A Brief Analysis of Biological Soil Crust in the Management of Rocky Desertification

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Abstract. Karst rocky desertification is a geo-ecological problem in Southwest China because of nature and man-made factors, which restricts the development of local economic and social. Soil and water erosion is one of the most harmful form of rocky desertification, but the management methods still keep in the exploratory stage. Biological soil crust is the organic complexes of biotic components including bacteria, fungi, mosses, lichens, algae and liverworts with soil particles. The development of biological soil crust could effectively improve the soil physical and chemical properties, enhance the stability of surface soil, and reduce soil erosion. Biological soil crust is very common in rocky desertification areas, which is very useful in the soil and water conservation.

Keywords: Biological soil crust, rocky desertification, Krst landform.

1. Introduction

Karst landforms are generally the result of mildly acidic water acting on soluble bedrock such as limestone or dolostone. The karst areas are characterized by high eco-sensibility, low environmental capacity, weak anti-jamming capacity and poor stability. It accounts for about 15%of the world’s land area, and is the home for about l 7%of the world’s population. Three large and continuous karst regions in the world are distributed in East Asia, the eastern part of North America and the middle and southern parts of Europe. Rocky desertification is the most serious geo-ecological problem in karst areas, which is a process of land degradation involving serious soil erosion. The extensive exposure of basement rocks, the drastic decrease of soil productivity and the appearance of a desert-like landscape. Karst rocky desertification has never occurred in the eastern part of North America and me middle and southern parts of Europe. Some researches on karst conducted in those areas mainly focused on hydrology and karst evolution. East Asia karst region, as the largest one of the three karst regions, is a typical fragile ecological zone, and has the most intensive karstification. Southwest China is distributed in a karst plateau area in the central part of East Asia karst region, where karst rocky desertification is one of the most serious environment problems. The sustainable development in this area has been restricted, threatening people’s living conditions [1]. Much research has been done on the karst rocky desertification in Southwest China, including the definition, distribution, causes, ecological-environmental effects and preventive strategies. According to the remote sensing investigation done by Huang et a. the total karst rocky desertification area of Guizhou and Guangxi provinces in Southwest China has reached 50 000 km2 and 47 000 km2, respectively. And it is spreading at a rapid rate of 2 500 km2/year. Rocky desertification risk zones can be defined as regions prone to rocky desertification, which call spread easily to other region. Rocky desertification risk zone delineation is a prerequisite for the analysis of the dynamic mechanism and is important for management and prevention of rocky desertification. Based on land use classification, rocky desertification risk zones could be delineated in combination with other karst environ-mental conditions, facilitating regional and hierarchical rocky desertification management and prevention.

2. Present situation of soil and water loss management in karst areas

The influence factors of soil erosion problems in rocky desertification region in China is complicated, which including different types of karst, karst geological conditions (lithology, structure), geomorphic conditions, land use mode and special underground drainage system etc. China's southwest rocky desertification of karst area can be divided into six prevention and control soil erosion areas according to the above factors: karst peak cluster depression area, karst gorge area, karst plateau area, down-faulted basin karst regions, karst plains area, karst trough valley area [1].Currently, control methods of soil and water loss in rocky desertification areas mainly include: (1) biotechnology technology, which including return farmland to forest (grass), the prevention and control of soil degradation technique, afforestation technology, small watershed management technology, afforestation and pioneer plant introduction technology in desertification areas, etc.(2) Engineering method, including the intercepting ditch slope excavation, grit chamber and other projects, construction of silt dam project in channel area, gentle slope zone of slope-to-terrace engineering, etc. (3) Method of water-saving technologies, including rainwater collecting technology, canal seepage control technology, the low pressure pipeline technology, sprinkler irrigation of micro-irrigation, the field water-saving technology and so on. The governance approach obtained the certain effect in some areas, but on the whole, the prevention mechanism research of rocky desertification is still in the stage of qualitative exploration.

3. Biological soil crust and it's ecological effect

Biological soil crust(BSC) are wide spread communities of diminutive organisms such as cyanobacteria, green algae, lichens, mosses and other organisms that are closely integrated with particles of surface soil, which results in the formation of a cohesive thin horizontal layer [2,3]. Biological soil crusts result from an intimate association between soil particles and cyanobacteria, algae, micro fungi, lichens, and bryophytes (in different proportions) which live within, or immediately on top of the uppermost millimeters of soil. Soil particles are aggregated through the presence and activity of these biota and the resultant living crust covers the surface of the ground as a coherent layer. This definition does not include communities where soil particles are not aggregated by these organisms (e.g., cyanobacteria/algal horizons in littoral sand and mudflats), where organisms are not in close contact with the soil surface (e.g., thick moss-lichen mats growing on top of decaying organic material, as in boreal regions),nor where the majority of the biomass is above the soil surface (e.g., large club-moss mats found in North American grasslands or dense stands of lichens, such as Niebla and Teloschistes species from the coastal fog deserts of California and of Namibia, respectively). However, the boundaries between the latter communities and biological soil crusts are fluid. In a similar fashion, there is no strict dividing line between the cyanobacterial, green algal, and fungal species that occur in soil-crust communities, yet are also found in a multitude of additional habitats (e.g., intertidal mates, tree trunks and leaves, rock faces). Multiple names have been applied to biological soil crust. These communities have been referred to as cryptogamic, cryptobiotic, microbiotic, microfloral, microphytic, or organogenic soil crusts. Evans and Johansen (1999) discuss the implication of the different expressions. Biological soil crust is the broadest term which clearly states that these crusts are dependent on the activity of living organisms, in contrast to physical or chemical crusts. In addition, the term biological soil crust lacks taxonomic implications, and thus is broadly applicable to all soil crusts, regardless of their species composition [4].

As one of the most important biological factors that maintain the stability of soil surface, BSC are essential components of healthy desert ecosystems, and have critical ecological functions in the arid and semi-arid regions. Studies of BSC in the arid and semi-arid regions revealed that the major environmental factors influencing BSC distribution are vegetation cover, precipitation frequency, topography, and disturbance. Ecological roles and ecosystem services of BSC have been documented by a large body of literature. In practice, although BSC are an important type of surface cover that occur on sand dunes after their stabilization by re-vegetation with sand-binding vegetation, the effects of BSC on the stability and sustainable development of sand-binding vegetation have not been sufficiently evaluated to date. Since the 1970s, re-vegetation has been an important method and effective approach employed to control the expanding and hazardous sand dunes in northern China. Biological soil crust strongly influence terrestrial ecosystems. Once sand-binding vegetation has been established on sand dunes, BSC are colonized and gradually develop from cyanobacteria dominated crusts to lichen and moss dominated crusts on dune surfaces. BSC could be used to determine sand-binding vegetation changes via altering soil moisture and water cycling using long-term monitoring data and field experimental observation. BSC changed the spatiotemporal pattern of soil moisture and re-allocation by decreasing rainfall infiltration, increasing topsoil water-holding capacity and altering evaporation [5, 6].

4. Analysis of biological soil crust in the management of rocky desertification

Karst rocky desertification is an important ecological and environmental problem restricting the sustainable development in the southwest of China. To address this issue, investigations and sampling sets of bryophytes were carried out in Zhiyudong mountain area of Yunnan province. The resulted showed that there were 11 families, 25 genera and 53 species of bryophytes. The decreasing order of richness and species of bryophytes were: no rocky desertification area (number of species: 34, richness index: 2.87) > mild rocky desertification area (number of species: 14, richness index: 0.19) > moderate rocky desertification area (number of species: 12, richness index: -1.17) > serious rocky desertification area (number of species: 7, richness index: -1.89); the difference of species coefficient in rocky desertification area were small: 0.3750(serious rocky desertification area with moderate rocky desertification area), 0.3077(the serious rocky desertification area with mild rocky desertification area), 0.3846(the moderate rocky desertification area with mild rocky desertification area). The resulted indicated that bryophytes could be the pioneer plants in karst rocky desertification area [7].

Perennial and devastating mining has make a mass of limestone exposed to the earth surface and the environment degraded seriously on Laowanchang gold deposit. After analyzing the biomass and saturated water absorbing capacity of the dominant mosses which are collected from limestone and lateritic gold sites in Laowanchang gold deposit, find that, on limestone, *Didymodon vinealis*, *Timmiella diminuta*, *Tortula yunnanensis*, *Didymodon rigidulus*, and *Anomobryum gemmigerum* are dominant mosses, with a biomass of 859, 364, 292, 228, 215 g/m^2, respectively and their saturated absorbing water capacity are up to 1 780, 9 170, 1 530, 2 980, 2 120 g/m^2, respectively. On ateritic gold sites, *Didymodon vinealis*, *Pogonatum neesii*, *Didymodon rigidulus*, and *Anomobryum gemmigerum* are dominant mosses, with a biomass of 854, 596, 333,158, 134 g/m^2,respectively and their saturated absorbing water capacity are up to 3 070, 10 020, 1 440, 1 710,4 130 g/m^2, respectively. These results show that *Didymodon vinealis* which owns the largest biomass is the main producer on limestone and lateritic gold sites and its saturated water absorbing capacity is very high, too. According to the analysis, it is found that the saturated water absorbing capacity is related to the biomass significantly, which means the mosses, having large biomass, are able to absorb large quantity of water. Especially, *Didymodon vinealis* are of important realistic significance function to the desertification control of limestone areas and the soil and water conservation in this mine[8].

5. Conclusion

Bryophyte as one of the main part in biological soil crust is pioneer plant of rocky desertification area, which saturated water quantity is closely related to its biomass, moss with larger biomass has strong water absorption ability. In the absence of soil, serious soil erosion and vegetation destroyed areas, bryophytes using its unique ecological functions in desertification control, water storage effect and function of soil, vegetation restoration and ecological management, which play a very important role. The composition of biological soil crust including cyanobacteria, green algae, lichens, mosses and other organisms, most of them can survive in very extreme environment, and through its own metabolism change the environment, keep the soil and water conservation effect. Use of biological crust in rocky desertification areas to control soil and water loss, as a kind of ecological measures, can use local materials, low cost, pollution-free characteristics, its application prospect is very broad. At present, the biological crust of rocky desertification area development, distribution and its ecological effect is still subject to further study.

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