Probe to Integrated Soil Conservation Techniques for Soil Erosion Prevention in Soft Rock Area

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Abstract: Soft Rock Region is an important parts of coarse sediment sources in Yellow River Basin. It is also one of the two sand storm sources of China. If you want to essentially prevent coarse sediment from silting in the lower reaches of Yellow River, control the spreading over range of sand storm and realize the better cycle of local ecological environment, you must treat the soft rock area integratedly and concentratedly. The paper studied the systematic techniques for controlling gully erosion on the basis of the experiment results of sediment retention by "flexible dam" in the area. The paper also presents a operational treatment model and mathematical formulas and makes an example planning of 510 small watersheds in Huangfu River.

1 Issues

Soft rock region locates in Dongsheng district, Zhunger Banner, Yijinhuolo Banner, Dalate Banner of Erdos City of Inner Mongolia and Shenmu county, Fugu county of Shaanxi Province with the area of 11.7 thousand km^2 where exposed area is 6.3 thousand km^2, sand-covered area 2.6 thousand km^2, earth-cover area 3.1 thousand km^2. Soft rock indicates thick sandstone, sand shale and mudstone in the Paleozoic Era, Mesozoic, Jurassic and the Cretaceous Period. This is the core area of bedrock oddment yield area in Loess Plateau which is an important part of coarse sediment yield in Yellow River. The characteristic of soft rock is that it is hard as stone when it is in dry and soft as mud when it is in wet as well as it is weathering when wind is blowing [1]. Because of strong frost-frozen action, loose layer on gully slope is 5cm—10cm[2]. This was proved by Ma Ainai[3]. For biology is hard to live in the area, local farmers describe the kind of rock as arsenic and call it soft rock.

Here landform is fragment, vegetation is rare, climate is dry, precipitation is less and more wind-sand storm, so is hard to treat. For long time, it couldn't be treated thoroughly. Since the 1980s, the government has implemented key dam for soil and water conservation and seabuckthorn ecological construction. This has settled better base for accelerating local soil erosion control.

The paper is focus on the integrated gully treatment technical system for rapid ecological rehabilitation and land and water development, at the same time seeking a operational model for soil erosion control in soft rock area radically.

2 Integrated soil and water conservation techniques for soil erosion control

The practice for several decade years proved that any single soil and water conservation techniques could not change soil erosion situation. You must carry out varied techniques so as to control soil erosion by aiming at soil erosion characteristic in the region.

(1) Soil erosion process

① There are eight months for non-runoff soil erosion such as frost-frozen and weathering. In 1988, the authors measured frost-frozen and weathering depth be 5cm in eastern No.1 branch of Xizhao gully. During 1999 and 2000, we set up 4 four frost-frozen and weathering spots in the upper section of Xizhao gully from No.1 key dam. After one year observation, the averaged frost-frozen and weathering depth was 1.94cm, the maximum was 3.5cm. In accordance, the frost-frozen and weathering depth was 5cm—10cm in Huangfu river. The changing process is of frost-frozen and weathering then desquamating in a cycle way. Therefore a large quantity of oddment materials piled up in the foot of gully slope. According to the investigation and calculation, the authors estimated that non-runoff sediment yield in ravines is about 90% of the total.

② Sediment discharge concentrates in several rainstorms during flood season especially in the first rainstorm of a year. Rainstorm here usually is in large quantity and short time. On the basis of observed data, rainfall duration with intensity more than 0.5mm/min is generally 15min—180min. Except dune area, duration of rainstorm in mini-gully is about 20min—60min. Flood is in the form of strand flow which sediment discharge capability is strong. The strong strand flow transports loose materials piled up in the gully feet. Because the gully bed ratio is between 1/10 and 1/100, strand flow will erode gully bed and banks after transporting materials piled-up in the gully.

③ Eroded sediment yield on slopeland is less than that in gully. Here is the bed of Erdos lake. After thousands of years erosion, big-sized grain remained. Including coarse grains covered up fine gains, so sediment yield on slopeland is less and wind erosion is more on cultivated land.

(2) The integrated soil and water conservation techniques for soil erosion prevention

① On the basis of soil erosion process in the region, we found soil erosion mainly appears in the developing gully head. If you want to control sediment yield source essentially, you should firstly control gully head and gully bank expansion. These are the key parts for soil erosion prevention. Based on the ten-year research on the experiment of plant “flexible dam” in soft rock region which has succeeded, we are sure that seabuckthorn can be used as dam works materials. As long as seabuckthorn is planted crossing flowing direction with certain distance between rows and individual plant in gully, then flexible dam system is arranged. The dam system will be entirely established within 3 years. This can either retain sediment or recover ecological environment. You will be benefit from such dam system for ten years. The authors have found the “flexible dam” techniques for preventing gully head erosion.

② In order to promote replacing slope farmland by trees and shrubs, recovering natural grassland, you must seek for high-yield farmland for replacing slope farmland. So you must use flat gully bed in the third and the fourth gully. You also must build high-yield farmland through building warping dams, key dams and techniques of artificial wetland and artificial bankland.

③ To build mini-reservoir in gully mouth for flood regulation.

The above mentioned “flexible dam” system techniques, rigid warping dam techniques, key dam and mini-reservoir techniques have formed a technical system for soil erosion prevention of quick gully ecological recovery, sediment retention, water storage and land regulation in small watershed. But key technique of the system starts from “flexible dam” which is the principal part of watershed ecological rehabilitation.

3 The sustainable development gully treatment model

By taking plant “flexible dam” as the principal part of sediment retention works, dam land, artificial wetland and artificial bank land as the main components of basic farmland, key dam as support and mini-reservoir as guarantee, the formula will be formed that coarse sediment will be retained in gullies, fine sediment will be retained in artificial bank land and dam land, artificial wetland and dam land produced between dams. This can increase runoff infiltration. And mini-reservoir will store all runoff not infiltrating[6][7]. So the objectives will be reached such as water and sediment will be treated separately, water and sediment is balanced, ecology is balanced so to get sustainable development. The following models are given in terms of a 20km^2 small watershed.

Basic model: $$F_d + W_d + K_d + V_d \quad (1)$$

Expanded model: $F_d+W_{dU}+W_{dL}+K_d+K_{dU}+K_{dL}+V_d$ (2)

F_d——plant "flexible dam" system in the fourth and fifth small gully of Yellow River.
W_{dU}——warping dam in the upper reaches of the fourth gully in accordance with the controlled area.
W_{dL}——warping dam in the lower reaches of the fourth gully.
K_d——key dam in the upper reaches of the third gully of Yellow River.
K_{dU}——sediment retention from parts between dams, runoff retention from main gully.
K_{dL}——runoff retention from part between dams, sediment retention from uncontrolled area.
V_d——mini-reservoir at outlet of the third gully of Yellow River.

4 The collocating number of rigid dam and flexible dam for the integrated gully treatment model in the form of sustainable development

The mentioned above integrated sustainable development treatment model in the soft rock region is concluded from the example collocation of rigid dam and "flexible dam" in Xizhao gully of Wulanmulun river. According the example, the collocating dam number in a small watershed with the area of 20km^2 is in the following table:

Works name	Mini-reservoir	Key dam	Warping dam	Flexible dam
	V_d	K_d	W_d	F_d
Quantity	1	3	9	81

Form the table above, you can find the relationship between dams as bellow:

$$V_d = 1 \tag{3}$$

$$K_d = 3V_d \tag{4}$$

$$W_d = 3K_d \tag{5}$$

$$F_d = 9W_d = 81V_d \tag{6}$$

At present, these formulas can be used as a guidance to practical action. In the soft rock region, they can be used as planning and construction regulations in gully treatment. These formulas also indicates that a better collocation ratio for integrated soil and water conservation techniques in preventing soil erosion in gullies under the function of "flexible dam". The collocation ratio expresses "flexible dam" to be in the position of principal part. i.e. it relies on "flexible dam" to rehabilitate gully head ecological environment and coordinate the proper ratio of gully works after retaining coarse sediment produced in gully head section. Meanwhile, it expresses the time sequence effect along gully bed.

According to the above formulas, we try to do a planning of soil and water conservation works in 510 small watershed in of Huangfu River with the total area of 3,240 km^2. Supposing the base small watershed area is 22.8km^2, the planned dam number will be:

$$V_d = 142$$

$$K_d = 3V_d = 426$$

$$W_d = 3K_d = 1{,}278$$

$$F_d = 9W_d = 11{,}502$$

5 Conclusion

The paper has provided the integrated soil and water conservation techniques for soil erosion

prevention in soft rock region, and given a full and systematic treatment model, also the quantitative relations of the model. The model can separate coarse sediment from fine sediment and retain them all in mini-gullies. This does not only prevent soil erosion radically, eliminate coarse sediment the danger to lower reaches and reservoir in the main channel of Yellow River, but also can replace slope farmland with basic farmland in gullies so as to promote to replace slope farmland with trees and shrubs. All of these can provide better basis for sustainable development in the region.

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