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Ecological Restoration and Renovation of Xin River Based on Sponge City Concept

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ABSTRACT

China is currently facing various water problems such as water scarcity, water pollution, floods, and loss of aquatic habitats. These water problem syndromes are systemic and comprehensive problems that urgently require a more comprehensive solution. The proposal of the "Sponge City" theory is based on this background. According to Jiaozuo "7.20 extremely heavy rainstorm Event", based on the sponge city theory, citing ecological principles, and following ecological principles, this paper discusses the ecological transformation of the Xin River to achieve the purpose of artificially rebuilding the river ecosystem.

KEYWORDS

Sponge City; Embankment repair; Ecological restoration.

1. INTRODUCTION

Sponge city is a new generation of urban rainwater and flood management concept, which refers to the city's ability to adapt to environmental changes and cope with natural disasters caused by rainwater like a sponge, and can also be called a "water elastic city". The international common term is "low impact development of rainwater system construction". When it rains, it absorbs, stores, infiltrates, and purifies water. When needed, the stored water is released and utilized to achieve free migration of rainwater in cities.

China is currently facing various water crises, including water scarcity, water pollution, floods, urban waterlogging, declining groundwater levels, and loss of aquatic habitats, which are very serious problems. After deep reflection, the crisis brought about by these water problem syndromes is not a problem that occurs under the management of the water conservancy department or a certain department, but a systematic and comprehensive problem. We urgently need a more comprehensive solution. The "Sponge City" theory is based on China's water situation characteristics and water problems, and provides a comprehensive ecological infrastructure approach to solve urban and rural water problems. [1]

2. THE CONNOTATION OF SPONGE CITY

The issues of water environment and water ecology are systematic and interrelated issues that span across scales and regions. The essence of many water problems is the overall dysfunction of water ecosystems, so the solution to water problems does not lie in the rivers and water bodies themselves, but in the environment outside the water bodies. For example, in the "7.20" extremely heavy rainstorm, a large amount of rain did not fall on the river course, so it is not necessary to just stick to the river

course for flood control. Therefore, starting from ecosystem services, the core of sponge cities is to build water ecological infrastructure by building water ecological infrastructure across scales and combining various specific technologies.

2.1. The essence of sponge cities:

The essence of sponge cities is to change the traditional concept of urban construction and achieve coordinated development with resources and environment. The urban construction model where people are accustomed to and transform nature to overcome nature has resulted in serious urban diseases and ecological crises; Sponge cities, on the other hand, follow the principles of conforming to nature, protecting nature, and coexisting harmoniously with nature. Traditional cities use land for high-intensity development, while sponge cities achieve harmonious coexistence between humans and nature, land use, water environment, and water cycle. Sponge cities reflect a completely different approach to water management from the traditional "water adapts to people" approach, and cities should be a landscape where people adapt to water.[2]

2.2. The goals of Sponge City

The goal of Sponge City is to enable the city to have a certain degree of regulatory ability under environmental changes and natural disasters, to create more comfortable living conditions for the population living in the city. One is to protect the original ecosystem. Through reasonable urban planning, we aim to maximize the protection of the original ecosystem and maintain the natural hydrological conditions prior to urban development. The second is to restore the damaged aquatic ecosystem. Various technological means are used to gradually restore and restore the hydrological cycle characteristics and ecological functions of water bodies, wetlands, and other ecosystems that have been damaged during urban development, while maintaining a certain proportion of urban ecological space and promoting the improvement of urban ecological diversity. The third is to effectively reduce the difficult urban operation conditions under rainstorm conditions through various infrastructure and system combinations.

2.3. Building Sponge Cities with Cross scale Thinking

The role of sponge cities is not only in the utilization and management of rainwater, but also in the protection of regional water cycle processes. Therefore, the construction of sponge cities should be carried out and coordinated from different ecological theories and method systems at different scales. We need to analyze the pattern of water ecological security and implement it in the overall land use planning and urban planning, becoming the ecological infrastructure of the region.[3]

At the macro level. The construction of sponge cities at this scale focuses on studying the spatial pattern of water systems in regions or watersheds, that is, analyzing the water ecological security pattern, and implementing the water ecological security pattern in the overall land use planning and urban planning, becoming the ecological infrastructure of the region. In terms of methodology, the landscape safety pattern method can be used to identify landscape elements and their spatial locations that are crucial for water source protection, flood control and storage, biodiversity conservation, water quality management, and other functions, and to construct a comprehensive water safety pattern around ecosystem services. Its significance lies in: firstly, clarifying the most important elements, spatial positions, and interrelationships in the existing water system, and maintaining the integrity of the water process by establishing no construction zones to protect the key spatial patterns of the water system; Secondly, treating the water ecological security pattern as a regional ecological land and restricted construction area in urban construction, limiting construction and development, and gradually carrying out ecological restoration can avoid further damage to the structure and function of the water system in future urban construction and land development; Thirdly, the water system can play a role in rainwater and flood regulation, water quality purification, habitat protection, and

cultural recreation, serving as the ecological infrastructure of the region and laying the spatial foundation for the construction of the next physical sponge system.

At the meso level. Mainly refers to the scale of urban areas, townships, villages, or urban new areas and functional blocks. The focus is on researching how to effectively utilize the rivers and ponds within the planned area, and combine them with the distribution of catchment areas and water nodes to reasonably plan and form a physical urban sponge system. Ultimately, this will be implemented in land use control planning and even urban design, comprehensively addressing the planning, design, and construction of waterfront habitat restoration, water balance, rain and pollution purification, and cultural and recreational spaces within the planned area.

At the micro level. "Sponge cities" must ultimately be implemented in specific "sponge bodies", including the construction of parks, residential areas, and local water collection units. At this scale, it corresponds to the integration of a series of water ecological infrastructure construction technologies, including the minimum intervention technology for protecting nature, ecological flood control technology friendly to floods, enhanced artificial wetland purification technology, green sponge technology for urban rainwater and flood management, and biomimetic restoration technology for ecosystem services. These technologies focus on researching how to use specific landscape design methods to enable the ecological functions of water systems to be fully realized.

In short, establishing a low impact development model that respects and conforms to nature is an effective measure to address urban water security and resource issues. By natural accumulation, peak shaving and storage can be achieved to control runoff rate; To restore aquatic ecology and restore the natural circulation of water through natural infiltration; Through natural purification, pollution can be reduced, water quality can be improved, and a solid foundation can be laid for water recycling.

3. ECOLOGICAL TRANSFORMATION OF XIN RIVER UNDER THE THEORY OF SPONGE CITY

3.1. Principles of Regional Aquatic Ecosystem Restoration Design

3.1.1. Regional principle [4]

The aquatic ecosystem in China is widely distributed, for example, in various regions ranging from cold temperate to tropical, from coastal to inland, from plains to plateau mountainous areas. Different ecosystems have different geographical locations, climate characteristics, river types, functional requirements, and economic foundations. Therefore, blindly copying and copying should not be allowed. A set of realistic and dynamic future goals should be formulated for each unique geographical location and regional culture.

3.1.2. Principle of prioritizing protection

Rivers are the soul and symbol of a city, playing a crucial role in local soil and water conservation, ecological balance, and other aspects. These resources have reached a balance in the long-term natural evolution process, and rivers that have not been considered to have been damaged or less damaged should be protected first. On the one hand, it can maintain the original ecological balance and save funds. On the other hand, studying and observing these original ecosystems can also provide reference value for the ecological restoration of degraded rivers. [5-6]

3.1.3. Ecological principles

The ecological principles mainly include ecological succession laws, biodiversity principles, ecological niche principles, etc. In the process of river ecological restoration, it is necessary to restore the ecosystem in stages according to its own succession law and construct the ecosystem structure and biological community based on the principles of ecological niche and biodiversity, so as to

achieve maximum utilization and optimal cycle state of material circulation and energy conversion, and achieve synchronous and harmonious evolution of hydrology, soil, vegetation, and biology.

3.1.4. Feasibility principle

Feasibility is the first consideration when implementing project plans. Including the feasibility of the environment and the feasibility of technology. In addition to the natural environmental conditions and spatial scope generated by the long-term development of nature and human society, the environment also includes economic and political factors. Under normal circumstances, the ecological restoration of rivers largely depends on the natural environmental conditions of the river. This is because there is a interdependence and interaction between the internal components of the current environment. In the restoration process, it is necessary to combine the local actual situation to make it ultimately a part of the natural landscape, to ensure that the restoration has naturalness and sustainability.

3.1.5. Principle of minimum risk and maximum benefit

The development of an ecosystem is a long-term and erroneous process. Due to its complexity and the unpredictability of certain environmental factors, as well as the limited understanding of ecological processes and internal operating mechanisms, it is often impossible for people to accurately estimate and grasp the consequences of ecological restoration and the ultimate direction of ecological succession. Therefore, in a sense, the restoration of degraded ecosystems carries certain risks. This requires a systematic and comprehensive analysis and demonstration of the restored objects before ecological restoration, in order to minimize risks. At the same time, efforts should be made to achieve maximum benefits with minimal risks. The benefits here include not only traditional economic benefits, but also ecological and social benefits.

3.2. Objectives of Xin River Ecological Transformation

The basic connotation of river ecological transformation is to follow natural laws and, based on community succession theory, control the succession direction and process of the restored ecosystem through physical, chemical, and biological means, increase the river's resistance to pollutants, and achieve a self-sustaining state of the system. Therefore, the basic goal of river ecological transformation is: [4-6]

(1) To achieve the stability of the river ecosystem, the physical and chemical components within the river must be maintained within a certain range. Instability cannot guarantee the succession and development of the ecosystem;

(2) Increase species composition and biodiversity to achieve the provision of ecosystem survival and self-sustaining capabilities;

(3) Increase green plants, transform the landscape, enhance visual enjoyment, and achieve sustainable regional socio-economic development.

3.3. Research on Xin River Ecological Restoration Technology

3.3.1. Pressure Analysis

(1) The key factors affecting water quality: The water exchange between the Xin River on campus and the outside world is controlled by manual input from water gates, so the water quality in this area is mainly influenced by internal release and external water diversion. The large amount of silt at the bottom of the river, in which phosphorus can enter the water body as it is released, affects the phosphorus content in the water body; The external source is manually input, and some of the internal pipelines of Henan University of Technology regularly inject water into the river.

(2) Key factors affecting aquatic vegetation: water transparency. The transparency of the water in the Xin River of the University of Science and Technology is relatively low, and emergent plants and floating leaf plants may grow poorly under low light conditions; However, submerged plants live underwater and are more sensitive to the transparency of water. The turbid water prevents sunlight from shining, causing it to gradually die without receiving light.

(3) The key factor affecting water transparency: Algae in the water contribute the most to suspended solids, and the turbidity of the water further leads to the death of submerged plants, which further affects the transparency of the water.

3.3.2. Measures for removing nitrogen and phosphorus from water bodies

(1) The control measures for nitrogen input include sediment nitrogen release control, secondary pollution prevention and control of aquatic plants, and influent nitrogen control. The control of sediment nitrogen release also includes: release channel blocking technology, aquatic plant absorption technology, denitrification microbial cultivation technology, etc.

(2) The removal and control of phosphorus include the removal of biological forms of phosphorus: zooplankton cultivation technology, filter feeding fish purification technology; Removal of particulate phosphorus: artificial reduction techniques, phosphorus mineralization fixation techniques, etc; Removal of soluble phosphorus: Aquatic plant absorption and storage technology, phosphorus accumulating bacteria absorption and sedimentation technology, etc;

4. ECOLOGICAL RESTORATION OF RIVERBANKS

The riverbank is a component of the natural ecosystem of urban rivers, which forms a transition from river water flow to land and soil. Riverside not only have basic functions such as flood control and navigation, but also should have functions of ecological restoration and coordination with the surrounding environment. The riverbank should fully demonstrate its hydrophilicity and contact with water is a basic desire of people at the water's edge. Revetment is generally installed in areas with severe water flow erosion, mainly to prevent erosion and scouring of the slope foundation soil by water flow and waves. It can be divided into slope type revetment, dam type revetment, wall type revetment, and composite type revetment.[6] At present, revetment technology is gradually developing from pure engineering measures to ecological revetment technology.[7]

4.1. Methods and techniques for ecological restoration of riverbanks

The restoration of the embankment depends on the local situation. In sections with gentle slopes, it should be maintained in a natural state, combined with plant planting, to achieve the goal of stabilizing the riverbank. For steep sections, when using cement and stone embankments for hardening, holes should be dug in the middle and some plants should be planted to increase the ornamental value. When gravity retaining walls must be built, adopting a multi-step layered treatment is better than a single high wall.

4.2. The connotation of ecological revetment

Ecological bank protection should be a systematic engineering that not only meets the function of riverbank protection, but also helps to restore the balance of the riverbank ecosystem. The specific connotation of ecological revetment should include the following aspects:

(1) Connotation of revetment

Ecological revetment is first and foremost revetment, followed by ecology. Therefore, ecological bank protection not only needs to meet the requirements of flood discharge and drainage in the river, but also needs to prevent soil erosion.

(2) Ecological connotation

The ecological connotation of ecological revetment is an important connotation that can reflect its basic characteristics. Its ecological connotation refers to the main goal of creating biodiversity in the riverbank ecosystem on the basis of ensuring the stability of the riverbank slope, in order to restore the heterogeneity of the riverbed surface and provide a good natural living environment for plants, animals, and microorganisms on the riverbank slope. The ultimate goal is to create diversity in the form of urban river ecosystems, The purpose is to improve the self-purification capacity of urban river water bodies.

4.3. Ecological revetment technology

4.3.1. Soil Ecological Engineering Technology

It is a commonly used technology in the United States and some European countries. This technology has evolved from the most primitive firewood bundle protection measures and, after years of research, has now formed a complete set of design and construction methods, which have been widely applied.

The principle of soil bioengineering revetment technology for ecological restoration of riverbanks is to use the effects of plants on climate, hydrology, soil slopes, etc. to maintain slope stability. The main functions and effects of soil bioengineering revetment technology include rainfall interception, runoff delay, soil slope infiltration, soil consolidation, soil slope humidity regulation, soil support, load and wind power transmission, etc.

The main technical methods of soil bioengineering revetment technology include wooden stakes, bundle of shoot materials, row of shoot materials, coconut shell fiber firewood cages, etc. [8-9]

4.3.2. Vegetation revetment

Developed root system soil fixing plants have a good effect on soil and water conservation, by effectively covering the slope surface with plants to prevent surface erosion and soil degradation. Using developed root plants for slope protection and soil stabilization can not only achieve soil and sand retention, prevent soil erosion, but also meet the needs of the ecological environment Landscape design can also be carried out. During the implementation of vegetation revetment, the main plants that can be selected for soil fixation with developed root systems include the first bud, sea buckthorn forest, black locust forest, and vine grass.

4.3.3. Ecological concrete

Vegetation type ecological concrete is research conducted in Japan in recent years in the field of river bank protection, mainly composed of porous concrete, water retaining materials, and topsoil:

Porous concrete is composed of coarse aggregates, cement mixed with blast furnace slag and silica fume, and an appropriate amount of fine materials, and is the skeleton of vegetation type ecological concrete;

The water retaining materials for ecological concrete often use inorganic artificial soil, absorbent polymer materials, moss peat and their mixtures.

The surface soil is laid on the surface of porous concrete to form a space for vegetation germination, while providing nutrients for the initial stage of vegetation germination.

Ecological concrete prefabricated blocks can be used in urban river slope or bank protection structures to form masonry retaining walls, or directly act as bank protection structures.

4.3.4. Ecological cement

The composition of ecological cement is basically the same as that of ecological concrete. It is a porous material with certain strength composed of solid, liquid, and gas phases.

Solid substances mainly include soil, fertilizers, organic matter suitable for vegetation growth, and cementitious materials composed of low alkaline cement and river sand. They are made into cement blocks of certain shapes, which are built together for bank protection. Herbs such as flowers and plants can be planted between the blocks.

Pores are formed by porous materials such as rice straw in the solid material of the planting base, to provide sufficient water and air for the plants. Water retaining agents can also be filled in the planting base to ensure that the plants can grow well on the slopes under constant sunlight.

4.3.5. Soil Solidifying Agent

High performance soil solidifying agents have been applied in the field of engineering in countries such as Japan for many years. They are widely used in road engineering, civil construction engineering, environmental protection engineering, agricultural water conservancy engineering, and solidify and treat various types of sludge. China introduced soil solidifying agent technology in the s, which was a high-tech product that was widely used for river and lake bottom solidification in the Beijing area.

Soil solidifying agent has both the properties of hardening the soil surface similar to concrete and the properties of the soft lower layer similar to soil. Therefore, the use of solidifying agent can cause the surface of the riverbed soil layer to crust, thereby achieving the effect of soil fixation and sand retention and making the bottom layer conducive to the reproduction of aquatic organisms, meeting ecological needs.

In urban river management, there is a contradiction between the need for hard river bottoms to prevent soil erosion and the need for soft river bottoms for aquatic reproduction. Therefore, it is recommended to use materials that can balance both. One of the better methods to solve the above contradictions is soil stabilizer.

4.3.6. Other Technologies

In addition to the above types of methods, there are also some comprehensive methods that combine the two or more methods mentioned above. This can more effectively restore the ecological environment of the riverbank, ensuring its stability and meeting the comprehensive requirements of urban ecological landscape construction.

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