

# Study on Soil Nutrient Change after Soil Ecological Restoration in Coal Mine Area of Northern Shaanxi Province

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## Abstract

**A field experiment was conducted to analyze the changes of soil nutrients in mining area after different microbial plant combined remediation. The results showed that the application of microbial agents could significantly increase soil total nitrogen content in coal mine area. The contents of GH, GS and GX were the highest, which were 0.54, 0.51 and 0.41 g/kg, respectively. The contents of available phosphorus and available potassium in AX treatment were the highest, reaching 57.1 and 194 mg/kg. Comprehensive analysis showed that microbial agent + mixed seed mode could effectively increase soil catalase content, among which AH had the best effect.**

## Keywords

**Microbial Agent; Combined Repair; Mining Area; Diversity of Plants.**

## 1. Background

Driven by rapid economic development, the demand for coal resources is increasing day by day. At present, China's coal reserves are about  $9.5 \times 10^{12}$ t, accounting for 11% of the world's total coal reserves [1], and the annual output reaches more than 1.3 billion tons. The amount of coal mining in China continues to increase, causing particularly serious damage to vegetation, soil and local ecosystem [2-3]. In view of some problems caused by coal mining, China has already started the ecological restoration of land in mining area, but the ecological restoration technology is still significantly lower than the developed countries in Europe and America. In particular, the contradiction between the rich coal resources and the fragile ecological environment in northern Shaanxi has become increasingly prominent in the development of resources in recent years. In recent years, the mining of coal resources has caused a series of local geological and ecological environmental problems [4].

In view of the problems of vegetation destruction, soil water shortage and fertilizer shortage, soil heavy metal pollution, ecosystem destruction and so on, it is necessary to carry out a lot of further research on remediation technology in coal mining areas. Bai Jia [5] et al. 's study showed that mining-accompanied jingtian could effectively remove heavy metal Cd in river-tidal soil and red and yellow mud, and its recovery efficiency was 26.81% and 20.79%, respectively. The study of Xu Decong [6] et al. showed that planting vetiver could effectively improve the contents of total nitrogen and available phosphorus in the surface soil, and the

nutrient content in the soil increased with the extension of planting time. The average values of total nitrogen and available phosphorus in the 0-5 cm layer under early planting vetiver were 4.64 times and 22.44 times of those under recent planting, respectively. Herbs and shrubs cooperate with each other to maximize the use of horizontal and vertical space, so that the completed community presents the above-ground stratification and horizontal mosaicity similar to the natural community, reduces the infiltration rate of water, and improves the ability of water and fertilizer preservation [7-9]. In this study, plants (vetiver and seabuckthorn) and microorganisms (rhizobium, EM agent and *Bacillus subtilis*) were selected as the research objects to study the effects of different combination patterns on soil fertility improvement in the coal mining area of northern Shaanxi Province.

## 2. Materials and Methods

### 2.1. Test Materials

Types of microbial agents tested: Selection of microbial agents: Rhizobium, *Bacillus subtilis*, EM bacteria. Test plants: vetiver and seabuckthorn.

### 2.2. Test Method

Sangshuta coal mine area in Gaojiapu Town, Shenmu City, northern Shaanxi Province was selected as the test site. The soil pH was 8.81, electrical conductivity 10.41 mS/m, organic matter 3.20 and total nitrogen 0.15 g/kg, available phosphorus 24.4 and available potassium 93 mg/kg, respectively. The coordinates are 109°12' -109°94' E and 37°42' -38°25' N. The area vegetation is scarce, soil erosion is serious, the land is barren. The experimental field was constructed in March 2021, and the area of a single plot was 4 m×4 m. The experiment was arranged according to the random block in Table 1. The application amount of microbial agent is 50 kg/mu. Dilute the microbial agent with a small amount of water, immerse the root of the seedlings that have washed the root nutrient soil into the diluent, so that they are fully stained with bacterial liquid, and cultivate the seedlings that have dipped in the root, and then irrigate the soil with the remaining bacterial liquid. Vetiver was planted at a spacing of 40×40 cm and sea buckthorn 40×50 cm.

**Table 1.** Field experiment setting

Main treatment	Vetiver(X)	Seabuckthorn(S)	Vetiver + Seabuckthorn(H)
Deputy treatment	Rhizobia(XG)	Rhizobia(SG)	Rhizobia(HG)
	<i>Bacillus subtilis</i> (XQ)	<i>Bacillus subtilis</i> (SQ)	<i>Bacillus subtilis</i> (HQ)
	Soil remediation agent (XA)	Soil remediation agent (SA)	Soil remediation agent (HA)

### 2.3. Measurement Index and Method

Potassium dichromate and external heating method were used for soil organic matter. The total nitrogen was determined by Kjeldahl method. Available phosphorus using molybdenum, antimony, scandium colorimetric method; Available potassium was determined by flame photometry.

### 3. Results and Analysis

#### 3.1. Effect of Microbial Plant Combined Remediation on Soil Total Nitrogen Content in Coal Mining Area

The total nitrogen content in the soil will directly reflect the soil fertility level. The nitrogen content in the soil after different treatments is shown in Figure 1. Compared with CK, the combined microbial-plant remediation treatment could significantly increase the soil total nitrogen content in coal mine area, and the increase amplitude was different. The increasing effects of different bacterial agents were as follows: Rhizobia >EM > Bacillus subtilis. Among the different planting plants, sea-buckthorn had a significantly higher effect on soil nitrogen than vetiver. The contents of GH, GS and GX were the highest, which were 0.54, 0.51 and 0.41 g/kg, respectively. The results of comprehensive analysis showed that Rhizobia + shrubgrass mixed seed had the best effect on soil nitrogen promotion, and the effect of planting sea-buckthorn was better than vetiver in all microbial treatments. These results indicated that rhizobia could effectively impregnate the roots of seabuckthorn and improve its nitrogen fixation ability. However, the disseminated ability of rhizobia to vetiver was weak, which could not create a mutualistic and symbiotic environment.

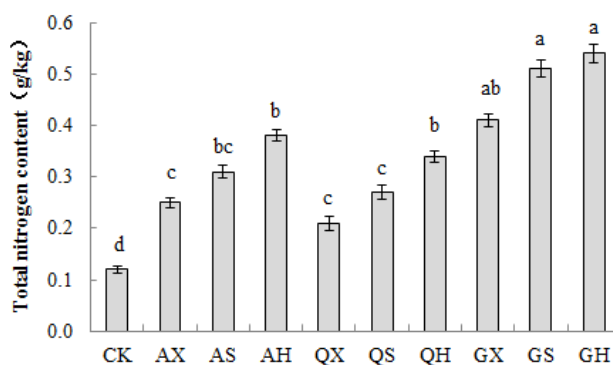


Fig 1. Effects of different treatments on soil total nitrogen content

#### 3.2. Effect of Microbial Plant Combined Remediation on Soil Organic Matter Content in Coal Mining Area

Soil organic matter content in coal mine area after different microbial-plant combination restoration is shown in FIG. 2. The soil organic matter content under AX, GX and QX treatments is significantly higher than that in the control group, increasing by 25.7%, 24.8% and 23.9%, respectively, while there is no significant difference in other treatments. Soil organic matter content under different microbial + vetiver treatments was significantly higher than that under sea-buckthorn planting and mixed planting treatments, indicating that there was a significant synergistic effect of microbial + vetiver on soil organic matter content.

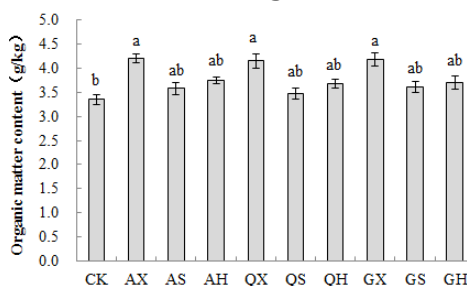


Fig 2. Effects of different treatments on the content of organic matter in soil

### 3.3. Effect of Microbial Plant Combined Remediation on Soil Available Phosphorus Content in Coal Mining Area

The contents of total nitrogen, available phosphorus and available potassium in the soil will directly reflect the soil fertility level. The available phosphorus content in the soil matrix after different treatments is shown in FIG. 3. Compared with the control, the available phosphorus content was significantly increased in different treatments. The content of available phosphorus in AX treatment was the highest, reaching 57.1 mg/kg, which was 139.9% higher than that of CK. Followed by AH and QX treatments, the available phosphorus contents were 55.6 and 51.2 mg/kg.

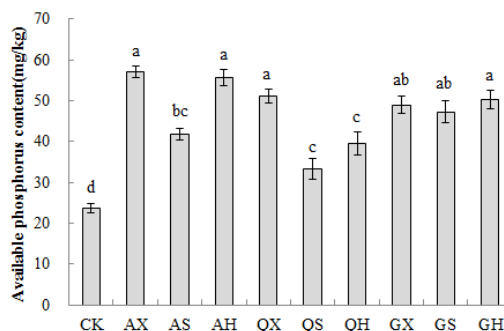


Fig 3. Effects of different treatments on available P in soil

### 3.4. Effect of Microbial Plant Combined Remediation on Soil Available Potassium Content in Coal Mining Area

The contents of total nitrogen, available phosphorus and available potassium in the soil directly reflect the soil fertility level. The available potassium content in the soil matrix after different treatments is shown in FIG. 4. Compared with CK, different treatments significantly increased the content of available potassium. Among them, the content of available potassium in AX treatment was the highest, reaching 194 mg/kg, which was increased by 104.2% compared with CK. Followed by AH and QX treatments, the available potassium contents were 178 and 174 mg/kg.

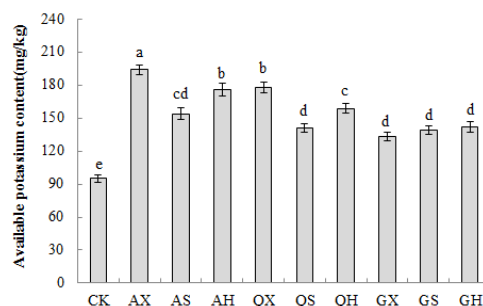


Fig 4. Effects of different treatments on available K in soil

## 4. Conclusion

Comprehensive analysis showed that soil nutrients in coal mine area were significantly improved after different microbial plant combined remediation, among which herbaceous plants had a better effect than shrubs. The possible reason was that the planting life was shorter, the growth of herbaceous plants was rapid, and the nutrient exchange between herbaceous plants and soil could be completed quickly to achieve a balanced symbiosis. Rhizobia could significantly increase nitrogen content among different bacterial agents, but EM bacteria had the best comprehensive effect. Considering the overall soil nutrient level, AX and AH treatments had the best effect on soil nutrient.

After planting different pioneer plants, the nutrient content of soil was significantly increased, and herb was better than shrub. Rhizobia could significantly increase nitrogen content among different bacterial agents, but EM bacteria had the best comprehensive effect.

Comprehensive analysis showed that the microbial agent + mixed species model could effectively improve the vegetation coverage and diversity of mining area, and improve the soil environment at the same time, among which AH had the best effect.

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