little rain.

On this basis, the geological composition of the slope of the water storage power station is analyzed. The thickness of the shale and shale intercalated with limestone is about 17 meters, with a bottom of purple red shale and an upper part of limestone intercalated with shale. The structure is characterized by layered fragmentation and layered structure, with a relatively hard texture and a top exposed height of 195 meters; The medium thick limestone formation has a hard lithology and a block like structure. It is pink layered limestone with a maximum thickness of about 15m, and its bottom plate is exposed at an elevation of 195m; The lithology of the shale rock formation is easily weathered, with most of it weathered into fragments and some parts weathered into mud. The exposed elevation of its bottom plate is 225m; In the interbedded rock group of shale and limestone, the shale is purple red in color, and the limestone is medium thick layered with a small amount of thin layer in shape. The lithology is relatively weak, mostly in a layered structure or layered fragmented structure, and the exposed elevation of the bottom plate is about 260m; The thick limestone formation consists of medium thick layered oolitic limestone and leopard skin limestone, with hard rocks and a bottom exposed elevation of 300m.

On this basis, ecological environment restoration strategies based on spatial production theory and ecological environment restoration strategies based on factor optimization were used as the control group for comparative testing.

3.2 Test Results and Analysis

When analyzing the test results, the development of vegetation coverage on the slope of the water storage power station during the target period was first counted, and the obtained test results are shown in Figure 1:

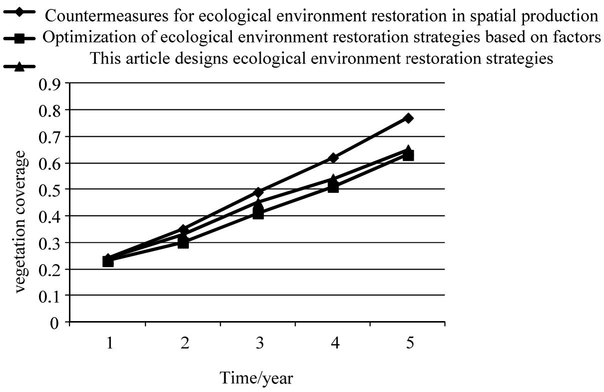

Figure 1. Comparison of the development of vegetation coverage on the slope of a hydropower station

Based on the test results shown in Figure 1, it can be seen that under the three ecological environment restoration strategies, the ecological environment restoration strategy designed in this article corresponds to the best development of vegetation coverage on the slope of the water storage power station. As of the fifth year of ecological environment restoration, the corresponding vegetation coverage rate has reached 0.77.

The improvement of the Shannon Wiener index of the restored vegetation community after one year of construction compared to the native vegetation community is shown in Figure 2.

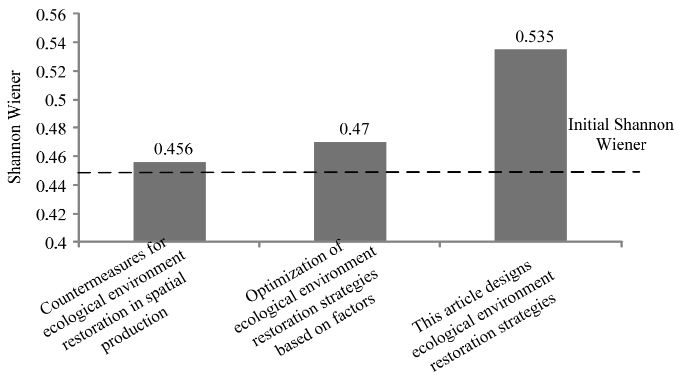

Figure 2. Comparison of Shannon Wiener Index of Vegetation Community Biodiversity Restoration after 1 Year of Planting

Based on the information shown in Figure 2, it can be seen that under the ecological environment restoration strategy designed in this article, the Shannon Wiener index of vegetation community increased from 0.446 to 0.535 after one year of planting, corresponding to a 20% increase, which is obviously due to the control group.

4 Conclusion

This article proposes a study on ecological environment restoration strategies for pumped storage power stations in northern rocky mountainous areas. Starting from the actual situation of slopes in different areas of pumped storage power stations in rocky mountainous areas, the vegetation site conditions and degree of ecological environment degradation of the slopes were objectively analyzed. Targeted restoration strategies were designed based on specific situations, greatly improving the effectiveness of ecological environment restoration. With the help of the research and design in this article, it is also hoped to provide reference value for the ecological environment restoration of actual pumped storage power stations.

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