The Study on the Sediment Production and Transportation on the Loess Hill Regions in the Eastern Parts of Inner Mongolia

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Abstract: The main production layer in loess hill region of in the eastern parts of Inner Mongolia is the loess, Pisayan, and Aeolian sediment. In which the Huangpucuan watershed sediment yield modulus is loess 17,000t/(km^2 • a), Pisayan 23,000 t/(km^2 • a), Aeolian sediment 1,400 t/(km^2 • a), in the Hunhe watershed loess reaches 5,200t/(km^2 • a)—7,500 t/(km^2 • a). Overland and cleuch have the same law on the sediment yield production and transport.

Keywords: sediment yield layer, sediment yield modulus, sediment yield transport, loess hill region

1 The surrounding of erosion

The loess hill region in the eastern parts of Inner Mongolia belongs to the north China platform at the edge of the loess plateau, loess accumulation depth changes greatly, it is situated in the monsoon climate and non-monsoon climate transition belt, the annual precipitation reaches 400mm as a semiarid climate. The native vegetation was shrub steppe or typical grassland, due to the unfavorable human activity in the history, most of the native vegetation is destroyed and substitutes for the secondary grassland and man-made vegetation, the vegetation coverage rate is low.

2 Sediment yield features

2.1 Erosion sediment yield layer

The Huangpuchuan and Hunhe is located in the loess hill region in the eastern part of Inner Mongolia as the first tributary of the Yellow River, Erosion sediment includes the Quaternary period loess, Pisayan, the Tertiary red soil and Aeolian sediment which contribute much to the coarse sand in the Yellow River.

2.1.1 Loess

The loess in the region belongs to sand loess, due to the later formation, the soil structure is loose with weak anti-erosion ability, The coarse sand with grain-size over 0.05mm make up for 78% of the total sand.

2.1.2 Pisayan

The Pisayan is the common saying for the Tertiary bed rock in the Huangpuchuan watershed including the Dyas, Triassac, Jurassac and Cretaceous system layer. The Pisayan was the clastic sedimentation for arenaceous rock, siltstone and mudstone, sometimes for the conglomerate and the shale. The Pisayan diagenesis is poorer with calcareous and argillaceous cemented, is easy for wind erosion.

2.1.3 Aeolian sand

The Aeolian sand is distributed discontinuously as band, sheet covered on the bed rock or loess, sand with grain-size over 0.05mm make up for 95% of the total sand. The Aeolian sand has gentle slope and integrity topography.

2.2 The sediment yield rate in different layer

The erosion sediment yield rate in different layer is determined using silt deposition data in the small reservoir-dam and the sediment discharge record by the hydrological station located in the same region.

2.2.1 The erosion sediment yield rate in the loess

The Huangpuchuan watershed has 240 small reservoir-dam with silt deposition data observation, it shows that the average erosion modulus reaches 17,700 t/(km^2 • a), the sediment discharge recorded in the Hejiageleng hydrological station plus the local reservoir deposition is 16,100 t/(km^2 • a). The comprehensive analysis results the erosion sediment yield rate in the loess reaches 17,700 t/(km^2 • a). The sediment modulus in the Hunhe watershed is calculated using the average 4 year observation data at the Kakou station before small watershed control project located in the Heling county, it is 5,638 t/(km^2 • a).

Table 1 shows sub-zone runoff erosion on the 2 watershed in the loess layer observation data, although it has a limited representitiveness in the whole hillside, it also shows some basic feature of sediment yield in the region.

Table 1 Sub-zone erosion with different slope

huangpuchuan	Slope(°)	3	6	12	20	25	40	50
	Erosion(t/(km^2 • a))	473	717	1,838	3,257	3,742	5,333	7,120
hunhe	Slope(°)	5	10	15	20		28	
	Erosion(t/(km^2 • a))	722	1 616	1,375	1,155		1,160	

2.2.2 The erosion sediment yield rate in the Pisayan

The Pisayan exists in the flatriges, mound, cleuch, but most appears in the cleuch, To determine the erosion sediment yield rate in the Pisayan need the surveying of the typical small reservoir-dam with the watershed covered by Pisayan at least 70%. The method using reservoir-dam deposition calculated the erosion sediment yield rate in the Pisayan is 26,000 t/(km^2 • a). Considering the deposition has some bed load, besides the 10 years effect of measures of soil and water conservation led the sediment decrease, the erosion sediment yield rate in the Pisayan is 23,000 t/(km^2 • a).

2.2.3 The erosion sediment yield rate in the Aeolian sand

The small reservoir-dam in the Aeolian sand is rear. From 4 small reservoir-dam with 80% Aeolian sand watershed analysis, the results shows that the maxim erosion sediment modulus is 2 423 t/(km^2 • a), while the minimum erosion sediment modulus is 529t/(km^2 • a), the average is 1 400 t/(km^2 • a).

2.3 The calculation model for the erosion sediment yield

Based on the 4 hydrological station observation data for the precipitation and sediment discharge on the Huangpuchuan, a set of erosion sediment yield model is established on the loess and Pisayan region.

Loess: $s=0.07p_f^{2.174}(p_{7+8}/p_{6+9})^{0.338}$ $r=0.53$

Pisayan: $s=0.07p_f^{1.772}(p_{7+8}/p_{6+9})^{0.443}$ $r=0.88$

In which, s is the annual erosion sediment yield, 10^4t, p_{7+8} is the precipitation in July, Aug., p_{6+9} is the precipitation in June, Sep., mm, p_f is the precipitation on the rainy season, r is the correlation coefficient.

Through the calculation test, the loess model calculation error is 0.139, the Pisayan is 0.045.

3 Erosion silt transport feature

3.1 Erosion silt transport feature on the hill slope

Based on the statistical analysis of the runoff and sediment on the 2 watershed with different degree

of slope and the 10° degree slope runoff sub-zone sediment process observation, there is a strong correlation between the runoff and the rain intensity. The hill runoff variation lags the rain variation. If the sediment concentration variation can represent the sediment variation, in the process of runoff-rain the sediment concentration has positive relation with the runoff, the sediment concentration increase sharply with the flow increase, when the sediment concentration reaches some point, its change is weaker than the flow variation, the sediment concentration maxim don't appears at the same time with the flow.

3.2 Erosion silt transport feature on the cleuch

In order to study the erosion and sediment transport process on the small watershed, 2 control station on the small watershed is established in the Huangpuchuan and Hunhe watershed respectively. Through the statistical analysis of the runoff and sediment on the 4 small watershed, it shows that there are positive relation among the amount of the flow, the sediment concentration, the precipitation and its intensity, the flood has the feature of flush and steep subsidence on the time curve. In the watershed area between 0.03 km^2—3.2 km^2, before and after the watershed control there is little difference on the sediment transport process, only in case after the watershed control both the flood peak runoff and the sediment concentration decrease more than 50% than before the watershed control. For example in a storm runoff and the sediment concentration process in the small watershed in the north and south ditch on the Hunhe river, the maxim sediment concentration can reach 1,070kg/m^3 in the flood, average sediment concentration is 880 kg/m^3, all belongs to the high sediment concentration flow. In the zone among the high sediment concentration, the sediment concentration variation is weaker than the flow variation, this is same to the results from the sub-zone sediment transport in the hill slope runoff. The flow variation in the cleuch affected by the precipitation intensity is weaker than in the hillside, the flow process usually have a unipeaked or bipeaked distribution, multiple-peaked hydrograph is rear.