International Journal of Biology and Life Sciences
ISSN: 2957-9511 | Vol. 2, No. 1, 2023

Effect of combined microbial-plant remediation on soil physical properties in mining area

Shenglan Ye [1,2,3,4,5] *, Juan Li [1,2,3,4,5], Dan Wu [1,2,3,4,5]

[1] Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China
[2] Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China
[3] Key Laboratory of Degraded and Unused Land Consolidation Engineering, Ministry of Natural Resources, Xi'an 710075, China
[4] Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an 710075, China
[5] Land Engineering Technology Innovation Center, Ministry of Natural Resources, Xi'an 710075, China

* **Corresponding author**: Shenglan Ye

Abstract: In view of the problems of vegetation damage, soil water and fertilizer shortage, soil heavy metal pollution, ecosystem damage and other problems existing in the long-term mining of the coal mine area, this study uses micro-organism-plant to bioremediation the coal mine area. The changes of soil physical properties were studied through pot experiment. The results show that the combined remediation can change the physical properties of soil to a certain extent, but the effect is not significant in the short term.

Keywords: Joint remediation; Soil remediation; Physical properties.

1. Background

China is the country with the largest coal consumption in the world. In the future, coal will still occupy the main energy position in China's energy utilization structure for a long time [1-2]. Plants take soil as the main material basis for survival. Coal mining has destroyed the soil layer structure of the original soil, resulting in serious water and soil loss, reducing the nutrient content in the soil, and also causing damage to the rhizosphere microhabitat where plants normally grow. In the late 1950s, China began to focus on the reclamation of abandoned mining areas. In 1989, China's first regulation on land reclamation, the Land Reclamation Regulations, was promulgated, indicating the direction for land reclamation in China. At the same time, the government has also paid great attention to the comprehensive renovation of mine waste land, which has significantly improved the recovery speed and quality of waste land. According to the survey results published by the National Environmental Protection Administration in 1996, the total amount of various types of abandoned land repaired in China in the five years after 1990 was about 533000 hm2, and the reclamation rate reached 26.83%.

Microbial remediation is to use some microorganisms in the soil to reduce the toxicity of pollutants in the soil and improve the soil conditions for plant growth. Its application cost is low, and its negative impact on soil fertility and metabolic activity is small. It can not only shorten the reclamation period, but also avoid the impact on human health and environment due to the transfer of pollutants. The content of soil organic matter in rare earth mines is extremely low, which is not conducive to the growth and reproduction of soil microorganisms. Microbial remediation must be based on increasing soil organic matter (such as applying organic fertilizer, burying plant branches and leaves or humus, or directly planting pioneer plants).

Phytoremediation technology is to follow the ecological law, improve the physical and chemical properties of soil (soil structure, pollutant content, etc.) by using some stress-tolerant plants and super-enriched plants, re-establish plant communities in ecologically fragile areas caused by human or natural damage, and play a greater role in biological treatment with rhizosphere microorganisms. It is the most effective means to restore the production potential and landscape of the mining area [9-11]. Compared with conventional physical and chemical methods, phytoremediation technology has the characteristics of low cost, small quantities, fertility and pollution-free, so it is called "cheap green remediation technology" and is widely used in the remediation of soil, water and sludge [12-13].

Therefore, this study adopts the pot experiment and the micro-organism-plant combined remediation technology, selects three different microbial agents and three plant planting methods, and carries out the pot experiment on the soil matrix of the mining area, in order to analyze the changes of soil physical properties, and provide a theoretical basis for the reclamation of abandoned land in the actual production in the future.

2. Materials and methods

2.1. Test materials

The test soil for this experiment was taken from the abandoned soil in the mining area of Yulin City, northern Shaanxi Province. The soil samples collected were 0-20 cm of surface soil, which was finely ground after drying, and then screened with 20 meshes for use. The types of microbial agents tested are rhizobium, EM bacteria and Bacillus subtilis, which are specially provided by fertilizer companies. At the same time, vetiver and seabuckthorn were selected as the restoration plants.

2.2. Test method

The indoor pot experiment was adopted. In the experiment, the microbial fertilizer (rhizobium agent, bacillus subtilis agent, EM agent) was spread by mixing soil. According to Table 1, 10 treatments were set up, and each treatment was repeated 3 times. The three parallel spaces of the same treatment should be more than 50 cm apart, and the interval between different treatments should be more than 80 cm.

Table 1. Test scheme setting

Main treatment	Vetiver (X)	Seabuckthorn (S)	vetiver+ seabuckthorn (H)
Treatment	Rhizobium (G)	G	G
	Bacillus subtilis(Q)	Q	Q
	EM bacteria(A)	A	A
Control	without adding any material (CK)		

2.3. Index measurement

The soil moisture content is determined by drying and weighing method; Consolidation test: one-dimensional confined compression test is adopted. The test soil sample is a small ring knife sample. The pressure levels during the test are 12.5 kPa, 25 kPa, 50 kPa, 100 kPa, 200 kPa, 400 kPa, 600 kPa and 800 kPa respectively; Direct shear test: the shear strength of soil samples is tested by the quick shear test method, and the vertical pressure is 50 kPa, 100 kPa, 200 kPa and 400 kPa respectively.

3. Results and analysis

3.1. Changes of soil compressibility in pot simulation experiment with different treatments

The compression characteristics of the soil in the bioremediation mining area were studied by the indoor consolidation test ε-p curve is shown in Figure 1. It can be seen from Figure 1 that the compressibility of the mining area soil is significantly reduced by the combined treatment of microorganisms and plants. Under the same vertical load, its compression deformation is smaller than CK. At the initial stage of loading (vertical pressure<200 kPa), ε-p curve is steep, and the deformation gradually tends to be stable with the increase of vertical pressure in the later stage, while the slope of the compression deformation curve treated by CK is always large.

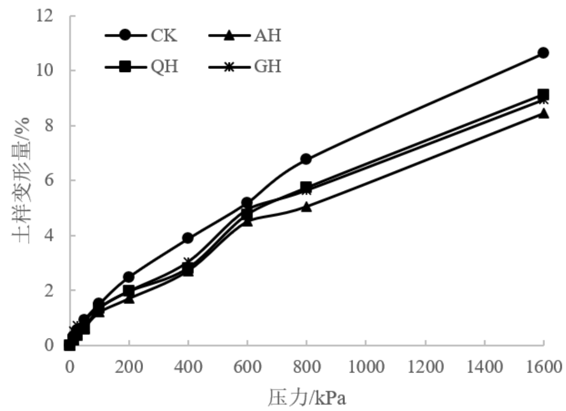

Fig. 1 The ε-p curves of soil under different experimental treatments

3.2. Shear strength characteristics of mining area soil with different treatments

The direct shear apparatus is used to test the shear strength of potted simulated mining area soil. The test method is fast shear test. The shear rate is set at 0.8 mm/min. After the shear box contacts with the dial indicator, count and record once every 10 seconds. When the pointer of the dial indicator remains stationary or rebounds, it indicates that the sample has been sheared and the test is terminated. The shear strength of soil mixed with different microorganisms and plants was obtained in turn. The experimental results are shown in Table 4. It can be seen from the table that under the action of vertical stress, the shear strength of soil under different experimental treatments has increased to a certain extent compared with CK. The shear strength of AH is the largest. However, the overall increase and decrease are small. The cohesion and internal friction angle of potted soil treated by microorganism and plant increased to some extent. See Table 2 for its change trend. Among them, the internal cohesion and internal friction angle treated by AH reach the maximum value. The cohesion and internal friction angle were increased to 72.68kPa and 34.22 ° respectively, and the cohesion was 1.6 times higher than CK.

Table 2. Direct shear experimental results under different treatments

Treatment	Shear strength				Cohesion (kPa)	Internal friction angle (°)
	50	100	200	400		
CK	88.2	78.6	119.2	238.4	44.66	24.75
AH	103.025	127.716	189.528	301.36	72.68	34.22
QH	93.1	107.24	145.18	282.97	57.75	28.43
GH	97.32	106.8	121.229	294.565	58.14	29.26

3.3. Effect of combined microbial and plant remediation on soil water content in pot experiment

It can be seen from Figure 3 that the combined treatment of different microorganisms and plants significantly increased the soil water content. The soil water content of different crop planting modes is herb>mixed species>shrub; The soil water content of different microbial agents is soil remediation agent>Bacillus subtilis>rhizobium. Comprehensive analysis showed that the soil water content of AX and AH treatments was the highest, 13.2% and 12.9% respectively, which were significantly higher than other treatments. Next were QX and GX, 11.6% and 11.2% respectively.

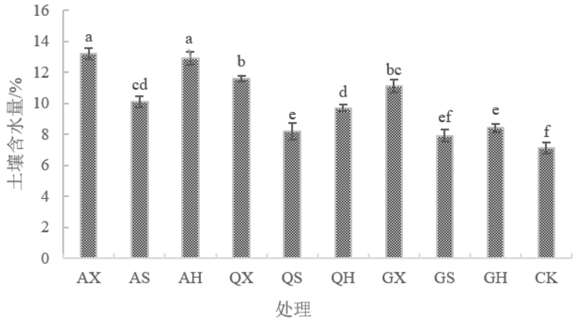

Figure 3. Change of soil water content under different microbial and phytoremediation treatments

Note: Different small letters above the bars mean significant at 5% levels.

4. Conclusion

Pot experiment was conducted to study the effect of the combined action of microorganisms and plants on the physical properties of the soil in the mining area, and the following results were obtained:

The compressibility of the soil in the mining area is significantly reduced by different test treatments. Under the same vertical load, its compression deformation is reduced compared with CK, while the shear strength is increased to a certain extent. The shear strength of AH treatment is the largest. However, in general, the changes in compressibility and shear strength are small.

Through comprehensive analysis, it is found that the microbial - plant combined remediation can change the physical properties of soil to a certain extent, but the effect is not obvious in the short term, of which AX and AH are the best.

Acknowledgment

Fund: Shaanxi Geological Construction - Xi'an Jiaotong University Land Engineering and Human Settlements Technology Innovation Center Open Fund Project (2021WHZ0093).

References

[1] Zhang X, Winchester N, Zhang X. The future of coal in China[J]. Energy Policy, 2017,110:644-65.

[2] Ge SR, Liu HT, Liu JL, Hu HS. Analysis of the current situation of energy consumption in China's coal mine production and energy saving ideas [J]. Journal of China University of Mining and Technology, 2018,47 (01): 9-14.

[3] Luo ZB. Study on the change and driving mechanism of soil microbial community structure after coal mining disturbance in the loess plateau [D]. China University of Mining and Technology, 2019.

[4] Jiang JF, Zhao QX, Gao YM. Research on land reclamation technology in abandoned mining areas in China [J]. Shanxi Coal, 2010,30 (006): 74-76.

[5] Yang WW. Research on ecological restoration technology and effect of mine wasteland -Taking an iron ore area in Lushan County, Henan Province as an example [D]. North China Institute of Water Resources and Hydropower, 2012.

[6] Wei Y, Hou Mingming, Wang Hongbin, Qing Hua. Research on ecological restoration and reconstruction of mining wasteland [J]. Mining Express, 2006 (11): 36-39.

[7] Tian XM, Li JH, Wang C, et al. Effects of applying bio-organic fertilizer for three consecutive years on soil nutrients, microbial biomass and enzyme activity [J]. Soil, 2014, 46 (3): 481-488.

[8] Steinauer K, Jensen B, Strecker T, et al. Convergence of soil microbial properties after plant colonization of an experimental plant diversity gradient[J]. BMC ecology, 2016, 16(1): 19.

[9] Liang J. The relationship between plant community succession and soil nutrient and microbial community in Ziwuling [D]. Xi'an, Shaanxi Normal University, 2011.

[10] Balusamy B, Kandhasamy Y G, Senthamizhan A, et al. Characterization and bacterial toxicity of lanthanum oxide bulk and nanoparticles[J]. Journal of Rare Earths, 2012, 30(12): 1298-1302.

[11] Zhang Haifang Soil microbial diversity of different vegetation restoration models in Hulunbeier sandy land [D] Tianjin, Tianjin Normal University, 2012.

[12] Wang Q, Gu Z, Zhou L. Study on the Soil and Plant Community Characteristics at an Early Ecological Restoration Stage in an Abandoned Quarry[J]. 2016.

[13] Ding Zili, Li Shuqian, Zhou Xu, etc Mechanism and application of phytoremediation of heavy metal pollution in soil [J] Hubei Agricultural Science, 2014,53 (23): 5617-5623.