

Interaction ~ Reclaimed Soil, Vegetation.

Mining Area: A Review

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Abstract: As the two main factors, reclamation soil, vegetation play important roles. deqingyuan restoration. Mining Area. in this paper the interactions are explored between the changes in soil and vegetation success in coal-mine ecosystems, potential functional relationships, success rules of reclaimed soil and vegetation, research methods and mechanism of interaction. since linear analysis was mostly used in previous research, while the continuous and dynamic research and comprehensive analysis were insufficient, so for future study, more Attentions should be paid to dynamic and comprehensive analysis on the interactions between soil and vegetable in order to offer new experiences for the study of land reclamation and ecological restoration.

Keywords: Land reclamation; soil; vegetation; Interaction Mechanism

1. Succession Law of reclaimed soil and vegetation in Mining Area

1.1 Vegetation Succession Law

The succession of plant communities is the process of vegetation restoration to continuously adapt and transform the soil, and it is also the process of competition and replacement of different species under soil moisture and nutrients and other resources.^[3] The vegetation succession in the mining area is divided into natural succession and artificial succession. natural succession is a very slow process, it can shorten the period of vegetation succession and improve the rate of vegetation succession.^[4] With the increase of reclamation years, the types, number, volume, biomass and average height of reclaimed vegetation in coal mine area increased, while the vegetation coverage rate increased.^[5] Growth has also improved significantly^[6].

1.1.1. Many scholars have made a series of researches on the driving factors of vegetation succession, including abiotic factors Author brief: Zhang Zhaotong(1994-)She is a graduate student of Jinan, Shandong province. She specializes in land consolidation and ecological restoration.E-mail: The zhangzhaotong1994@163.com

Climate factors, human interference, hotels near in killing vegetative forms of and biological factors such. Found vegetation of play for is many kinds of factors comprehensive role of results in different of play for stage drive factors also different. Play for early main non-biological factors as an drive factors^[7]At this time SoilPHIs high soil fertility poor^[8]N,P, Organic matter lack of control the vegetation of Growth Development^[9]Coal Mine Area initial environment conditions of quality will decided to plant community of diversity and Composition Structure^[10]And coal mine area plant community first of species composition also will influence vegetation play for the Process^[11]. In play for medium-term climate factors^[12], Human interference^[13]And hotels near regional natural in killing vegetative

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forms^[14]Influence the vegetation play for the orientation and rate. Climate conditions by influence precipitation and temperature to influence vegetation of growth development to influence play for rate; benign of human interference will speed up the vegetation play for PROCESS OF, and adverse of human interference will hinder vegetation play for Process of the serious of even May will vegetation appears reverse play; hotels near regional of Breeding Experience by external force of diffusion role spread to reclamation area the reproductive on vegetation of quantity and style impact. Play for late due to community in species diversity increase of between struggle and of in competition become more fierce biological factors become the main driving force^[15].

1.1.2. Plant community play for stage in play for Process in plant community towards top community play for structure and function will happen corresponding of change community height gradually increase level differentiation more and more obvious, species of composition by single type steering complex species rich degree increase^[16]Final formation of top community is more species symbiotic, structure and function stability, can resist bad environment change of plant community^[17]. Domestic and foreign scholars according to different of division rules and methods will plant community of play for process divided into different of stage. The first kind of classification methods is according to the Community in advantage of the types of the Division. Bed Xiaowei^[18]Will plant community of play for divided into secondary bare land-Grass community-Shrub community-Forest Community4A stage. Contrast for make with people such^[19]More detailed to Division for bare land-Grass-Shrub-Coniferous Forest-Deciduous broad-leaved mixed forest-Needle broad-leaved mixed forest final to survive of the top community7//A stage. The second kind of classification methods is according to species composition and species diversity to the Division.NovakSuch.^[20]Think Reclamation1 ~ 4Years of vegetation main to A, biennial plant-based reclamation years5 ~ 10The annual vegetation is mainly dominated by perennial herbaceous plants.10 ~ 25Shrubs began to appear in the year, reclamation25Herbs formed over the years-Shrubs-The reclaimed ecological landscape of tree combination has the largest number of trees. Wang Qiong, *et al.*^[21]The reclamation vegetation succession in coal mine area is divided into primary succession period, primary replacement period, high-grade replacement period, high-speed recovery period and recovery stable period.5.Stage. And Hao Rong, etc.^[22]It is believed that the process of reclamation vegetation succession should be divided into the following aspects: simple species composition, abundant species composition and stable species composition.3.Stage.

In conclusion, the succession of plant community is a long and complex process. Different Stages of succession are driven by different factors, and continue to evolve in the direction of top plant community, with the original community in all aspects of the Phase

The iconicity increased from low to high, and the ecological structure and function gradually stabilized.

1.2 Law of soil succession

1.2.1. In the process of succession, soil physical properties were improved. The soil porosity increased due to the effect of vegetation root system and the improvement of soil texture.^[23]Soil bulk density decreased, and the distribution of soil bulk density was more^[24]. The water holding capacity of soil was increased due to the effect of surface vegetation, and the soil porosity increased, which led to the enhancement of soil water permeability.^[25] In addition, soil conductivity and soil volume quality decreased with the extension of reclamation years.

Soil volume quality decreased, indicating that soil compaction and soil fertility had changed.^[26]

1.2.2. With the reclamation work carried out in Coal Mine Area, soil fertility gradually enhanced. SoilPHSoil Organic Matter, soil organic matter,N,P,KThe content^[27]. In the process of succession, with the restoration of vegetation, the number of litter increased. After microbial decomposition, soil organic matter increased and soil fertility improved, produce more organic acids, which will lead to alkaline soil in the early stage of successionPHGradually reduced^[28]. Due to the impact of tillage, plant Nitrogen Fixation and artificial fertilization, soil total nitrogen and alkali-hydrolyzable nitrogen increased, and close to the content of the original landscape^[29]. Soil total phosphorus, total potassium, available phosphorus, available potassium content also increased^[30]On the one hand, it is due to the artificial application of phosphorus and potassium fertilizer in the Process of reclamation, on the other hand, it is due

to P, K Elements, and soil P, K Adsorption, desorption and immobilization capacity.

1.2.3. The microbial community structure of the soil has been evolved with the natural restoration of vegetation, soil Enzyme activity gradually increased. Yu Miao^[31] With the extension of reclamation years, the number of microorganisms in soil, the number of root fungal strains and the diversity index of root fungi increased year by year. Fresquez Wait.^[32] The study also verified that the number and diversity of fungi gradually increased with the increase of reclamation years. Baldrian Wait.^[33] It was found that in the same soil layer, the Soil Enzyme Activity and soil microbial biomass of the repaired land were significantly higher than those of the untreated land. Wang Xiang^[34] The results showed that the activity of soil invertase in reclaimed land was higher than that in the unreclaimed land. 31% The activity of catalase increased 61% Soil urease activity increased. 100% The activity of polyphenol oxidase in soil was the most obvious. 117%.

In short, in the initial reclamation period, soil sticky and heavy compaction resulted in larger soil bulk density, smaller porosity, poor overall quality, less total microbial biomass and lower soil enzyme activity. But with the increase of reclamation years,

Soil moisture and nutrient conditions were improved, water retention performance was gradually enhanced, ventilation condition was gradually improved, soil fertility was gradually enhanced, soil microbial species and quantity were increased, and enzyme activity was enhanced.

2. Study on interactive effects of reclaimed soil and vegetation

Previous scholars used linear regression to calculate the correlation coefficient when studying the relationship between vegetation community and environmental factors.

Or a single factor description method, these studies did not combine all kinds of influencing factors to explore, unclear the degree of interaction between multiple factors. Multiple Factors of soil and vegetation are selected for multivariate analysis to study the coupling relationship between vegetation and soil. Comparison of the advantages and disadvantages of the methods for studying the interaction between vegetation and soil..

2.1 Multiple linear regression

Multiple linear regression is use mathematical statistics in regression analysis to determine two or two more than variable between each other rely on the quantitative relationship of a kind of Statistical Analysis Methods^[43]. Many researchers in the multiple linear regression after will coupled model or linear regression model to more clear to the interaction influence relationship between the analysis. Xu Ming and^[44] Select 9A vegetation factor and 11A soil factor of them between the correlation the linear fitting and construction the vegetation-Soil System Coupling coordination model. Prach Such.^[13] By multiple linear regression model on vegetation characteristics and climate and soil variable between the related relationship between expression. Also have scholars in the vegetation and soil between the interaction influence Relationship Analysis for an arcane with other of methods for example path analysis, Spearman Rank related analysis and principal component analysis. Du Feng and^[45] Combined with multiple regression and path analysis the grassland community biomass and vegetation soil nutrient effect clear vegetation play for Process in vegetation and soil of Interaction Effect. Paper Haiyan and^[46] In study degradation sandy grassland vegetation and soil distribution characteristics and correlation when combined Spearman Rank related analysis and regression analysis describe herbs plant and soil traits, herbs plants and shrubs of relationship. Alday

^[47] Combined with the multiple linear regression and principal component analysis of methods to explore the Mediterranean climate of reclamation Coal Mine in soil variables and vegetation structure and vegetation of change between the correlation.

Multiple linear regression of methods can analysis the soil and vegetation between whether there interaction influence get negative correlation and related

Of size of conclusion. But can't comprehensive in-depth to reflect variable between internal more complex of influence principle and requirements sample quantity enough big obey typical probability distribution application even

though the widely but has very big of limitations.

2.2 Jorg Gray Association Analysis

Jorg gray association analysis is on a system development change situation quantitative describe and compare the of methods in Dynamic Process Analysis have is big advantage^[48]. In the related analysis when due to natural conditions and human their own conditions and the limitations many factors between the relationship is in a known and unknown between the for Jorg gray, very difficult to accurately measure related degree of objective size this situation under can select Jorg gray association analysis. In certain degree on the make up for the linear regression analysis of defects the sample size of how much and whether law are same application?^[49]. Huang wen juan and^[50]By calculation vegetation live root of and soil physical and chemical properties of Jorg gray associated coefficient to reflect soil physical and chemical factor on community underground biomass of influence,

And pointed out that the influence plant underground biomass formation of promote and limit factor. Lou Era^[51]In explore the plant community structure characteristics and micro-Terrain Soil

Soil Nutrient of coupling relationship characteristics run with to Jorg gray association analysis methods found plant community structure and soil nutrient of coupling relationship will for micro-terrain different and the difference. Xue Gull and^[52]Use Jorg gray correlation degree Construction vegetation-Soil coupling model to explore the plant community diversity, cool-season and warm-season grasses in the northeastern US. Soil Biol. biochem coupling relationship.

Jorg gray association analysis of Sample requirements low but it also has

Set of limitations in analysis process in divided into reference sequence and compare the sequence every a group experimental only analysis the compare the sequence of reference sequence of influence and can't reflect interaction Influence, and don't meet in the world-dimension of order-preserving effect can't reflect negative correlation.

2.3 Gradient Analysis Method

The gradient analysis method, also known as the ranking method, arranges the quadrat or plant species in a certain space so that the sorting axis can reflect a certain ecological gradient, to explain the distribution of vegetation or plant species and their relationship with environmental factors.^[40]. Gradient Analysis is generally used to analyze the relationship between plant communities and environmental factors, and has been applied to the interaction between vegetation and soil. The main methods used are downward trend correspondence analysis.(DCA)Canonical Correspondence Analysis(CCA)And downtrend Canonical Correspondence Analysis(DCCA).DCAIt is mainly used to analyze the relationship between communities.CCAAndDCCAIt is mainly used to reveal the relationship between species and environment,DCCAIs analyzing vegetation-The most advanced multivariate analysis technology of environmental relations can effectively eliminate"Bow Effect"^[53].FrouzWait.^[54]AppliedTWINSPAN,CCAMethods To study Western CzechSokolovCoal Mine vegetation communities and soil development, found that they are25Has experienced a major change, and this kind of change is related to each other.JeloudarWait.^[55]In the study of the relationship between vegetation and soil in Iran mining areaTWINSPAN,CCA,DCAMethod. Wang hongdan, *et al.*^[56]In the study of the influence of soil and terrain factors on vegetation restoration in the dump of open pit coal mine in the Loess AreaDCAThe conclusion is that there is a significant correlation between vegetation and soil factors, but there is no obvious correlation between vegetation and terrain factors.

2.4 Canonical Correlation Analysis

Canonical Correlation analysis is a multivariate statistical analysis method which uses the correlation between the comprehensive variable pairs to reflect the overall correlation between the two groups of indicators.^[57]. Scholars at home and abroad have applied canonical correlation analysis to study the correlation between vegetation and soil, which is mainly based on Principal Component Analysis and cluster analysis. Using Cluster Analysis to classify the ecosystem, to analyze the Succession Law of vegetation and soil; using canonical correlation analysis to reveal the

interaction between soil and vegetation.

Principal component analysis is used to determine the factors that play a leading role in the interaction. Tan qiujin^[58]Combine this3.

The coupling relationship between vegetation and soil in different ecosystems was studied by different methods, and the law and Mechanism of ecosystem succession were revealed. Peng Xiaoxia, *et al.*^[59]Selected representative woody plant community, soil properties and topographic factors22.The overall characteristics and the relationship between them are analyzed.

Canonical statistical analysis, principal component analysis, clustering analysis and canonical correlation analysis. Han meirong^[60]Yu Liping^[61]In the study, Principal Component Analysis and

The model correlation analysis is combined.

Canonical Correlation analysis uses Principal Component Analysis to reduce dimension and simplify complex correlation. Although the method is applied to compare

It takes each group of variables as a whole to carry out research, and does not study the various variables inside the whole, and can not reflect the characteristics of time and change trends.

3. Interaction mechanism between reclaimed soil and vegetation

3.1 Effects of Reclaimed Soil on Vegetation

Soil is the basis of vegetation growth and development, which can continuously provide nutrients and water for vegetation.^[3]Soil Animals and soil microbes participate in nutrient cycling, accelerate the decomposition of soil organic matter, promote the transformation of soil humus, regulate soil fertility, and then affect the growth and development of vegetation.^[62]. Soil Nutrients affect the growth and development of plant organs, regulate the demand of plants for water, heat and gas, and play a crucial role in the process of vegetation succession. The species, composition and quantity of soil nutrients all affect the growth and development of vegetation,N,P,KContent and distribution of essential elements affect the growth of plants.^[63].Fernandez^[64]Pointed out that the soilC,NSpecies Composition of plant community structure.SainjuAndGood^[65]It was found that the density of vegetation roots was positively correlated with soil organic matter, total nitrogen, water soluble phosphorus and exchangeable cations.PHThere was a negative correlation.PuWait.^[66]It is believed that the root morphology and Development of vegetation are closely related to the distribution of nutrients in soil and the allocation of nutrients.

Soil moisture is a direct source of water needed for vegetation growth and development. Since most coal mining areas in China are located in arid and semi-arid areas, water has become an important factor restricting vegetation restoration in mining areas.^[67]. The vertical distribution of soil moisture affects the use of water by vegetation. The coefficient of variation of soil moisture and Soil Effective water parameters directly affect the growth of vegetation.^[6]. Soil Water Content not only affects the root biomass, but also affects the productivity of plant communities, and limits the transpiration and Photosynthesis of plants. Within a certain range of soil water holding capacity, with the decrease of soil water holding capacity, the photosynthesis and transpiration rate of young trees gradually decreased.^[68].

Soil microbes decompose the litter of vegetation and increase soil fertility, which can promote the mineralization of soil organic matter and the transformation and supply of plant nutrient elements, so as to promote the growth of vegetation. And can

Biological nitrogen fixation, increase the source of effective nitrogen in the soil, for the absorption and utilization of plants.BurdWait.^[69]Found that soil microbes can increase plant

Survival rate of seedlings and aboveground biomass of plants. The formation of soil microorganisms, especially mycorrhizal fungi, can promote the root activity of plants. The synergistic effect of mycorrhizal fungi can improve the rate of secondary succession of plant communities and protect biological diversity, the effect of vegetation restoration is the best.HetrickWait.^[70]It is believed that mycorrhiza can promote the restoration and reconstruction of vegetation in coal mining area by improving soil structure and producing nutrients.

3.2 Effects of reclaimed vegetation on Soil

3.2.1. Effects of vegetation on soil physical and chemical properties First, Vegetation Restoration

Soil water holding capacity and pore condition, soil bulk density and stable infiltration efficiency can be effectively improved in the Process of soil reclamation, the effect of direct vegetation and indirect protection of litter on soil structure stability increased, thus improving soil texture. Studies have shown that soil infiltration rate depends on the change of silt content, vegetation coverage and soil bulk density.^[71]MorenodeWait.^[72]It is believed that the surface runoff and runoff coefficient decrease exponentially with the increase of vegetation coverage, which can improve the stable infiltration rate of soil.MarianoWait.^[73]In the study of SpainTeruelIn coal mines, it was found that soil erosion rate decreased sharply with the increase of vegetation coverage. Zhang Yuanyuan^[74]It was found that vegetation restoration and plant community succession would change the spatial heterogeneity of soil and improve the physical and chemical properties of soil. Single long roll^[75]It is believed that the root distribution range of vegetation affects the soil water content, and the root distribution depth determines the size of vegetative space and the ability to absorb and use soil water and nutrients. Secondly, vegetation will form litter after litter, which contains a large number of nutrients. Soil Microorganisms will decompose litter as decomposers to form humus, which will return nutrients to the soil, improve soil fertility. And the roots of the vegetation

Through the secretion of various substances such as amino acids, vitamins, organic acids to the soil to increase nutrient content in the soil.MinAndKim^[76]In research

In the reclaimed mining area on the west coast of South Korea, it was found that the species richness and biomass of vegetation would affect the content of soil organic matter.BurischWait.^[77]It is believed that the spatial root and nodule distribution of nitrogen-fixing plants have an effect on soil nitrogen content. The higher the root density and nodule density, the higher the soil nitrogen content. Huo Feng

^[78]The results showed that with the increase of vegetation coverage rate, soil total nitrogen and organic matter content showed an upward trend.

Potassium Content andPHA downward trend.ParrottaWait.^[79]It is found that vegetation restoration can promote the restoration of soil structure and fertility, and then promote the restoration of the whole ecosystem structure and function.

3.2.2. First of all, there was a significant positive correlation between vegetation diversity and root Fungal Diversity, fungal number and microbial biomass, vegetation can effectively improve soil water holding capacity and pore condition in the process of restoration, which provides necessary conditions for the survival and growth of various microorganisms in the soil. Effect of vegetation cover density and diversity on soil microbial activity^[80]The contents of amino acids, vitamins and Extracellular enzymes secreted by plant roots affect the number and diversity of microorganisms, and promote the transformation and absorption of nutrients in soil.^[81] Plant litter increases soil organic matter

Quality content, improve the soil micro-environment, and provide material basis for soil microbial activities.^[82]And then affect the formation of soil microbial community.^[83]

Secondly, in the process of vegetation restoration, the litter and root exudates of vegetation will affect the enzyme activity in soil.^[84]Soil Enzyme Activities and soil nutrients and soil bulk density are related to different degrees.^[85] Enzymes in soil are mainly involved in the decomposition, synthesis and transformation of various organic matter in soil, and the oxidation and reduction of inorganic substances.^[86]Soil Enzymes are more involved in the process of Organic Matter transformation, thus improving its activity. Moreover, soilPHThe content of heavy metals in soil inhibited the growth and activity of microorganisms.

Being affected by soilPHEffect of heavy metal content and nutrient status on soil microorganisms^[87].

4. Summary and outlook

In order to effectively and reasonably carry out the Ecological Restoration and Reconstruction in coal mine area, it is particularly important to study the interaction between soil and vegetation. In this paper, the succession of soil and

vegetation, the research methods of interaction and the mechanism of interaction are systematically reviewed. It is found that there are some problems in the current research: simple linear methods are mainly selected for the Study of Interaction between vegetation and soil, which lacks innovation and dynamic analysis and comprehensive research on interaction between vegetation and soil, therefore, the future research focus in this field is:

(1). Innovative methods for interaction between vegetation and soil. At present, when experts study the interaction between soil and vegetation in reclamation area, they mostly adopt linear regression, gray correlation analysis, canonical correlation analysis and gradient analysis, the methods are simple and lack of innovation. The factors of soil and vegetation are separated and analyzed. Therefore, we should strengthen the innovative research on the methods of interaction between vegetation and soil, such as the methods of complex networks, and establish a complex network model of interaction between soil and vegetation, and through the analysis of each index of the network to explain the interaction between soil and vegetation mechanism.

(2). Dynamic Analysis of interaction between vegetation and soil was strengthened. Most of the scholars in the study of the interaction between vegetation and soil, the selected data is short-term data, but the vegetation and soil continuous succession, the relationship of interaction influence is constantly changing, so the analysis results have certain limitations. Therefore, we should not only analyze the correlation between vegetation and soil in a certain or very short period of time, but also focus on continuous and dynamic research.

(3). Comprehensive Study on Interaction Mechanism between vegetation and soil. At present, in analyzing the interaction mechanism between vegetation and soil, some scholars are studying the physical and chemical properties of soil, and the other part is studying the biological indicators of soil, the results of this analysis are not comprehensive enough, so it should be integrated with physical, chemical and biological properties, in addition, the interactive response mechanism between vegetation and soil should be studied in depth and comprehensively with the political, economic and cultural factors.

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