

Research progress and harnessing method of soil and water loss in Pisha Sandstone region

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Abstract. Pisha Sandstone region is the most vulnerable and the most dramatic area of soil erosion, severe soil erosion on the ecological bases of China's energy security constitutes a serious challenge. Research progress of soil erosion in pisha Sandstone region was reviewed based on the need of soil and water ecological construction in Pisha Sandstone region and harnessing the yellow river including soil erosion mechanism, soil erosion dynamic monitoring and soil erosion simulation assessments. Meanwhile, the latest progress of soil and water conservation measures was analyzed, and the existing problems and future harnessing measures of soil and water loss were discussed. This study is to explore the comprehensive management method and provide scientific theory for constructing soil and water conservation project in Pisha Sandstone region.

1. Introduction

The soil erosion modulus reached 30,000-40000 t/ (a•km²) in the Pasha Sandstone area of the upper Yellow River, which is the most vulnerable and the most severe soil erosion in the loess plateau (Fig.1). The Pisha Sandstone area of 16,700 km² mainly distributed in Inner Mongolia, Shaanxi and Shanxi province of northern China, the amount of sediment entering into the Yellow River has averaged nearly 200 million ton over the years [1]. The lower reaches of the Yellow River became known as the "suspended river" for large number of coarse sediment deposition from the Pisha sandstone area, which will bring the great threat of flood control safety the Yellow River. After years of harnessing, ecological environment in the loess plateau regional has improved, but soil and water loss is extremely strong in the Pisha sandstone area for its special geological conditions. Pisha sandstone is very hard under dry condition, but it is easily to become fragile for eroding water. Soil erosion control technology still didn't solve the key scientific problems in the Pisha sandstone currently, especially the development and construction projects such as mining, roads and other human activities are growing the ecological deterioration has not been effectively curbed. The improvement of the ecological environment and the reduction of coarse sediment into the Yellow River are still major ecological challenges and still constitute an important factor for the flood control safety threats in the lower reaches of the Yellow River. Based on this, soil erosion control measures were reviewed for sandstone areas in this article. This study is helpful to get the comprehensive management method for constructing soil and water conservation project in Pisha Sandstone region.



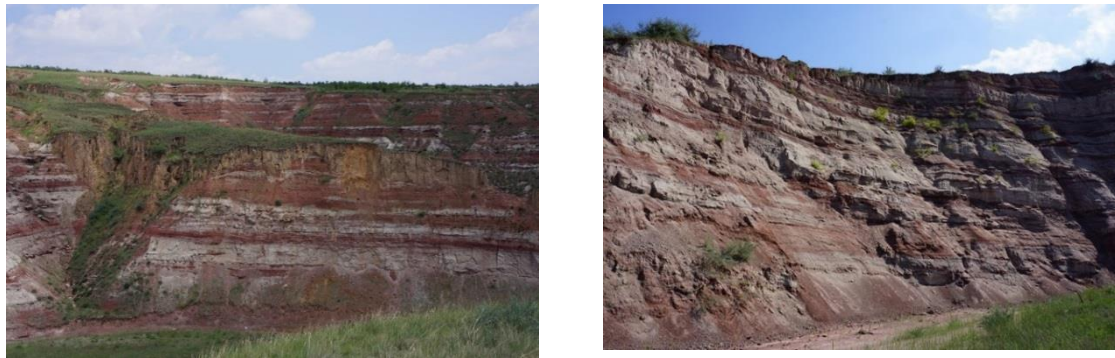


Figure 1. Erosion environment in Pisha Sandstone area.

2. Research progress of studying soil and water loss

2.1. Soil erosion mechanism in the Pisha sandstone area

In recent years, some research work has been carried out on the soil erosion mechanism of the Pisha sandstone area. Wang analyzed different erosion sediment sources in a type typical small watershed, the results showed that the sediment is mainly from the gully-slope, accounting for 79% - 84% of total output of small watershed sediment [2]. Shi *et al.* showed that the erosion of the Pisha sandstone area is so intense, which is related with the mineral composition, chemical composition, lithologic composition, particle size composition, structural characteristics and engineering properties. The weak cementation of mineral calcite is the most cause to resist erosion, and the weathering feldspar and montmorillonite also had played a huge role in decreasing the corrosion resistance [3]. Tang *et al.* analysed the natural observation data of the physical and chemical properties in 1983-1997 and showed that the amount of sediment yield was higher than the local loess and sand [4]. Bi and Wang pointed out the gravity and wind erosion for short distance of soil erosion, and the rainstorm runoff is the main transport power of long distance transport from the top of slope and gully slope to gully bed eventually making rain formation sand transport [5]. Su and Zhang studied the relationship between the sediment yield and runoff resistance coefficient, Froude number using field water scouring experiment [6].

2.2. Soil erosion monitoring in the Pisha sandstone area

Some research results have been done on the monitoring experiment on the effectiveness of soil and water conservation measures in the Pisha sandstone area. Yang and Li did the experiment of retaining the runoff and sediment of the plant flexible dam and showed that the channel of flexible dam is deposited using sediment grain size distribution analysis and the ability of retaining the sediment is obvious [7]. Yang and Li studied the improvement effect of seabuckthorn plants on the channel according to the soil organic matter data monitored in the Pisha sandstone area. The results showed that the soil fertility was improved greatly and the growth ring of plant community was improved [8]. Ye *et al.* studied the rate of sediment deposition in southern Inner Mongolia using high precision of GPS dynamic measurement technology and analysis functions of MAPGIS combining with the depositional cycle of warping dams and showed that the average annual deposition rate of warping dams is 10371 t/(a.km²) [9]. Gao and Jiang studied the change of land use of Changchuan watershed in according to the image data of Landsat-MSS in 1976 and Landsat TM image data of 1987 and the 2000 and showed that the order of the distribution in the area of land use is shrub forest, grassland and unavailable land, the area of the three land use types accounted for 75% of the total area of the study area [10].

2.3. Soil erosion assessment in the Pisha sandstone area

Ye *et al.* verified the applicability of WEPP model to soil erosion simulation of forestland, grassland and fallow land in three different ways of land use of slope in the Pisha sandstone area based on the meteorological and soil erosion data in 2004-2009 and showed that the soil erosion simulation result is good [11]. Gui *et al.* carried out the application in the evaluation of seabuckthorn ecological function by the BP neural network and constructed a BP artificial neural network model [12]. Xu and Gao evaluated effects of different soil and water conservation and returning farmland to forest (grass) measures on soil erosion and showed that the influence of soil and water conservation biological measures, engineering measures and returning farmland to forest (grass) in reducing soil erosion benefit is remarkable [13]. In addition, Wang *et al.* studied seabuckthorn plantation ecosystem service function evaluation using the method of frequency analysis and expert consultation method and constructed the principle of soil and water conservation, nutrient accumulation, biodiversity conservation, forest protection and the index system including soil, fertilizer, soil erosion modulus, soil organic matter content, soil nitrogen fixation rate [14].

3. Research progress of soil and water loss law in the area

3.1 Biological measures

In the 1980s, some researchers found that the seabuckthorn could be adapted to the growth in the Pisha sandstone area. In 1985, exploiting the seabuckthorn as a breakthrough to accelerate the management of the loess plateau the new strategy of biological control of soil and water loss. Bi and Li pointed the idea of using the seabuckthorn flexible dam to resist soil erosion [15]. By the use of fluid dynamic obstacles blocking water by planting hippophae in mountain ravines, flood and sediment was deposited. Because the seabuckthorn plant has the function of blocking sand, and can cross water, it is called the plant "flexible dam" (Fig. 2). In 1992, the experimental study on the flexible dam of the plant in the xizhaogou watershed in the Inner Mongolia dongsheng district was carried out. In 1998 Ministry of Water Resources launched the project of seabuckthorn ecological engineering using seabuckthorn for controlling soil and water loss and have played a role in reducing soil and water loss [16]. Wu and Hu calculated the flood and sediment reduction benefits by planting hippophae and showed that the proportion of seabuckthorn forests in the total forest area increased year by year, flood and sediment reduction benefit increased consequently [17]. Wang and Wu made a survey of soil and water conservation measures and pointed out the biological measures with seabuckthorn as a breakthrough for the development of biological measures to governance [18]. So, it is necessary to combine the technology of "flexible dam" of seabuckthorn plant with large and medium block as the skeleton as the main body of silting dam and the construction of a branch dam.



Figure 2. "Seabuckthorn Flexible Dam" in Pisha Sandstone area.

3.2 Engineering measures

Engineering measures of controlling soil and water loss including gully head engineering, slope protection engineering (including terrance, level trench, and scale-hole, river bank piece, intercepting

ditch, etc.), the channel engineering (including shuitangba, check dam and small held engineering, warping dams, etc.). In fact, due to the low degree of pisha sandstone diagenesis, difference of degree of consolidation between sand grains, the structure strength is low, and the original rock particle coarse, porosity is big, easy to collapse under the influence of water, weak ability to resist water scouring, therefore, it is difficult to directly to pisha sandstone as warping dam material, this greatly restricted the warping dam construction in the region. Although the soil and water conservation science experimental station in has been carried out on the construction of the silt dam in the area of the sandstone, the materials used mainly are the deposited sediments and the sandstone weathering materials, which have a fine particle size. At present, there is no case of the construction of silting dam using the original sandstone.

Recently, the technology was developed with sand and pisha sandstone to become field land [19]. The study was based on pisha sandstone and sand having two substances in the soil with the principle of complementarily by reasonable tests. However, the technology is mainly used for sand reclamation, and it is difficult to solve the problem of soil erosion control in large areas of the area. Other researchers did the experimental study of EN-1 on the stability of the slope soil solidified mechanism using natural slope erosion test, laboratory soil test and artificial slope erosion simulation test with the combination of research methods [20]. EN - 1 was developed to protect slope in the late 1950 s, can't satisfy the solid resistance with hydraulic erosion, gravity erosion and wind erosion interaction coupled erosion environment. Therefore, the anti-erosion material measures and the modification of damming materials are still new researches.

4. Further research direction of soil and water loss

In view of the weak points of soil erosion research, the direction of the pisha sandstone areas of soil and water loss should be strengthened to slope-channel system or small watershed as erosion and sediment yield geomorphic unit of sediment transport research. Soil and water conservation measures in pisha sandstone should include material, engineering, biological measures. In terms of erosion mechanism, the mechanism of erosion dynamics and the mechanism of erosion are revealed. In the technological innovation, the research and development of the anti-erosion and the original rock modification technology and materials should be strengthened; in the simulation experiment, the dynamic mechanism, material properties and effects of arsenical sandstone erosion were studied through physical model and field observation. In the aspect of mathematical model evaluation, demonstration area was established based GIS to analyze and evaluate the benefit analysis and evaluation information system, and carry out the comprehensive benefit analysis and evaluation of demonstration area. Research methods should be carried out on the multidisciplinary crossover and professional work, make the soil and water loss and soil erosion model construction getting more extensive technical force support, further enhancing the level of science and technology of the pisha sandstone soil and water loss management; On the research methods, should combine remote sensing (RS), geographical information system (GIS), global positioning system (GPS), wireless communication system as well as the high and new technology such as computer network for technical support, setting up three-dimensional soil and water loss monitoring, observation and information sharing network in pisha sandstone area.

5. Conclusions

soil and water loss control technology in pisha sandstone area still lack of the project of effective erosion control measures and the original modified materials to build warping dams . Therefore, through independent research and development and the thought of integrated innovation, choose the arsenic sandstone erosion features prominent, is representative of the typical small watershed, pisha sandstone configuration of soil and water conservation harnessing technology and integration pattern research, construction of arsenic sandstone biostimulation resist integration research demonstration area, the dynamic monitoring model corrosion has comprehensive benefit of the growth in the study area and its influencing factors, to carry out the demonstration comprehensive benefit analysis and

evaluation in the study area is still an urgent need to break through and solve scientific problems and key techniques, is also the ecological fragile area of soil and water loss control technology development new trend.

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