

RIVER ECOSYSTEM RESTORATION IN CHINA

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From the structure and function of river ecosystem and the most basic theory of the food chain, ecological niche theory, species succession theory and the self-organization theory, this paper expounds the natural ecological function and the social service function of urban river ecosystem, and analyses the five existing problems, namely hydrological process simplification, river morphology artificialization, wetland function weakening, water quality deterioration and aquatic ecological degradation. Moreover, based on the current situation of river ecosystem restoration at home and abroad, this paper discusses its concepts, objectives, tasks, and principles, then studies the measures of the river ecosystem restoration, and finally, takes a river as an example to have preliminary study on it.

1 INTRODUCTION

Modern urban development overuses the social and economic attributes of urban river and ignores the health of river ecosystem itself. With the development of social economy, the progress of science and technology and the improvement of people's living standard, the river ecological restoration, especially urban river ecological restoration, is attracting more and more wide attention by the international community.^{[1][2]}

2 RIVER ECOSYSTEM THEORY

2.1 Ecosystem

2.1.1 Composition

Ecosystem is a natural whole formed between biological communities and their living environment which are interdependent, mutually constraining, and develop together. That is, biological communities plus natural environment is ecosystem. Biological community is also called life system. The natural environment is called the life support system. A healthy ecosystem must have a life support system that is suitable for the survival of all sorts of living beings.

2.1.2 Structure

The structure of ecosystem is how its elements interrelate and interact with each other, which mainly includes nutritious structure, space structure and time structure, corresponding to the food chain theory, ecological niche theory, and biological succession theory.

2.1.3 Function

The function of ecological system can be divided into its own ecological function and the social service function for human survival, development and enjoyment.

Its own ecological function mainly includes energy flow, material recycling, species transmission, etc. Its service function mainly includes serving as human habitat, maintaining the conditions of human existence and enjoyment, helping mankind to better use the natural resources.

2.1.4 Self Design Theory

Natural ecological system has various forms of self-organization function, also known as the self design theory. That is, some species can endure the test of natural selection to find the corresponding energy and suitable environmental conditions which can support a progenitive population with a sufficient number.

2.2 Functions of Urban River Ecosystem

The natural ecological function and social service function of the river ecosystem is more outstanding among urban river which is an important part of fluvial natural ecosystem.

2.2.1 Natural Ecological Functions and Its Conditions

The basic ecological function of river mainly includes that it is the basic habitats of aquatic and partly terrestrial life, that it is the movement and transmission channel for fish as well as other organisms and their seeds, that it has filtering and blocking effect and that it is the source and sink of matter and energy.

The basic condition of realizing natural ecological function is the liquidity of river water, while the connectivity of river's geographical landscape is the basic guarantee of river liquidity.

2.2.2 Social Service Function

Social service function of urban river mainly includes flood control function, landscape function, drain and self-purification function, water supply function, shipping function, breeding function, etc. In different regions and rivers, the importance of those functions alters. The function of urban river is comprehensive, and the demands in water supply, water purification, flood control, and natural ecology compete against each other.

3 MAIN PRESENT PROBLEMS OF RIVER ECOSYSTEM

3.1 Hydrological Process Simplification

The construction and application of the reservoirs on the main and branch streams and other water conservancy projects greatly change the process of river discharge and the water surface curve of river. In most cases, the peak flow will be weakened, the low water flow improved, and the water surface curve reduced, so that the hydrological process will be simplified.

3.2 River Morphology Artificialization

The construction of such buildings as dams, embankments, pipelines, bridges, docks, and the implement of rehabilitation project such as dredging, straightening, lining and canalization make the existing plane figure, cross section, hydrogeometric relation and the longitudinal slope of bottom and surface lose the characteristics of natural river. River morphology is greatly affected by artificial buildings.

3.3 Wetland Function Weakening

Due to the continuous exploitation in river wetland, such as agriculture, animal husbandry, forestry and mining, the fluvial natural wetland area obviously atrophies, wetland habitat fragmentizes, habitats disappear, biodiversity declines, and all of these then make the function of wetland weaken.

3.4 Water Quality Deterioration

As a result of the discharge of industrial, agricultural and domestic sewage, the dissolved oxygen in river, especially the urban river, is reduced; its self-purification ability abates, thus making the water quality deteriorate.

3.5 Aquatic Ecosystem Degradation

Urban development brings huge benefits for the human society. At the same time, it brings about varying degrees of impact and destruction on the multiple natural and social functions of the river ecosystem, such as ecology, self-purification, water supply, flood control, landscape, and shipping, so that the river ecosystem degrades.

4 RIVER ECOSYSTEM RESTORATION

4.1 Concept and Goal of River Ecological Restoration

Ecological restoration has different expressions, such as full restoration, restoration, strengthening, rebuilding, creation, naturalization, etc. Therefore, different opinions lead to big difference among the target, process and related measures of river ecological restoration.

The goal of river ecological restoration is supposed to restore the necessary ecological and social functions which are deteriorated or even lost, improve its regulating mechanism, and realize the new dynamic balance, combined with the project planning of flood control, river regulation and cityscape construction.

4.2 Task of River Ecosystem Restoration

The task of the river water ecosystem restoration can be summarized as follows:

- (1) improve the geomorphology features of the river;
- (2) improve the conditions of water quality, quantity, hydrology and hydraulics;
- (3) restore biodiversity.

The focus of river restoration is the first and second task. Through these, species diversity of ecosystem will be recovered on its own, according to the theory of self-organization.

4.3 Restoration Measures

River ecological restoration is divided into passive and active restoration. Passive restoration relies mainly on the self-design, self-organization, self-healing and self-cleaning function of its ecosystems to achieve the goal of ecological restoration. Active restoration is needed if the river ecosystem has degraded to a certain degree. That is, taking moderate artificial intervention in combination with the resilience of the ecosystem to realize the goal of ecological restoration.

According to whether the engineering measures are used, river ecological restoration can be divided into engineering measure and non-engineering measure.

4.4 Ecological Restoration Materials

River ecological restoration materials can be classified into biological materials, non-biological materials and composite materials. Composite material is made from a mix of biological materials and non-biological materials, such as geogrid gravel soil plant composite materials, three-dimensional vegetation net composite materials and gabion box gravel plant composite materials.

5 CASE STUDY

The researched reach is approximately 120 km long and ended with a bigger reservoir project that has an area of 1768 km², which flows through a larger city of northeast China. However, the excessive exploitation and utilization of resources lead to the occurrence the above five problems in the reach.

5.1 Guarantee of Ecological Flow and Regulation of Hydrological Processes

5.1.1 The Lowest Ecological Water Level

To determine the lowest ecological water level (and the minimum ecological flow), river natural runoff conditions, all kinds of functional requirements and aquatic biological growth needs should be considered. According to the analysis, the river's lowest ecological water level is 114.00 m.

5.1.2 The Minimum Ecological Flow

Using the method of average flow of the driest month^[3], Tennant method^[4] (also called Montana method), referencing the previous research results and considering various functional requirement, here suggests that the minimum ecological flow is 270 m³ / s in the drought period (from October to March), 550 m³ / s in the plentiful period (from April to September).

5.1.3 The Highest Water Level and Maximum Flow

River ecosystem requires periodic floods to maintain biodiversity and health, but the flood should not exceed the flood control standard. Therefore, the highest water level and maximum flow is the corresponding water level of 121.13 m (a cross section) and flow rate of 17900 m³ / s at the flood control standard (once in one hundred year) in the reach.

5.1.4 Regulation of Hydrological Processes

To restore the hydrological process, it is necessary to take into account the extensive demands on flood control, ecology, society, and economy, and implement multi-objective reservoir ecological operation for the reservoir in research area and the reservoir upstream in main stream and tributaries, such as drawing off the pulse water, preventing the flood from too homogenization to harm the biological growth, reproduction, and at the same time, controlling the pulse flood disasters in major flood period.

5.2 River Morphology Restoration

Due to the construction of the cascade reservoirs and embankment, the degree of river morphology artificialization becomes higher, but the winding form still exists, as well as a lot of beach islands, shallow and deep pools. Seeing that the existing dikes are the important part of flood control system which formed during the years of history, and short of flood control standard, it is suggested that both sides of the embankments position stay unchanged, the existing winding of river flow pattern and the unnatural form of both sides of the embankments positions maintained.

In view of the current situation that artificial structures such as dikes and dams damaged the longitudinal, transverse and vertical connectivity of river flow, though the fluvial longitudinal connectivity is difficult to repair, measures of ecological river bank protection can be taken to improve the lake-land ecotone ecosystem of the both sides and restore its transverse and vertical connectivity.

The researched reach has compound section, and the amphibious crisscross beside the embankment is the key area of ecological restoration. According to the place, hydraulic conditions, width of embankments and its buffer, it can be divided into six types, and the paper puts forward the corresponding repair measures for each type.

5.3 Restoration and Protection of Beach Island's Wetland Functions

Beach Island refers to the shallows, beach or river beach between the normal water level and the flood level in the river, and is the wetlands formed during the natural evolution of the river. In addition to the main function of flood passage, Beach Island can also regulate runoff, control pollution, regulate climate, control erosion, protect biodiversity, and has other social functions such as recreation, entertainment and scientific research.

In the case, Beach Island ecological restoration measures include building no causeway, returning the wetland space, recovering the vegetation, etc.

5.4 Protection Measures of Water Quality

There are two measures to improve water quality. One is reducing pollution source, that is, to reduce the amount of discharge of urban industrial, agricultural and domestic sewage, improving urban sewage treatment rate and achieving emissions standards; the other is improving the revetment, beach island wetland degradation of pollutants capacity and water bodies' self-purification capacity through the foregoing ecological restoration measures.

5.5 Improvement of Ecosystem

Through the above restoration measures of hydrological processes, river morphology, island beach wetland and water quality, the river ecological system will surely be improved.

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