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Study on Environmental Management and Ecological Restoration of Coal Mine Wasteland

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The purpose of this study is to improve the ecological environment of coal mine wasteland and promote the transformation of coal industry. To this end, this paper studies the environmental management and ecological restoration of coal mine wasteland. Through reviewing the literatures, the relevant concepts were clarified. Then, combined with the experience of ecological restoration and landscape design in domestic coal mine wasteland, Huainan Coal Mine was taken as the research object, and ecological restoration and landscape design were conducted according to the coal mine location and the land use scale. This can help to realize the industrial landscape innovation of coal mine wastelands and the protection of natural ecological conditions, which is of great significance for balanced development of the natural ecology and human ecology in coal mine wastelands.

1. Introduction

The mining industry is an important force in promoting the development of the national economy, but it also causes serious pollution to the ecological environment around us. Coal mining, as a pillar industry of the national economy, is an important social asset. According to statistics, China's coal mining reserves rank third in the world. However, the ecological environment problems such as subsidence area and land subsidence in the gob area have also attracted people's attention, and they attach more importance to the environmental management and ecological restoration of coal mine wasteland. Thus, this paper discusses the environmental management and ecological restoration of coal mine wastelands based on previous studies. Through the literature review, the relevant concepts were clarified. Then, combined with the experience of ecological restoration and landscape design in domestic coal mine wasteland, Huainan Coal Mine was taken as the research object, and ecological restoration and landscape design were conducted according to the coal mine location and the land use scale.

2. Literature review

Yakun et al. pointed out that before the 1970s, most of the European and American countries reformed quarries, which were small in scale and less used in sustainable use design concepts. As environmental problems are gradually recognized, some regulations and theories have emerged one after another, providing a reference and measurement criteria for subsequent mine restoration (Yakun et al., 2016). Lima et al. pointed out that in the 1950s, the New York Central Park, built on a wasteland, incorporated the ecological theory into the design concept earlier. The impact of British natural squire landscape architecture on park landscape design was particularly evident. Frederick Law Olmsted, through training a variety of climbing and surface plants, such as shrub trees and vines, tried to show rich, extensive and mysterious effects on steep and fragmented terrain in a "pictorial" planting style. Central Park, known as "New York Backyard Garden", had a great influence on the ecological landscape restoration of abandoned wasteland in the 1970s based on outstanding ecological design concept and beautiful natural scenery (Lima et al., 2016). Venkateswarlu et al. pointed out that Buttes Chaumont Park, built in 1867 in France, transformed quarries and landfills into eco-natural parks and limestone in the matrix was preserved. Concrete and waste materials were used to imitate natural mountain topography, plant vegetation on a large scale and create the image with harmonious

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integration of natural scenery and artificial landscape, which provided a reference and demonstration for other countries to carry out mine restoration and reconstruction in the future (Venkateswarlu et al., 2016).
Kumar et al. used grey constellation clustering method to divide Mentougou coal mining area into ecological restoration area, ecological maintenance area and ecological conservation area, selected three indicators of ecological damage degree, population density and per capita income, and defined the restoration mode and direction of the three areas. Moreover, based on the results of the regionalization, they also guided the ecological agriculture restoration project (Kumar et al., 2017). Cele and Maboeta applied decision support methods to land evaluation and restoration planning. The results showed that the concept of the whole decision process was very simple, the enforceability was very strong, and it was easy to grasp the management steps (Cele and Maboeta, 2016). Saini et al. carried out ecological engineering reclamation planning and design for urban coal mining subsidence area, and designed nine reclamation zones including crop, vegetable planting area, solid waste filling reclamation and cultivation area, ecological agricultural park, deep water aquaculture area, crop reclamation area and shallow subsidence reclamation area, so as to achieve the purpose of improving economic efficiency as well as improving economic performance (Saini et al., 2016). Ranjan et al. also carried out land reclamation and ecological reconstruction planning for abandoned open-pit coal mines, including soil reconstruction and surface shaping. Meanwhile, leguminous forage was planted to fix nitrogen by plants and fly ash was applied to improve soil in order to accelerate soil maturation and improve soil fertility. In addition, there are Gushan Mining Area Ecological Construction Planning, Huaibei Mining Area Ecological Protection General Planning, Heidaigou Open-pit Coal Mine Land Reclamation and Ecological Reconstruction Planning and so on (Ranjan et al., 2017). Cross et al. sprayed a commercial seed mixture on the abandoned land of a city mining area in the semi-arid Mediterranean climate of central and Western Spain with a hydraulic seeder for vegetation restoration in the mining area. The results showed that it was inappropriate to use mixed plant species in the process of vegetation reconstruction in the abandoned mining area, and the local pioneer species needed to be verified in the future phytoremediation. It is essential to promote natural clustering in ecological restoration (Cross et al., 2018). Tripathi et al. believed that it is very necessary to check the effect of repair after surface mining. Usually, physical and chemical properties of soil are used as indicators to evaluate soil quality, but biological indicators of soil can better reflect the role of soil in providing ecological services (Tripathi et al., 2016). Buondonno et al. used the biological indicators of fauna in soil as the effect of restoration in the mining area after four years. They adopted four treatments, namely soil dispersal, soil dispersal + grass planting, soil dispersal + tree planting, and soil dispersal + grass planting + tree planting. The results showed that the effect of soil dispersal was the worst; soil dispersal + sowing grass and soil dispersal + planting grass + planting tree all cultivated the soil conditions of grassland; soil dispersal + planting tree treatment gave birth to a preliminary forest soil structure. In evaluating soil remediation, the number of groups, diversity of spring-worms and faunal structure are the most sensitive faunal parameters of soil fauna (Buondonno et al., 2018).
In summary, the above research work mainly studies the development course, management experience, methods and effects of environmental treatment and ecological restoration of abandoned coal mines, but few studies combine environmental treatment with ecological restoration. Therefore, based on the above research status, the environmental management and ecological restoration of coal mine wasteland are focused on. The basic principles and methods of environmental management and ecological restoration are put forward. Taking Tangshan City as an example, the characteristics and scope of abandoned land and activities in mining areas are determined from the perspective of space and time. Through environmental management and ecological restoration of abandoned land in coal mines, the local citizens' sense of identity and belonging can be greatly increased.

3. Principles and methods

Coal mine wasteland refers to the land damaged by mining activities, without being repaired after production, so that it cannot be used normally by people. The coal mine wastelands generated during the mining process mainly include open pits, tailings, dumping sites, subsidence sites, and the contaminated land that has lost economic value in mining. Its ecological impact is mainly produced from two aspects: the dumping area of solid waste, and the subsidence area of the coal mining area. Other ecological impacts are mainly caused by these two. The mining activities seriously affect the restorability of the local landscape ecosystem itself, even resulted in the degradation of ecosystem, e.g., the reduction or loss of biological and vegetation species diversity, the decreasing of ecosystem productivity, the violent invasion of exotic species due to changes in soil quality, and the increase of original native species in this area etc. As the damage intensifies, the balance and stability of the ecosystem have been changing, and the degree of damage continues to increase. In the mineral operation, the ecological landscape of the mining area is usually subjected to considerable damage. Before mining, it is forest, grassland or vegetation covered mountain. Once mining, the vegetation disappears,

the mountain is destroyed, the slag and garbage are piled up, and the native ecosystem is completely destroyed, eventually forming a land that is completely different or even inconsistent with the surrounding environment.

Tangshan City is an early coal mining base in China. With the resource depletion, it faces various serious geological and environmental problems. Tangshan Nanhu Park was built on the site of the original Kailuan Coal Mine. The large-scale mining caused the surface to sink, with total subsidence area of about 20,800 hectares, and different size of subsided land block was formed; the stable and unstable accumulated water area reached 2,093 hectares, and the newly added sinking land was gradually increasing by about 100 hectares per year. The abandoned land and collapsed areas caused by coal mining have seriously damaged the ecological environment of Tangshan Nanhu park and its surrounding areas.

For this, the main treatment method is the construction of artificial hill. The artificial hills built on the side of the huge garbage mountain covers an area of more than 80 meters from north to south and about 10 meters from the ground. The piles of high and low undulating mountains are like a retaining wall, which blocks the overflow of the garbage seepage. On this basis, the rubbish body was covered with compacted soil. The compacted surface layer is covered with high-quality soil for planting crops. The deciduous shrubs such as willow trees and torch trees are planted on the mountain. The wild native vegetation with strong vitality is also planted (Figure 1).

Figure 1: Garbage Mountain after the renovation of Tangshan Nanhu Park

Table 1: Tangshan Nanhu Park Design List

Designer	Tsinghua Planning and Design Institute	location	Tangshan City
Location	South of Hebei Centre	Time	1977
Original use	Kailuan Coal Mining Area	Size	1300 hectares
Approach	Treatment of sewage, treatment of abandoned land in sinking areas, reducing artificial buildings to retain large areas of animal and plant growth and habitat		
Design Features	Ecological Wetland Park, comprehensive recreation site, openness		

Regarding this wasteland in large sinking area, the method with the minimized cost and minimum pollution can be taken as follows: landfill of coal gangue and construction waste, greening of valuable soil, and creation of changeable landscape according to the actual situation in the area. The large-scale cultivation of trees, shrubs and aquatic herbs provides a good living environment for birds, insects and other organisms, and ultimately forms a good ecological environment for the entire park.

For Tangshan citizens, there aren't usually good leisure places and lack of wetland parks. Due to the uneven distribution of local precipitation seasons, the establishment of wetland parks has played a better role in regulation. The successful transformation of coal mining subsidence site into wetland parks can significantly promote the species diversity. It not only improves people's living environment but also their quality of life. Table 2 shows the design list of Tangshan Nanhu Park. Figure2 depicts the planning graph.

Figure 2: Botanical Garden Planning Plan

4. Results and analysis

The location, scope and land use scale of Huainan Coal Mine are shown in Table 2. At present, there are six coal mining subsidence lands in the whole mining area, five of which are unstable subsidence areas, and the other is stable land. In the high ground water level area, the section with collapse depth over 2 meters is accumulated with water all year round, causing large ecological changes. The original farmland cultivation area has been replaced by the collapsed water area. Table 3 lists the area of coal mining subsidence land.

Table 2: Location, scope and land use scale of Huainan coal mine

Location	North Central Anhui Province	Time	2009
Original use	Pan Xie New Mining Area	Size	1571km²
Approach	Treatment of sewage, treatment of abandoned land in sinking areas, reducing artificial buildings to retain large areas of animal and plant growth and habitat		

Table 3: Statistical Table of Coal Mining Subsidence Area in Mining Area

Subsidence area name	Gob area	Subsidence area
Nine major subsidence areas	7.24	13.52
Xie Li Sinking Area	14.18	20.01
Xinli Subsidence Area	17.71	23.62
Panji Subsidence Area	16.82	40.75
Zhangji Subsidence Area	5.32	17.93
Xinji subsidence area	7.23	16.99
Total	68.5	132.82

Based on this, in the function planning of general plan, the characteristics and scope of the wasteland and activities of the mining area should be determined from the perspective of space and time. The key areas of Huainan abandoned land design are solid waste yards and subsidence sites.

As an artificial ecological wetland park, the ecological landscape area can guide the natural wetland system to achieve a benign circulation state and exert the engineering effect of artificial wetland. At present, six large-scale coal mining subsidence lands in the city have been transformed into subsided lakes, providing a good landscape foundation for the construction of ecological wetland parks. An effective way combining urban and natural ecosystems is to build urban wetland parks. Location selection should be based on ecological restoration areas of coal mine wastelands with ecological resources on the edge of the city. On the one hand, it is a transitional buffer zone and protective barrier for the core protected areas of cities and wetlands; on the other hand, wetlands can regulate local climate and provide urban residents with more natural leisure and entertainment venues.

In terms of the selection for landscape plant species, the following principles should be followed. Proper trees in proper places: first the tree species that adapt to the local environment, strong stress resistance, and good growth should be selected; the selected vegetation in special plots should be able to degrade the heavy metal content in the poor soil. Species diversity: use of species and genetic resources is expanded, to improve species diversity and genetic diversity. Enriching plant ecotype and life form: on the basis of reasonable proportion, arbour, shrub, vine and Herb plants are comprehensively utilized. Vegetation in the mining area: According to the different mining conditions in the Huainan mining area, the appropriate tree species are selected. In the subsidence area, Salixaureo-pendula or fast-growing willow can be planted; re-cultivated land with better soil conditions can develop nursery, planting the seedlings such as boxwood, robinia idaho, cedar, etc.; for the poorly restored soil, fast-growing vegetation is dominated, and the ornamental plants with wood-producing value can also be selected properly, such as robinia idaho, ash, and Ailanthus Desf. For the solid waste yard, since the soil layer is thinner, vegetation with strong vitality and vitality can be planted, such as amorpha or Robinia pseudoacacia.

In addition to the selection of the landscape plant species above, the environmental conditions of the coal mine wasteland have their own particularities, so, care should also be taken to ensure safety, production and smooth flow of various pipes. If there are overhead lines, pipelines and underground cables nearby, the relevant regulations must be strictly implemented to determine the tree species and planting depth (Table 4).

Table 4: Spacing requirements for trees and overhead lines

Overhead line name	Horizontal distance	Vertical distance
Below 1KV	1	1
Below 1-20KV	3	3
Below 1-20KV	4	4
Below 1-20KV	5	5
Telecom line	2	2
Telecommunication overhead line	0.5	0.5

5. Conclusions

From the perspective of ecological restoration and landscape design, this paper studies the ecological restoration techniques and the effect of landscape planning design on ecological restoration in coal mine wasteland through the analysis for successful foreign and domestic cases. Besides, it explores the landscape planning and design of wastelands in Huainan Coal Mine. Based on the currently remodelled land, some negative features of the site haven't been obliterated or covered up; instead, they're turned into certain positive features through ingenious design, and becomes a regional feature. In the future transformation process, emphasizing on the industrial landscape features of the region on the basis of reasonable planning, it can greatly increase the sense of identity and belonging of local citizens.

It is foreseeable that the ecological restoration and landscape planning design of coal mine wasteland can receive people's more attention soon and it will become a new sub-discipline field. With the deepening of China's market economic system and more concerns about sustainable development issues, the cultural

heritage of the wasteland landscape will be protected, the characteristics and integrity of the landscape will be preserved, and various potential value of the abandoned land landscape will be explored.

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