Discussion on the Construction of Ecological Restoration Model of Shichuan River

Jing Wang1,2,*, Shiqian Gao1, Biao Peng1, Yulu Wei1

1Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Land and Resource, Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an 710075, China
2Institute of Water Resources and Hydro-Electric Engineering, Xi'an University of Technology, Xi'an 710048, China

*Corresponding author’s e-mail: wangjing0722@126.com

Abstract. This paper took Shichuan River in Fuping County of Shaanxi Province as the research object, discussed the targeted ecological restoration model that integrated water quantity, water quality, landform and biological community. The restoration model has made a positive contribution to accelerating the development of the southern new district of Fuping County, coordinating the harmonious development of urban and rural areas, and provided scientific and technological support for similar renovation projects in other river basins.

1. Introduction

Rivers are the link between land and ocean and play a vital role in the material cycle of the biosphere. River ecosystem is a complex ecosystem including aquatic ecosystem, riparian terrestrial ecosystem and watershed wetland ecosystem. It can provide habitat for organisms, filter self-purification sewage, and it is the channel of energy and material circulation.

In recent years, due to the deterioration of the global ecosystem, the water consumption has increased dramatically, the annual rainfall has decreased, and the high temperature weather has increased, resulting in seasonal zero flow or nearly dried up of some rivers, which posed a serious threat to river ecosystem. Therefore, it is extremely urgent to carry out river ecological restoration.

The river ecosystem is composed of two parts: organism and habitat. The former is the life system of the river, while the latter provides an appropriate environment for organisms. The uncertainty of biological species and activities make the river ecosystem in dynamic change all the time, which brings difficulties to the river ecological restoration.

The concept of natural river management was proposed by Seifert in Germany in 1938. In the 1960s, some developed countries tried to apply ecological principles to the restoration of natural forms of rivers [1]. The Kissimmee River in the United States has some achievements in rebuilding its meandering channel. Lei successfully realized the restoration of river hydraulic characteristics by using artificial ecological floating bed [2]. Joseph proposed to restore the natural plane structure and curved shape of the river by controlling the river's steering structure [3]. Later scholars regarded the restoration of
biological integrity and biodiversity as the ultimate goal of river ecological restoration [4]. David believed that habitat is the carrier of life, and habitat diversity is the basis of biological restoration [4].

The early neglect of river ecological restoration in China led to a large number of river zero flow, which seriously restricted the economic development of the surrounding areas. In 1999, based on the practice of river ecological restoration in developed countries, Liu S.K. put forward the ecological restoration theory [5], Song L.W. proposed that the seasonal rivers in the North should be restored by falling water to repair the damage caused by the small flow in dry season [6]. Tang H.L. confirmed that the ecological floating island has a high purification effect and algae control effect through experiments [7]. With the intensification of river management in China, some river ecological restoration model have been formed, which combined water regulation, water quality improvement and biological restoration [8]. However, due to insufficient research on the difference characteristics of rivers, it is difficult to construct a scientific restoration model adapted to local condition.

This study took the Shichuan River in Fuping as the research object, and proposed a targeted restoration model to initially explore the method of constructing ecological restoration models of large basins, and provided technical support for the ecological restoration of other rivers.

2. Generality of the Study Region
Fuping County is located in the central part of Shaanxi Province, the transition zone between the Guanzhong Plain and the Northern Shaanxi Plateau. It belongs to the warm temperate continental semi-arid monsoon climate, with large temperature difference between day and night. The terrain is generally high in the northwest, low in the southeast, and uneven in the middle, with an elevation of 375.8m to 1439.0m. The average annual precipitation is 528mm; the precipitation is unevenly distributed during the year and the precipitation from July to September accounts for about 50%. The average annual surface evaporation is 1229mm, the average annual temperature is 13.1 °C, and the average frost-free period is 226 days.

The Shichuan River is located in the south of Fuping County. It is the first tributary of the Weihe River. The upper reaches are the Qishui River and the Jushui River. The two rivers meet at the junction of Fuping and Yaozhou District, and flow into Fuping County from Chakou Village of Meijiaping Town, and the territory flows from the northwest to the southeast. It has a total length of 36.4km and a drainage area of about 134km². The riverbed is a natural river channel with no artificial restoration measures. It is 300m-1000 m wide, but the main river channel is only 50m-70 m wide, with an average ratio drop of about 4.6 ‰. Seasonal rainfall make the water flow increased and the riverbed can be extended to 100 m every autumn. Shichuan River is a typical seasonal river which the river flow is extremely unstable and often zero flow during the dry season.

In the 1970s, a large number of reservoirs were built in the upstream, which cut off the flow. Only during rainy season can the water be abundant in the downstream. Then, due to negligent management and dredging sand and stones, the river bed was seriously damaged and the river gradually dried up. With the development of industry, soil, water and air resources have been serious polluted by the direct discharge of industrial and domestic waste water, the burning of garbage and the random stacking of wastes, resulted in the deterioration of river ecosystem. Aiming at water quantity, water quality, landform and biological restoration, the ecological restoration model of Shichuan River was constructed. The project was carried out mountains, rivers, forests, fields, lakes and grass comprehensive improvement on both sides of Jinlong Bridge in Fuping County, with a length of about 2.2 km from the east to west, covered an area of about 133.3 hm². It has built 2.2 km ecological river course, 42 hm² riverbank landscape greening belt and riverside landscape park.

3. Construction of Ecological Restoration Model
River ecological restoration is developed on the basis of ecology. Through engineering and biological measures, river ecosystems achieved a benign dynamic balance between biomass, water quantity, water quality, hydrology and other biological and non-biological structures, so as to curb the destruction of the river ecosystem and restore the necessary functions of the river.
The ecological foundation laid the complexity of ecological restoration (Figure 1), and the role played by the river ecosystem laid the foundation for the necessity of river ecological restoration. Based on the four-in-one restoration model of water quantity, water quality, landform and biological community, this paper summarized the experience of ecological restoration of Shichuan River and provided reference for comprehensive regulation of large basin.

3.1. Water quantity restoration technology
Water is the foundation of the river. Sufficient water flow can satisfy the material circulation of the river ecosystem. The river replenishment technology is one of the commonly used measures for water restoration.

According to the relevant planning, the Guxian Yellow River Diversion Project and the Hanji-Weihe Water Diversion Project will be built in the future, which will transport more than 4,800,000m³ of water resources to Shichuan River and solve the problem of seasonal zero flow permanently. By exploring the utilization of rainwater resources, building Dongzhuan Reservoir and storing water resources during the rainy season, the project design the mode of "up-storage, middle-prevention and down-discharge". It can solve the water demand for nearby towns and industrial enterprises, reduced the pressure of river water resources. At the same time, build groundwater reservoirs can regulate groundwater recharge and conserve water resources to improve the river ecological environment.

In addition to increasing water supply by hydration and reservoir storage, river anti-seepage technology should also be adopted to reduce the amount of water loss, using plant-growing anti-seepage blocks to improve the water permeability of the river bottom, then planting aquatic plants in the blocks can not only prevent the water infiltration, but also purify water quality and provide environment for biological growth.

3.2. Water quality restoration technology
According to pollutant sources and treatment objects, water quality remediation can be divided into pollution source control, water body remediation and sediment pollution remediation. In view of the
main source of pollution is the discharge of industrial wastewater, centralized management of coastal wastewater outlets should be carried out to strictly control the quality of influent water. Because the sediment exists in the bottom of the river, once it is polluted, it is difficult to control. Digging the sediment directly is quick and effective, but the cost is too high. Generally, microbial remediation and phytoremediation are commonly used. The former is a commonly used method of sediment remediation at present, which has high treatment efficiency and low cost. The latter has low technology cost and will not cause secondary pollution. The plant roots can stabilize the riverbed, and the green plant can beautify the landscape river. The combination of the two technologies can effectively control sediment pollution.

Shichuan River is a slightly polluted river because it once replaced by water, so it was repaired by in-situ treatment technology. Micro-topographic aeration technology and aquatic biological method belong to the technology of in-situ remediation of slightly polluted water. Micro-topographic aeration technology use the combination of deep and shallow pits to increase hydraulic cycle by setting up stone cage dams and throwing rubble into river basement, so that dissolved oxygen and pollutants can react rapidly and degrade organic pollutants in water body. The aquatic biology method is based on the ecological principle, using the purification ability of aquatic organisms and the role of the food chain to purify water, especially for rivers with damaged biodiversity.

3.3. Landform restoration technology
The aim of landform restoration is to avoid the disturbance caused by river rigidity, curvature and straightening and dam construction, to build the river into a natural landform with horizontal and vertical natural continuity and diversity, and provide habitat foundation for the biological survival and reproduction.

The landform restoration of the Shichuan River mainly included the cross-sectional structure, the curvature and straightening of river and the ecological revetment. When designing the section, the cross-section structure is selected according to the demand and the natural section of the river channel. Below the normal water level, the rectangular dry masonry section was used to maintain the normal flooding of the river channel. Above the normal water level, the ecological engineering bag slope protection technology was adopted to provide habitat for the organisms, the depth and shallowness landform types was set in the river channel to increase the water flow vitality. Meandering is the most stable state of river ecosystem. The whole river should be curved and straight, and it should also be equipped with inverted reverse flow trees or artificial rockfills to change the geomorphological structure in a small area. The ecological protection of riverbank should be carried out by combining plant, civil engineering or new materials. Grass and shrub planting should be planted on the riverbank, which can form a landscape while protecting the river bank, avoiding the problem that hard slope protection is difficult to provide biological habitats.

3.4. Biological community restoration technology
The biological objective is to maintain biodiversity and integrity to ensure the sustainable operation of river ecosystems. Longitudinal meandering of rivers forms the pattern of alternation of rapids and gentle flows; the cross-sectional shape diversity of the river is shown as deep channel and side beach crisscross. The permeability and porosity of riverbed materials provide habitats and spawning grounds for organisms, and the water quality, water quality and landform restoration laid the foundation for the restoration of biological communities. Planting emergent plants, floating plants and submerged plants and putting fish fry in the river basin will increase the biodiversity of rivers and the complexity of the food chain, thus maintaining the health and sustainable development of rivers and giving full play to the ecological functions of rivers.

4. Conclusion
Shichuan River used the four-in-one ecological restoration model of water quantity, water quality, landform and biological community. The upstream reservoir replenishment, "up-storage, middle-
prevention and down-drainage" mode and the river anti-seepage technology were applied in water quantity restoration. The in-situ treatment technology, micro-topography aeration technology and aquatic biology method were used in water quality restoration. In landform restoration, the river cross-section structure, river curvature and straightening and ecological revetment were adopted. In the biological community restoration, emergent plants, floating plants and submerged plants were planted, and fish fry were released in the river basin to increase the biodiversity of the river and the complexity of the food chain. The proposal of Shichuan River restoration model has made a positive contribution to accelerating the development of the new district in the southern part of Fuping County, coordinating the harmonious development of urban and rural areas, and provided scientific and technological support for similar remediation projects in other river basins.

References
[1] Zhong C. X., Zhang W. River ecological restoration based on river regulation [J]. Advances in Science and Technology of Water Resources, 2004, 24 (3): 12 - 14, 30.
[2] Rao L., Qian J., Ao Y. H. Influence of artificial ecological floating beds on river hydraulic characteristics [J]. Journal of hydrodynamics.2014, 26 (3): 474 - 481.
[3] Li H. B., Du L. N., Zou Y., et al. Eco-remediation of branch river in plain river-net at estuary area [J]. Procedia Environmental Sciences.2011, 10: 1085 - 1091.
[4] David L. Galat, Irene Zweimüller. Conserving large-river fishes: is the highway analogy an appropriate paradigm [J]. Journal of the North American Benthological Society: 2001, 20 (2): 266 - 279.
[5] Chen X. R. Progress of River Restoration Research at Home and Abroad [J]. Journal of Hydroecology, 2011, 32 (5): 122 - 128.
[6] Song L. W., Wang J. Z. Discussion on the effect of water drop in ecological restoration of rural rivers [J]. Science and Technology Innovation Herald, 2009, 33: 116 - 118.
[7] Tang H. L. Ecological restoration techniques to water eutrophication and case studies on heavily polluted ponds [D]. Guangzhou, South China University of Technology, 2012.
[8] Li W. J., YangY. X., Yu H., et al. Discussion on the ecological restoration of rivers in the Haihe River Basin [C]. Proceedings of the Annual Academic Conference of Chinese Society of Environmental Sciences. 2009: 418 - 420.