

Progress of Soil and Water Conservation Research in the Yellow River Basin

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Abstract

From the demand of soil and water conservation work by the national strategy of Yellow River management in the new period, the progress of soil and water conservation scientific research in the Yellow River basin is reviewed, including the research of soil and water erosion law, the research of sand interception and erosion reduction effect of silt dam, the research of soil erosion prediction and forecasting technology, the analysis of water and sand reduction benefit of soil and water conservation, the research of soil and water erosion management technology, and the construction of soil and water conservation scientific research platform. At the same time, the major scientific research achievements in recent years are summarized systematically, including the distributed soil loss model in the sandy and coarse sandy area of the Yellow River, the definition of the concentrated source area of coarse sediment and water-sand changes, the identification of the arsenic sandstone area in the Yellow River basin and the key technology and application of erosion prevention and promotion. The progress and effectiveness of scientific research on soil and water conservation in the Yellow River basin are sorted out, with a view to providing references for ensuring the long-term stability of the Yellow River and promoting ecological protection and high-quality development in the Yellow River basin.

Keywords

Soil Erosion; Soil and Water Conservation; Yellow River Basin; Progress in Scientific Research.

1. Introduction

The Yellow River is the mother river of the Chinese nation and has given birth to the splendid Chinese civilization. However, the special natural conditions and frequent human activities have made the Loess Plateau the most extensive area of soil erosion and the most erosion-intensive area in the world. The serious soil erosion in the Loess Plateau area leads to fragile ecological environment and degraded ecosystem, which directly affects the stability of the Yellow River, exacerbates the development of desertification and associated disasters, and

seriously restricts the development of the ecological security protection barrier and ecological construction of the Yellow River [1,2]. The special natural environment of the Loess Plateau region determines its diverse types of soil erosion and complex causes, which is very difficult to manage. Since the founding of New China, China has been strengthening scientific experiments and research on soil and water conservation in the Loess River Basin, and has achieved fruitful results, providing technical support for the management of soil erosion in the Loess Plateau and the comprehensive management and development of the Loess River Basin. This study reviews the progress and effectiveness of scientific research on soil and water conservation in the Yellow River Basin with a view to providing reference for soil and water erosion management in the Loess Plateau in the new era.

2. Progress of Scientific Research on Soil and Water Conservation in the Yellow River Basin

2.1. Research on the Basic Theory of Soil and Water Conservation

(1) Research on soil erosion patterns. The establishment of the Tianshui Scientific Experimental Station for Soil and Water Conservation in 1942 marked the beginning of experimental observation of soil erosion patterns on the Loess Plateau in China, and the field observation work flourished afterwards. The experimental stations mostly adopt the standard plot test method to study the quantitative relationship between soil erosion and rainfall, slope, slope length, tillage method and other factors, to determine the critical slope for slope farming land retreat, to explore the erosion method of slope farming land and its erosion and sand production process [3], to investigate the hydraulic characteristics of loess slope runoff and erosion dynamics mechanism, the response of erosion process to vegetation spatial layout, the erosion and sand production relationship of slope-channel coupled system, and the relationship between erosion and sand production of river channel system. A large number of research results have been achieved in the areas of the response of the evolution process of river system to the configuration pattern of soil and water conservation measures [4-5], which have promoted the development of erosion dynamics research in China.

In the 1960s, researchers deduced the proportion of gravity erosion sand production to total sand production in the watersheds of Nanxiaohegou, Lhiyuangou, Luyigou, and Wangjiagou based on the measured runoff-sand production relationship [6]. In the 1970s, researchers concluded that the sediment transport ratio of small and medium-sized watersheds in the middle reaches of the Yellow River was close to 1 on the basis of slope erosion and gully erosion sand production studies [7], which provided a basis for establishing Since 1980s, some scholars have analyzed the role of gravity erosion on the formation of high-sediment-bearing water flow and revealed the important role of gravity erosion on sand production in the watershed [8].

(2) Research on the role of silt dams in sand interception and erosion reduction. In the 1980s, researchers proposed the concept of relative stability of the dam system, which was inspired by the natural geomorphic dams, and the concept of "ensuring the safety of the dam system under a certain frequency of flooding, high yield and stable production of the dam under the flooding of the guaranteed frequency of harvesting, the basic use of sediment out of the ditch, the full and reasonable use of water and sand resources, and the small amount of maintenance work". Since 2000, the concept and conditions of the relative stability of the dam system have been further clarified, and the role of silt dams in solving the sediment problem in the Yellow River has been discussed [9, 10].

(3) Research on soil erosion prediction and forecasting technology. The research on the erosion and sand production model in the Loess Plateau watershed started after the founding of New China, mainly the slope erosion and sand production model was established in the 1950s and 1960s, the general soil loss equation of the United States was introduced and improved in the

1970s, and the prediction of sand transport process was started in the 1980s. Since 2000, with the financial support of the Ministry of Water Resources, we have carried out research projects such as "Research and application of mathematical model for sand production in sandy and coarse sandy areas of Loess Plateau" and "Research on coupling technology and application of multi-scale spatial watershed model", and established a small-scale erosion and sand production mechanism that can be applied. We have established heterogeneous and heterogeneous models such as basin-scale erosion and sand production mechanism model, secondary rainfall flood sediment operation prediction model, and mesoscale watershed and regional-scale annual soil erosion prediction model [11], and they have been applied in watershed comprehensive soil and water conservation management planning and water conservation measures effect evaluation.

(In the 1940s, with the establishment of runoff cells and small watershed runoff and sediment observation stations in the main types of Loess Plateau, researchers began to observe and study the effectiveness of soil and water conservation measures in sand control. Especially from the 1980s, the Yellow River Institute of Water Conservancy and related units have analyzed and evaluated the characteristics and applicability conditions of each calculation method and its related models, quantitatively analyzed the role of natural factors and human activities, and provided scientific basis for macroscopic decisions on the management of the Yellow River [12].

2.2. Soil Erosion Management Technology Research

(1) Management model. Since the founding of New China, soil erosion control in the Loess Plateau has been innovated in practice, and the control mode has gradually changed from single control to a combination of engineering, biological and farming measures, from scattered control to concentrated and continuous scale control, highlighting the construction of ditch and dam system, and from single benefit to comprehensive ecological, social and economic benefits. In 2016, the "Loess Plateau Water and Soil Erosion Management Standard" proposed the integrated management model and its optimal configuration of measures in the Loess Hills and Gullies, Loess Plateau and Gullies, Wind and Sandstone Areas, which realized the spatialization and typology of management measures.

(2) The spatialization of control measures and the quantification of type configuration.

(In the 1950s, researchers carried out research on engineering, planting and tillage measures, including dam construction by water fall, directional blasting, terracing and planting grasses by flying. In 1985, the research and promotion of water fall dam construction won the second prize of the National Science and Technology Progress Award [15]. 1992, Bi Cifen et al. carried out experimental research on the flexible dam of sea buckthorn plants in arsenic sandstone areas and established the theoretical framework of plant sand control [16].

In the 1960s, a large-scale construction of terracing on sloping land was carried out on the Loess Plateau, and great results were achieved. in the mid-late 1980s, the transformation of sloping land entered a low tide, and the development almost came to a standstill. since the 1990s, the construction of terracing has reentered a faster development track, exploring a sustainable development path for arid areas that combines governance and development, and harmonious living between human and nature [17].

(3) Arsenic sandstone area anti-erosion and promotion of management technology. Based on the "12th Five-Year Plan" national science and technology support project "integration and demonstration of anti-erosion and promotion technology in the middle reaches of the Yellow River arsenic sandstone area", the Yellow Academy of Sciences has developed anti-erosion and promotion materials for arsenic sandstone and modified dam building technology for arsenic sandstone in the middle reaches of the Yellow River arsenic sandstone area [18]. 18], constructed a three-dimensional configuration technology and model of anti-corrosion and promotion measures in the arsenic sandstone area [19], explored a new way of comprehensive

management of soil erosion in the arsenic sandstone area in the middle reaches of the Yellow River [20], built a 20,000 m² slope channel binary three-dimensional configuration consolidation and promotion demonstration project and a 32,600 m³ reservoir capacity silt dam modification demonstration project, and achieved the innovation of basic principles and key technological breakthroughs in the field of soil and water conservation in the loess plateau in the arsenic sandstone area. and key technology breakthroughs.

2.3. Soil and Water Conservation Research Platform Construction

In the early 1940s, the experimental research on soil erosion runoff plots on the Loess Plateau started at Liangjiaping experimental base in Daliushugou in Tianshui, and in the 1950s, the experimental research on runoff plots was extended from Tianshui to the Loess Plateau gully area represented by South Xiaohegou in Xifeng, Gansu, and the first sub-area of the Loess Hills gully area represented by Suide Leek Garden Gully in Shaanxi, forming a representative experimental research layout of the main soil erosion types in the middle reaches of the Yellow River. A representative experimental research layout of the main soil erosion types in the middle reaches of the Yellow River [21]. In the 1970s, researchers began to focus on artificial rainfall simulations to make up for the long period of natural rainfall and the lack of data. Since the 1990s, CAS and MWR have established the "State Key Laboratory of Soil Erosion and Dryland Agriculture on Loess Plateau" and the "Water and Soil Conservation Ecological Engineering Technology Research Center of MWR", which have created a good scientific research platform for the research of soil erosion control on Loess Plateau.

In 2011, the "Key Laboratory of Soil Erosion Process and Control on Loess Plateau of Ministry of Water Resources" was approved by the Ministry of Water Resources. Since its establishment, the laboratory has built the world's largest artificial rainfall simulation test hall, a large artificial rainfall simulation test base in Tianshui, ten major ecological and hydrological observation bases in Kongtui, and a number of field observation stations in the Erdos Plateau arsenic sandstone area, such as the Junger Banner observation station, which has played an important role in the accumulation of basic observation data.

3. The Main Scientific Research Achievements in the Yellow River Basin

3.1. Distributed Soil Loss Model and Engineering Application Research in the Sandy and Coarse Sandy Area of the Yellow River

From the late 1990s, CAS and related universities in China have carried out research on soil erosion models, support systems and applications on the Loess Plateau, revealing the erosion mechanism and laws of the Loess Plateau soil in the steep slope environment, establishing the gravity erosion of the channel and the sediment transport ratio model of the watershed sub-flood; creating a grid-type distributed soil loss model with independent intellectual property rights in a complex erosion environment. It realized the parametric analysis of erosion and sand production process, spatial deconcentration and aggregation, and matching of soil loss simulation in areas without data; developed the international frontier technology of close coupling of GIS and soil loss model, realized the close coupling of distributed soil loss model based on DEM and GIS, quantitatively evaluated the response of soil erosion under the action of human activities and optimized the design plan of soil and water conservation project.

3.2. Concentrated Sediment Source Area Definition and Water-Sediment Change

With the financial support from the Ministry of Science and Technology, the Ministry of Water Resources, and the special project of Yellow River Management, the Institute of Yellow Science and Technology and the Bureau of Hydrology of the Yellow River Conservancy Commission have integrated and innovated to propose the identification technology and index system of

coarse sediment concentrated source area by physical detection of sediment cyclone layer, hydrological sediment balance analysis, and simulation inversion of riverbed evolution, and defined the area of coarse sediment concentrated source area of 18,800 km², and determined the soil and water conservation measures on the Loess Plateau. We have developed an evaluation model of the impact of human activities on sand production based on the subsurface erosion resistance, and an adaptive simulation technique of the flow production mechanism coupled with the flow production by full storage and super seepage. The contribution of human activities and natural factors to the changes of water and sand in the Yellow River.

3.3. Key Technologies and Applications for Identifying and Resisting Erosion and Promoting the Growth of Arsenic Sandstone Areas in the Yellow River Basin

Arsenic sandstone, formed 250 million years ago, consists of sandstone, sand shale and mud sandstone, which is as hard as stone without water and as rotten as mud with water, and it is difficult for forest and grass to grow. For this century's problem, the Yellow Academy of Sciences, in conjunction with relevant universities and research units, has sent researchers to travel more than 50,000 km, through multi-dimensional data collection, hundreds of groups/sessions of mechanism tests and multi-dimensional information analysis and evaluation technology integration, to accurately We have defined the distribution area of arsenic sandstone, developed arsenic sandstone modification technology, and developed arsenic sandstone modified dam building materials, which can achieve the goal of controlling the water disintegration and destruction of arsenic sandstone structure, and realize the functional integration of erosion control and vegetation restoration, and reduce erosion by more than 90%.

3.4. Water and Sand Change Driving Mechanism and Control Technology in the Wide Valley of the Yellow River Desert

Xi'an University of Science and Technology and the Upper and Middle Yellow River Administration and other units, with the safe and efficient operation of the Loess Plateau silt dam system as the core, systematically analyzed the role of the silt dam system in fixing and reducing erosion and regulating peak energy, analyzed the cascade mode of the basin dam system and its interaction relationship, clarified the role of different cascade silt dams in storing water and stopping sand, determined the main factors affecting the safety of the silt dam system, revealed the risk of the silt dam system project The results were applied in the construction and operation management of silt dam system in 7 provinces (districts) of Loess Plateau.

3.5. Loess Plateau Silt Dam System Gully Erosion Control Mechanism and Safe Operation of Key Technology

Relying on the national "973" project and provincial science and technology projects, CAS carried out a series of research work, revealing the spatial and temporal variation of water-sand change in the wide valley of the upper reaches of the Yellow River desert, proposing a dual-process simulation technology of river-irrigation water cycle, evaluating the driving effect of irrigation water diversion on the change of water-sand relationship in the river; revealing the mechanism of reservoir regulation of water-sand relationship. The mechanism of reservoirs regulating water-sand relationship is revealed; the dynamic equilibrium threshold relationship of flooding process under reservoir control is discovered, the regulation mechanism of water-sand relationship between Longyangxia and Liujiaxia reservoirs and its role are quantitatively elucidated, and the technical solutions of reservoir control and watershed management for optimizing water-sand relationship are proposed.

4. Effectiveness of Scientific Research on Soil and Water Conservation in the Yellow River Basin

(1) A multi-scale soil erosion model system for the Yellow River Basin has been constructed. The Loess Plateau Soil Erosion Simulation System V1.0 was released by the national "Earth System Science Sharing Network" for sharing with the society, and started to be implemented as a key promotion project of the Ministry of Water Resources in 2011. At present, 5 training courses have been held in Yan'an City and Yulin City, Shaanxi Province, with a total of 200 technical and managerial staff trained. The system has been widely used in the production practice of watershed management planning, ecological engineering feasibility study and design in Shaanxi, Shanxi and Henan provinces, providing important basic support for decision making in different periods of yellowing management.

(2) It has promoted the establishment of coarse sediment interception project in the middle reaches of Yellow River. The research results of coarse sediment concentrated source area and water-sand change have been included in the "Comprehensive Planning of Yellow River Basin (2012-2030)" approved by the State Council and adopted in the "Outline of Comprehensive Management Plan of Loess Plateau Area (2010-2030)" jointly issued by four ministries and commissions, namely, National Development and Reform Commission, Ministry of Water Resources, Ministry of Agriculture and State Forestry Administration, and the National Development and Reform Commission has approved the project proposal of Yellow River Coarse Sediment Concentrated Source Area Sand Interception Project proposal of Phase I of the project.

(3) Supported the construction of major water conservancy projects in the upper reaches. The Yellow River desert wide valley channel water and sand change driving mechanism and regulation technology results have been applied in the top ten hole tui and other water, soil conservation planning and ecological construction practice, the Yellow River Black Hills Gorge project demonstration and other major scientific research practices and work. The dual-process coupled mathematical model of water and sand transport and water circulation in irrigation areas in the main stream of the Yellow River in Ningxia and Inner Mongolia has been applied in the allocation and scientific management of water resources in the Yellow River irrigation area in Ningxia and Inner Mongolia.

(4) Key technologies for resisting erosion and promoting growth in ecologically fragile areas have been developed. The research results of arsenic sandstone area identification and anti-erosion key technology in the Yellow River Basin have been successfully applied in the construction of silt dams in arsenic sandstone area, the construction of Erdos Water and Soil Conservation Science and Technology Demonstration Park, the prevention and control of soil erosion on the slopes of key river embankments, and the control of desertification in Kubuqi and other projects, radiating to Inner Mongolia, Gansu, Henan and other provinces (regions). The breakthrough of the key technology of arsenic sandstone erosion resistance and growth promotion has established the international leading position of desertification control in China.

5. Conclusion

"The ecological protection and high-quality development of the Yellow River Basin is a major national strategy, as is the coordinated development of Beijing-Tianjin-Hebei, the development of the Yangtze River Economic Belt, the construction of the Guangdong-Hong Kong-Macao Greater Bay Area, and the integrated development of the Yangtze River Delta." This has put forward new and higher requirements for the ecological construction of soil and water conservation in the Yellow River basin in the new period, and also provides important development opportunities for the cause of soil and water conservation. Soil and water

conservation has the basic quality of fully considering various factors such as nature and society, coordinating and coordinating all forces, and scientifically integrating various measures to achieve ecological-economic-social synergistic development. Therefore, in the implementation of the major national strategy of ecological protection and high-quality development in the Yellow River basin, the in-depth development of soil and water conservation is an inevitable requirement to promote ecological protection and management in the region, to guarantee the long-term stability of the Yellow River, to win the battle against poverty in the region and to achieve the strategic goal of high-quality development. In the face of new goals and new tasks of ecological construction of soil and water conservation in China in the new era, the scientific research on soil and water conservation in the Yellow River will take the strategic needs of national ecological civilization construction as the traction, follow the requirements of soil and water conservation in the new era put forward by the Ministry of Water Resources, focus on the basic and critical scientific problems of soil and water erosion control in the Loess Plateau and the development of the Yellow River management and other major national strategic needs, improve the level of scientific research, and contribute to the ecological security of the Loess Plateau. We will make important contributions to the ecological security of the Loess Plateau.

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