Research Progress on The Relationship between The evolution of Micro-geomorphology and Erosion and Sediment Yield of Colluvial Deposits of Benggang

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Abstract. The spatial pattern and micro-geomorphology of colluvial deposits of Benggang, as a secondary collapse deposits of Benggang wall erosion, are not only directly related to the sediment yield, sediment transport process of Benggang erosion, but also to the redistribution of the material on Benggang wall and slope surface. They directly affect the degree of hazard of Benggang erosion. From the point of view of the influence of micro-geomorphology on erosion and sediment yield, this paper systematically reviews the research progress of the relationship between erosion sediment yield and micro-geomorphology evolution of colluvial deposits of Benggang, and puts forward the focus and direction of future research.

1. Introduction

Benggang is the erosion phenomenon of specific geomorphology after the collapse of thick weathering (rock or soil) under the combined action of gravity and hydraulic power. It is the advanced stage of eroded gully development and the highest degradation of ecosystem in the red soil area [1]. Its annual average erosion modulus can reach 10,000 to 160,000 t/km²·a [2]–[3], and the hazard is second only to landslides and mudslides. The collapse of the collapse mound and the accumulation and re-erosion process of the colluvial deposits [4] has made the deposits of the unique spatial combination form and evolution process [5]. As a secondary colluvial deposits of Benggang erosion, it has loose soil, high content of coarse particles and large slope. It is easy to produce slope splash and gully erosion under rainfall conditions. It is the main source of the erosion sediment of Benggang. The colluvial deposits as the central link of the entire collapse open system, its soil erosion status is directly related to the erosion process and the degree of damage of the entire Benggang [6]–[7].

At present, the research on the soil erosion law of the slope of colluvial deposits has gradually matured, especially in the aspects of slope-runoff yield, sediment yield and sediment transport law, and made many achievements [7]–[10]. As a kind of colluvial deposits under a special background, the spatial pattern and micro-geomorphology are directly related to the sediment yield and sediment transport processes of collapsing erosion and the redistribution of collapse and slope materials, which directly affects the damage degree of the Benggang erosion [11]–[12]. Micro-geomorphology as an important factor affecting slope erosion and sediment production [13]–[14] has been a research focus [15]–[17]. However, the research on the influence of micro-geomorphology on erosion and
sediment yield is still in the exploratory stage. The soil erosion process and driving mechanism under the evolution of micro-geomorphology need to be further studied, especially the contribution rate and influence mechanism of the micro-geomorphology to the process of erosion and sediment production.

[11][18].

Fig.1 The field photographs of Benggang

2. Research Status

2.1. Study of erosion and sediment yield of colluvial deposits of Benggang

The sediment produced by the accumulation and re-erosion process of colluvial deposits can account for 80% of Benggang erosion, which is the most important and fastest erosion process in the whole erosion process [19]. As the main source of secondary geomorphology and sediment in the process of Benggang erosion, colluvial deposits has been paid more and more attention by scholars. A lot of research work has been carried out on the hydrodynamic process [11], water erosion process [10][18], sediment transport [8], moisture movement [20][21] and so on. Colluvial deposits of Benggang can be divided into two types: the scattered type and the sliding type [10]. They are combined with catchment slope, collapse wall, scouring channel and alluvial fan to form a complete and complex landform system of the valley basin. [2][12][22][23]. The re-erosion of the colluvial deposits is the key link in the transformation of collapsed wall soil into Benggang sediment, which directly affects the collapse wall and the redistribution of the slope material. Loose soil mass and low clay content make it easy for runoff erosion and sediment transport to occur under the action of sheet flow and stock flow. As a result, soil particles become coarser and finer from top to foot of slope, and with the increase of rainfall intensity and gradient, the composition of soil coarse particles and accumulation rate increase [7]. The difference in soil infiltration and soil water content in different parts of the colluvial deposits makes it easy for the colluvial deposits to form a gully microscopic topography under the action of raindrop erosion and runoff erosion, which directly affects the process of erosion and sediment yield on the slope of the colluvial deposits [20][24]. The effect of total rainfall and duration of rainfall on runoff and sediment yield on slopes is more obvious in tropical and subtropical regions. Special attention should be paid to the study of colluvial deposits erosion [12]. Unit flow power can well explain the characteristics of water erosion on slope surface of colluvial deposits. Upper water inflow and topographic gradient are also the main factors affecting erosion and sediment yield of the colluvial deposits [25]. The rill erosion on the slope is an important part of the water erosion process of the colluvial deposits surface, which is directly related to the morphological evolution of the entire colluvial deposits and the degree of erosion and sediment production [24].

As the central link of the entire Benggang open system, the colluvial deposits plays an important role in connecting the preceding and the following. Its own development and change directly affects the development and evolution of the entire Benggang through the mutual adjustment with the collapse wall and alluvial fan [6]. At present, although some research results have been obtained in the
research on the mechanism of erosion and sediment production in colluvial deposits, they are often limited to the analysis of soil physical and chemical properties of the colluvial deposits itself and the combination of indoor simulated rainfall experiments. Some scholars have carried out field experiments on colluvial deposits by means of field rainfall experiments, but only preliminary studies on runoff and sediment yield and water distribution on slopes have been carried out [21]. There are still limitations in the selection and acquisition of indicators for erosion and sediment production in the collapse process, mainly based on the quantitative and qualitative analysis of individual indicators [10], which cannot explain the soil erosion in a systematic and detailed way. At the same time, the law of soil erosion process on different slopes of colluvial deposits is still unclear, which needs to be further studied [12][24].

In recent years, the research on erosion and sediment yield of man-made deposits has gradually arisen. Through indoor and field rainfall and drainage simulation experiments, the response of slope erosion to water erosion, the hydrodynamic process and erosion process of deposits have been studied. [26][27]. Because the process of formation and evolution of man-made deposits is quite different from that of colluvial deposits of Benggang, the relevant research results can not be used to study and explain the complex soil erosion phenomenon of them.

2.2. Study on the effect of evolution of micro-geomorphology on erosion and sediment yield

Geomorphology, as one of the geographic environmental factors, is closely related to soil erosion. Micro-geomorphology refers to the relatively small scale of geomorphology, and it is also the smallest unit of geomorphology. It can be described by comparing the spatial combination of elements with the characteristics of geomorphology[28].The specific definitions of micro-geomorphology are also different for different research objects. On the scale of watershed research, it mainly refers to the local topographic and geomorphological forms of each geomorphic type and the combination forms of different topographic and geomorphic types of different parts of a single geomorphic type, which are mainly expressed by the micro-topographic and geomorphic indices such as slope, slope length, slope direction and the spatial combination relationship with the surrounding geomorphic types[29]. On the scale of slope research, it mainly refers to the topographic relief and spatial distribution pattern of the slope. It is mainly expressed by macro-topographic landform index factors such as topographic roughness, topographic relief, elevation variation coefficient and slope shape. [30]~[31].

Micro-geomorphology directly affects runoff, infiltration and sediment transport on slope [32][34], its evolution process is closely related to erosion process, and erosion process also directly affects the development and evolution of slope topography and geomorphology [35][36]. As an index factor of micro-geomorphology, surface roughness has been adopted by many scholars, and a lot of research work has been carried out on the influencing factors, measuring methods and the relationship between surface roughness and erosion and slope hydrological processes.

The study found that for different slope research objects, the surface roughness can reduce the slope erosion process [37], and also increase the potential erosion of the slope and increase soil erosion [38]. The relationship between surface roughness and erosion and sediment yield is still unclear, and further research on the influence mechanism of surface roughness on slope erosion process is needed. In the past, the detailed quantitative information on the surface roughness during the erosion process was extremely limited. The empirical index model [36] was used to estimate the surface roughness, and the relationship between micro-geomorphology and slope runoff and sediment yield was studied [39][40].

With the introduction and application of high-tech such as 3 d laser scanning and close-range photogrammetry [18][41][44], making microtopography quantitative, diversified, and procedural forms of morphologies have become possible. The macro and micro geomorphological factors have been applied to the study of soil erosion, which provides a new idea for the study of micro-geomorphological morphology and the dynamic process of soil erosion. However, due to the scale and complexity of micro-morphology, the change of micro-morphology pattern and its influence
mechanism on erosion and sediment yield in the process of soil erosion need further systematic and in-depth study.

In the research field of Benggang erosion mechanism, the research on the impact of micro-geomorphology on soil erosion process is still in the preliminary exploration stage. The main method is to extract micro-morphology parameters such as slope roughness of artificial remolded colluvial deposits by means of indoor simulation experiments and advanced technologies such as three-dimensional laser scanning, and to correlate with runoff, sediment and sediment transport processes. The influence of micro-geomorphological characteristics of colluvial deposits on runoff and sediment yield on slope is analyzed and studied. [10][18]. However, the indoor artificial simulated the slopes of colluvial deposits currently have some defects in reducing the field colluvial deposits. The parameters of micro-geomorphological morphology collected are not comprehensive and detailed enough to systematically and comprehensively clarify the driving mechanism and contribution rate of micro-geomorphological morphology to erosion and sediment yield of colluvial deposits.

3. Conclusion and Prospect

As a unique geomorphologic landscape of Benggang erosion and a major source of erosive sediment, the colluvial deposits has both spatial and temporal scales. At present, it is necessary to carry out in-depth systematic research from the following aspects:

1) As a key factor affecting soil erosion, micro-geomorphology is still in the preliminary exploration stage in the study of the mechanism of colluvial deposits erosion. The micro-geomorphological parameters still need to be further classified and refined[10]. At present, qualitative analysis is mainly used.

2) At present, the study on erosion mechanism of colluvial deposits is mainly based on indoor simulation experiments, and only the simulated slopes with different gradients are taken as the research objects. The relevant research results are difficult to extrapolate. In view of the particularity of micro-geomorphology and soil erosion process of Benggang, field in-situ monitoring and process simulation experiments should be strengthened.

3) Based on the results of current research on micro-geomorphology and soil erosion process, as well as the research status of the mechanism of Benggang erosion, it is necessary to further refine the parameters of micro-landform and slope soil erosion process, carry out the analysis of micro-geomorphology characteristics of colluvial deposits and its impact mechanism on erosion and sediment yield.

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