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Study on Suitability Evaluation of Goaf Collapse Area in Shijiangpan Coal Mine

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Abstract

Land Reclamation suitability evaluation is the basis and premise to determine the utilization direction of land damaged by mineral exploitation after reclamation. Taking shijiangpan coal mine as the study area, combined with the characteristics of damaged land, this paper constructs the evaluation index system, and uses the index sum method to evaluate its suitability. The results show that sand content, soil bulk density and field water capacity have a prominent impact on the suitability grade evaluation; The reclamation area is moderately suitable for farming, gardening and forestry, and highly suitable for fishing and reclamation.

Keywords

Coal Mine; Goaf Subsidence Area; Reclamation Suitability Evaluation; Index Sum Method.

1. Introduction

China is a country with a large population and agriculture. Sufficient and high-quality agricultural land is an important guarantee for national and regional security and stability. Since the reform and opening up, with the rapid development of China's economy, the scale of development and utilization of mineral resources has expanded rapidly, and the problem of agricultural land damage has become more and more prominent, aggravating the contradiction between man and land [1-2]. According to statistics, the total area of land damage caused by mining in China exceeds 4 million Hm2, and the annual growth rate is 13000 hm2, which brings another huge pressure to the already tense protection of agricultural land resources in China [3]. Land reclamation is an important way to realize the balance between occupation and compensation of agricultural land, and it is also a science and technology vigorously developed by the country [4-6]. As a technical means to evaluate whether the damaged land is suitable for use and the degree of suitability after reclamation, land reclamation suitability evaluation is the basic basis for land reclamation decision-making, improvement way selection and scientific preparation of land use planning, and plays an important role in reclamation work [7-10]. Taking the coal mining subsidence area of shijiangpan coal mine as an example, this study uses the index sum method to evaluate the suitability of land reclamation of its damaged land, in order to provide theoretical support for the decision-making of land reclamation and the selection of land improvement ways.

ISSN: 1813-4890

2. Overview of the Study Area

Shijiangpan coal mine in Northern Shaanxi is open-pit mining, with a production scale of 2 million T / A. It is located on the side of the stonemason in Shigetai village, Daliuta Town, with geographical coordinates of 39 ° 22 ′ 59 ″ N and 110 ° 10 ′ 12 ″ E. The composition of mine land mainly includes open pit, stockyard, mine safety construction and development, office and living facilities in the mining area, ore crushing station, mine highway, temporary topsoil stacking site, etc. The total damaged area of mine land is 81.6864hm2, including 77.7989hm2 of excavated damaged land and 3.8875hm2 of damaged land. Including 28.3798hm2 of cultivated land, 47.4810hm2 of forest land, 2.4723hm2 of mining land, 3.2942hm2 of residential land and 0.0591hm2 of transportation land. The damaged land is distributed in the open pit of the west mine section, the mine highway of the west mine section, the land for office and living facilities, the ore crushing station, etc. Causing damage such as excavation and occupation. The land to be damaged in the mining area is distributed in the stope of the east mine section, the excavation of the mine highway in the east mine section and the occupation of the temporary stacking site of topsoil.

3. Evaluation Method of Vegetation Restoration Suitability

3.1. Selection of Evaluation Factors

Due to the large area of the evaluation area, many factors are considered. Considering the commonness under the particularity, the difference of ecological factors is mainly reflected in the difference of soil quality. According to the selection principle of evaluation factors, sand content, bulk density, organic matter, total nitrogen, available phosphorus, available potassium, pH value and field water capacity are selected as evaluation factors, which are processed and analyzed by correlation coefficient method.

Table 1. Suitability evaluation factors

Indicator name	Selection reason
Sand content	Affect water, fertilizer, gas and heat supply
Bulk density	It reflects the soil structure, tightness, porosity and biological activities in the soil, and affects the fixation and release of nutrient elements in soil aggregates
Organic matter	Reflect the supply of soil nutrients, regulate the dynamics of soil microorganisms and affect other physical and chemical properties
Total nitrogen	An important index to measure soil nitrogen supply
Available phosphorus	It reflects the storage and supply capacity of phosphorus in soil
Available potassium	Characterization of soil potassium supply
pH	It affects the growth of vegetation, the absorption of nutrients by vegetation, and the growth and reproduction of soil microorganisms
Field capacity	Reflect soil moisture status

3.2. Determination of Membership

The membership function is actually the expression of the functional relationship between the evaluation index and the crop growth effect curve. The evaluation of soil quality should first evaluate the advantages and disadvantages of each evaluation index. Because the advantages and disadvantages of each index are fuzzy and continuous, this study establishes the membership function to evaluate the advantages and disadvantages of each evaluation index.

The function formula is:

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$$f(X)=\begin{cases}0.1 & X \le X_1 \\ 0.9\times\dfrac{X-X_1}{X_2-X_1}+0.1 & X_1 \le X \le X_2 \\ 1.0 & X \ge X_2\end{cases} \quad (1)$$

Where X1 and X2 are the minimum and maximum values respectively.

3.3. Determination of Index Weight

In this study, the correlation coefficient method is used to determine the weight. The calculation method is to calculate the correlation coefficient between each single index first. The correlation coefficient of each factor is shown in Table 2.

Table 2. Correlation coefficient of each evaluation index

Evaluating indicator	pH	Sand content	Bulk density	Organic matter	Total nitrogen	Available phosphorus	Available potassium	Field capacity
pH	1							
Sand content	0.396	1						
Bulk density	0.256	0.375	1					
Organic matter	0.009	0.195	0.391	1				
Total nitrogen	0.143	0.392	0.109	0.000	1			
Available phosphorus	0.000	0.064	0.342	0.005	0.020	1		
Available potassium	0.000	0.267	0.372	0.000	0.000	0.000	1	
Field capacity	0.217	0.479	0.321	0.490	0.345	0.271	0.257	1

3.4. Determination of Comprehensive Value of Soil Quality

Soil quality is the comprehensive function of multiple evaluation indexes. In this study, according to the weight and membership of each evaluation index, the index sum method is used to calculate the comprehensive value of reclaimed soil quality. The calculation formula is as follows:

$$SQI = \sum_{i=1}^{n} K_i C_i \quad (2)$$

Where SQI is the soil quality index; Ki is the weight of the ith evaluation index, reflecting the importance of each evaluation index; Ci is the membership degree of the ith evaluation index, reflecting the advantages and disadvantages of each evaluation index; N is the number of evaluation indicators.

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4. Result Analysis

It can be seen from table 3 that among the eight evaluation indexes, the weight coefficient values of sand content, soil bulk density and field water capacity are greater than the average value of the weight of each evaluation factor, indicating that the weight of these three evaluation factors is large and has a prominent impact on the suitability grade evaluation, that is, the dominant and restrictive evaluation indexes affecting the reclamation of coal mining subsidence areas are sand content, soil bulk density and field water capacity.

Table 3. Weight of each evaluation index

Evaluating indicator	Average value of correlation coefficient	weight
pH	0.1459	0.0893
pH	0.3097	0.1896
Sand content	0.3094	0.1895
Bulk density	0.1557	0.0953
Organic matter	0.1441	0.0882
Total nitrogen	0.1003	0.0614
Available phosphorus	0.1280	0.0784
Available potassium	0.3400	0.2082

Calculate the membership degree of each index according to formula (1), as shown in Table 4.

Table 4. Membership degree of each evaluation index

Evaluating indicator	pH	Sand content	Bulk density	Organic matter	Total nitrogen	Available phosphorus	Available potassium	Field capacity
Membership degree	0.63	0.43	0.28	0.36	0.45	0.35	0.48	0.55

According to the actual situation of the subsidence area, combined with the reclamation requirements of various types in the land reclamation standard, the total score of each evaluation unit in the subsidence area is comprehensively analyzed, and the approximate range of the grade score of each land suitable type is shown in Table 5.

Table 5. Evaluation results of land reclamation suitability

Suitable grade	Land reclamation suitability direction			
	Suitable for farming	Suitable for garden	Suitable for forest	Suitable for fishing
High suitability	0.325	0.326	0.355	0.441
Moderate suitability	0.342	0.488	0.480	0.371
Barely fit	0.216	0.166	0.119	0.146
Unsuitable	0.117	0.021	0.046	0.042
Evaluation results	Moderate suitability	Moderate suitability	Moderate suitability	High suitability

It can be seen from the data in Table 5 that ① the reclamation area is moderately suitable for farming, gardening and forestry, and highly suitable for fishing and reclamation. In other words, the reclamation of fishery land is the priority direction of reclamation, followed by farming,

gardening and forestry. ② For the direction suitable for cultivation, there is little difference between the membership degrees of high suitability and medium suitability in the evaluation results. The purpose of mutual transformation can be achieved by adjusting the evaluation indexes. For the direction suitable for garden and forest, there is a large difference between moderate suitability and high suitability, and it is difficult to change.

5. Summary

According to the established mathematical model of land reclamation suitability evaluation, combined with the general situation of coal mining subsidence area, evaluate the land reclamation suitability of the reclamation area, analyze the evaluation results, and finally determine the suitable direction of land reclamation in the reclamation area. Through the suitability evaluation of the reclamation area, the main conclusions are as follows:

(1) In terms of cultivated land reclamation, the relevance of each evaluation index to the corresponding suitability level is different, that is to say, the importance of the evaluation index to the cultivated land reclamation in the reclamation area is different. Among them, the contribution of sand content, soil bulk density and field water capacity to suitability is the highest.

(2) In order to improve the suitability evaluation level of cultivated land reclamation, select sand content, soil bulk density and field water capacity to adjust the indicators with high correlation degree of high suitability level, and the suitability level changes from medium suitability to high suitability, so as to achieve the expected purpose. At the same time, the adjusted evaluation index provides the basis for the technical measures of land reclamation.

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