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Effects of Soft Rock Addition on Stability of Sandy Soil Structure

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Abstract

In order to find out the effect of soft rock addition on the structural stability of the composite soil, this paper selects the composite soil-forming technology of arsenic sandstone and sand as a typical example, and sets different composite ratios of soft rock and sand (1:0, 1:1, 1:2, 1:5, 0:1) field test plots to monitor the crushing strength and microscopic soil structure of composite soil aggregates under different treatments. The results show that with the addition of soft rock, the proportion of small particles released from the aggregates of the composite soil is significantly reduced, which enhances the stability of the aggregate structure and reduces the strength of the aggregates damaged by water. The microscopic images of the composite soil show that after the addition of soft rock, the composite soil has an aggregate structure formed by organic matter activity and clay particle cementation, the number of composite stacking pores increases, and the cementing ability of soil particles is enhanced. In conclusion, the soil structure stability and erosion resistance are better when the ratio of soft rock and sand is 1:2 and 1:5.

Keywords

Soft Rock Addition; Stability of the Composite Soil; Composite Ratios.

1. Introduction

The composition and stability of aggregates are closely related to many soil properties and ecological environment, and are mainly affected by soil organic matter, clay minerals and texture. The evaluation of soil structure is often carried out from two directions of soil aggregates and pores [1-2]. Soft rock and sand are widely distributed in the Mu Us sandy land, the previous research results show that the combination of soft rock and sand can enhance the soil's anti-erosion ability, thereby preventing further erosion and desertification of the Mu Us sand land, and build and enhance the basic productivity of the compound soil [3-5]. A good soil structure is an important material basis for maintaining the soil ecological environment function, but there are few reports on the stability mechanism of the combination of pi-sandstone and sand to improve the soil structure. Therefore, studying the micro-mechanism of the combination of soft rock and sand to improve the stability of sandy soil structure has important theoretical value for enriching the scientific basis for the combination of pi-sandstone and sand, guiding sand land improvement, and effectively preventing and controlling land erosion and desertification.

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2. Materials and Methods

2.1 Site Description and Experimental Design

This research was conducted in Chuyuan Village, Fuping County, Shaanxi Province, China (34°42′N, 109°12′E). The study area belongs to the gully area of the Weibei Loess Plateau, and the climate is continental temperate, semi-arid, and semi humid. The annual average temperature, average sunshine hours, and total annual solar radiation are 13.4°C, 2,389.6 h, and 123.9–127.8 kcal/cm2, respectively. The dry and wet seasons are distinct, and natural conditions can meet the growth needs of crops.

A total of 5 experimental treatments were set up in this experiment: the mixing ratios of different arsenic sandstone and sand are: 1:0 (CK), 1:1 (T1), 1:2 (T2), 1:5 (T3), 0:1 (T4). Set up 5 test plots, the plot area is 2m × 2m=4m2, and the 5 test treatment plots are arranged in a straight line shape from south to north.

2.2 Sampling and Measurement Methods

After the wheat was harvested at the end of May 2020, disturbed soil samples were collected at 0–30 cm to determine soil aggregates, organic matter, and other physicochemical properties. We removed impurities, such as roots and gravel, from the soil and minimized human interference during the transportation of soil samples to avoid impact on soil structure. Soil microstructure features were characterized using an FEI Q45 SEM produced by the American FEI company.

3. Results and Analysis

3.1 Effects of Soft Rock and Sand Compound on the Structural Stability of Soil Aggregates

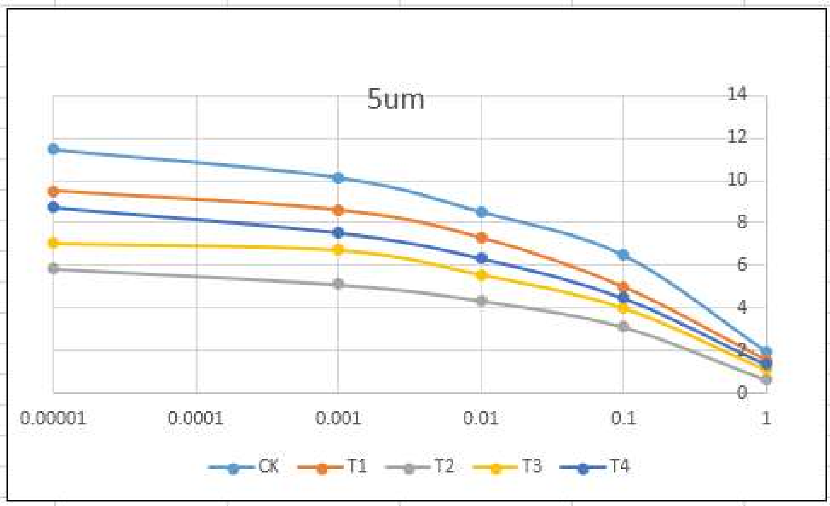

Figure 1. Percentage of < 5 μm microaggregates released by the crushing of composite soil aggregates under different treatments

Compared with the control treatment, under the condition of the same electrolyte concentration, the number of micro-aggregates released by the rupture of the aggregates decreased continuously with the change of the compound ratio of soft rock and sand (Figure 1). When the concentration of NaCl solution was 0.01 mol L-1, The percentages of <5 μm microaggregates under T1, T2, and T3 treatments released by aggregate breaking were 7.29%, 4.37%, and 5.59%, respectively, and the breaking strength of agglomerates was reduced by 14.5%, 48.8%, and 34.4% compared with CK, respectively. The results show that, on the one hand, the change of the compound ratio of soft rock and sand significantly reduces the proportion of aggregates broken and released into small particles, the mutual cohesion between soil particles is enhanced, the strength of aggregates damaged by water is reduced, and the structural stability of aggregates are enhanced. On the other hand, at high electrolyte concentration, the degree of fragmentation of the aggregates is significantly weakened, and the aggregates are slightly expanded or broken after the addition of soft rock, which provides a

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certain theoretical basis for the prevention and control of natural disasters such as soil erosion and landslide collapse in the later stage. Through comparative analysis, it is found that after the combination of soft rock and sand in different proportions, the formation and stability of soil aggregates are different, and the stability shows the trend of T2 > T3 > T4 > T1 > CK. The soil structure stability and erosion resistance were improved better when the ratio of soft rock and sand was 1:2 and 1:5.

3.2 SEM Images of Soil Microstructure under Different Compound Ratios of Soft Rock and Sand

The surface morphology of soil microstructure under different compound ratios of pi-sandstone and sand was observed by scanning electron microscope (Figure 2). Figures 3e and 3f are the microscopic images at 100x and 1000x magnification, respectively, with the ratio of arsenic sandstone and sand at 1:5.The composite soil is dominated by large particles and lacks clay particles that bind the large particles of the soil. The surface of the composite soil particles is relatively smooth, there are few concave and convex adsorption ion contact surfaces, and the particle gap is large. The degree of cementation between particles is weak, and it is difficult to find traces of roots and soil biological activities (Figures 2e and 2f). With the increase of the compound ratio of soft rock, the cementing ability of soil particles increases, the content of clay and silt particles increases, and the surface of the composite soil particles becomes relatively rough (Figures 2b). In the composite soil, organic matter activity and agglomerate structure formed by clay cementation appeared, and a small amount of crop roots were observed (Figures 2a), and the number of composite stacked pores increases. In conclusion, the addition of soft rock increases the clay silt of sandy soil, promotes the agglomeration and cementation of sandy soil, improves the loose and poor soil structure of sandy land and increases the stability of compound soil structure.

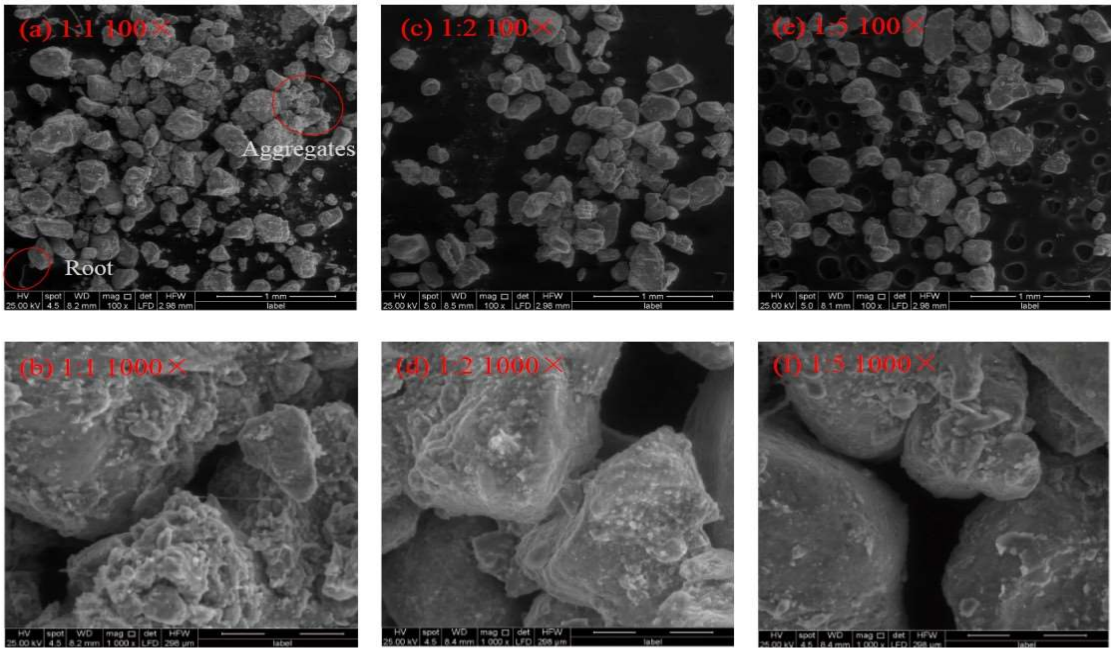

Figure 2. SEM images of soft rock and sand in different proportions

4. Conclusion

The proportion of small particles released from the aggregates of the composite soil is significantly reduced with the addition of soft rock, which enhances the stability of the aggregate structure and reduces the strength of the aggregates damaged by water. The percentages of < 5 μm microaggregates released from aggregate breakage under T1, T2, and T3 treatments were reduced by 14.5%, 48.8%, and 34.4% compared with CK, respectively. The structural stability of the composite soil showed a

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trend of T2>T3>T4>T1>CK, and the soil structural stability was improved better when the ratio of Pi-sandstone to sand was 1:2 and 1:5.

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