Transformation from Traditional "Grey" Infrastructure to Sponge City

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Abstract: Under the high development of urbanization in China, the management of water resources such as sewage purification and rainwater has become one of the important reasons to limit its development. Relying on its own concept of regulation and control focusing on the whole water ecosystem, Sponge City has no suspense as the most suitable guiding theory to solve the ecological and rainwater problems at present. In view of the difficulties in sewage purification and rainwater utilization, this paper analyzes the advantages and disadvantages brought by traditional "grey" infrastructure and "sponge city". From two aspects of survival, transformation and filtration, rainwater should be arranged as a whole and rationally planned to create a natural and ecological urban drainage system in which sponge city and traditional "grey" infrastructure are coordinated with each other. Through the analysis and summary of literature review, this paper obtains the difficulties encountered in popularizing "sponge city" in the current urban development process in China, and discusses how to balance sponge city with traditional "grey" infrastructure combined with critical thinking. What's more, it expounds the complex diversity of rainwater and its interdependent and indispensable relationship with sponge cities and traditional "grey" infrastructure.

1. Introduction

With the gradual deepening of urbanization in China, people begin to pursue ecology and green. the government is increasingly aware of the importance of sustainable development resources such as ecology and natural green. The rainwater as one of the recyclable resources have been discovered and gradually arranged properly as a natural water resource, rainwater cannot be separated from the assistance of sponge city if it wants to join the ecological cycle of the city and complete many natural transformations work such as survival and transformation under independent conditions. Compared with other rivers and lakes, the biggest difference of rainwater is that it is extremely difficult to collect and concentrate, soit needs the assistance of traditional "grey" infrastructure construction. The filtration and diversion of rainwater is the basic condition for survival and transformation, andit has become the top priority of whether participate in the water ecological cycle of sponge city. Taking Tianjin Qiaoyuan Multidimensional Pit and SuDs Project in Britain as examples, the rational planning of rainwater and the natural regulation of water ecology are realized.

2. Sponge City and "Grey" Infrastructure

2.1 What is sponge city and "grey" infrastructure

The essence of water problem is the dysfunction of the whole water ecosystem, and the key to solve the water problem lies in the environment outside the water body, not in the river course and the water body itself. The research object must be changed from water body itself to aquatic ecosystem. The structure and function of water ecosystem are revised by ecological approach. The overall service functions of ecosystem are enhanced: supply service, regulation service, life bearing service and cultural spirit service [1, 2]. Starting from ecosystem service, water ecological infrastructure is constructed across scales [3, 4] combined with various technologies.

"Grey Infrastructure", that is, Civic Infrastructure, is traditionally defined as "a network composed of roads, bridges, railways and other public facilities necessary to ensure the normal operation of industrialized economy" [5]. With the advancement of industrialization in China, the "grey" infrastructure such as rivers and dams are becoming more complete. In some remote areas, there is still an urgent need for the government to support the construction of more perfect river dams and other facilities. However, in some economically developed areas, it has even appeared saturation or even surplus. Traditional urban construction would lead to vegetation destruction, road hardening, precipitation concentration, urban heat island effect and other consequences, which may inevitably lead to the increase of surface runoff after rainstorm, and even lead to a series of water problems such as urban waterlogging [6]. China's infrastructure is becoming more "standardized". They are often single-function designs. For example, rivers are bent, straightened and hardened for the single purpose of flood control. This practice ignores the combination of infrastructure and urban open space, and ignores its social, aesthetic and ecological functions, which seriously affects the overall contribution of infrastructure to the city [7].

2.2 Relationship between sponge cities and "grey" infrastructure

From the point of view of drainage mode, it can be divided into municipal drainage pipes or channels with "grey" infrastructure as the main body, sponge cities, which are water ecological infrastructure composed of rainwater gardens, permeable pavements and constructed wetlands. At present, the drainage mode of cities at home and abroad is mainly traditional urban construction mode, and hardened pavement is used on a large scale. During heavy rain, it mainly relies on "grey" infrastructure such as pipes and pumping stations to drain water. With "quick elimination" and "terminal concentration" control as the main planning and design concepts, urban waterlogging and sudden changes in drought and flood often occur. What sponge city wants to build is a system for developing low-impact rainwater, which mainly uses technical means such as "infiltration, stagnation, storage, purification, utilization and drainage" to realize the benign hydrological cycle of the city, improve the self-regulation ability of water ecology, maintain or restore the water ecological function of the city, and form a sponge-like city that can regulate rain and flood by itself. [8] [9]

For our country, it is the basis for the healthy development of sponge city in the future on restricting and encouraging the construction of sponge city through provisions. In order to develop better, we need to explore constantly according to the actual situation in the future. Although ecological construction is the core of sponge city construction, it is obviously unrealistic to face the huge drainage task only by the self-regulation of the ecosystem in the face of the rapid development of the city, especially for super-large cities with large population and prone to waterlogging. It is imperative to have a drainage project with a certain scale. [10]

3. Cases of Successful Sponge Cities at Home and Abroad at Present

3.1 Methodology

Sponge City has changed the traditional rainwater discharge mode and adopted the same rainwater management method as nature, which makes the rainwater secondary utilization and internal circulation mode, forming scattered storage and preliminary purification. Based on the subtle relationship between sponge city and traditional "grey" infrastructure, this paper further expounds that sponge city plays a more natural, flexible and natural adjustment mode in the current urban relationship compared with the past. The study selects two classic cases from the perspective of the existence and conversion of rainwater and the diversion and discharge of rainwater as support, summarizes the applicability and necessity of the two models, and provides guidance and strategies for this study.

3.2 Case analysis

3.2.1 Storage and transformation of rainwater-Tianjin Qiaoyuan

This area used to be a classic wetland and salt marsh landscape, but it disappeared due to the development of the city and the construction of too single "traditional" infrastructure, resulting in garbage everywhere, sewage flowing across and saline-alkali soil in this area. Because of the wide range of water level adaptability and pH tolerance of ground cover plants and wet plants, many potholes with different sizes and depths can solve the problem of site garbage at the initial stage. When precipitation is abundant, these pits can form naturally accumulated ponds, wetlands and seasonal pools, or waterless pits with improved soil under the erosion and filtration of rainwater (Figure 1). Diversified ecological communities create and start the natural process of plant adaptability and community evolution. With the change of seasons, potholes with different pH values, large and small, with water and no water, are connected in series in each plant planting area, forming a rich and diverse plant community (Figure 2).

Figure 1. Pool design diagram

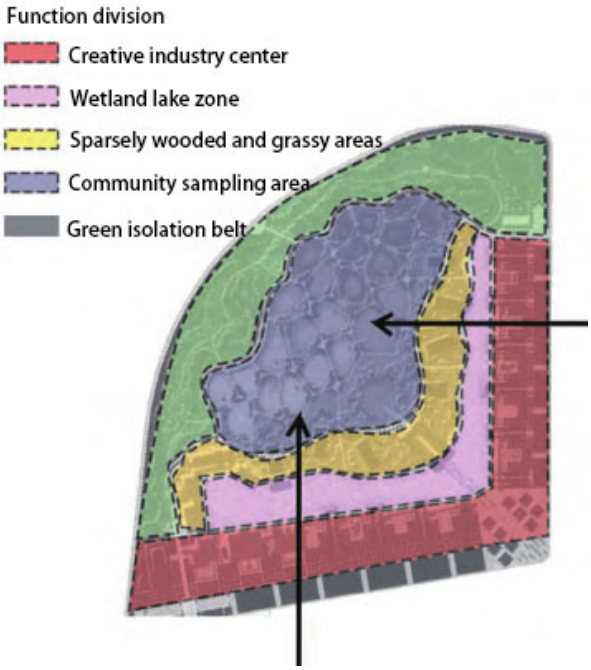

Figure 2. Functional partition

3.2.2 Rainwater filtering and diversion- British SuDs

The British government, whose annual rainfall can reach 1500mm, began to implement "Sustainable Drainage (SuDs)" in China [11]. Underground diversion and filtration of artificial and natural rainwater are carried out by laying permeable pavement and digging green depression respectively, and polluted rainwater is led from the surface of traffic road to hydrocarbons at the base of road for human intervention pollutant control, and then absorbed and evacuated by foundation soil. Perhaps, it is directly filtered by plant roots in green depressions. (Figures 3 and 4). This is very similar to the theoretical connotation of sponge city, which uses the self-repairing ability of land and hydrology to improve water quality, conserve water sources, retain sewage and relieve the pressure of heavy rainfall.

Compared with other countries, the biggest feature of SuDs project in Britain is to destroy the original facilities as little as possible, but only modify and utilize them on the original basis, which means that for cities with a large number of ancient buildings in China that are not convenient for direct renovation and reconstruction, we can try to build sponge cities from SuDs. [10].

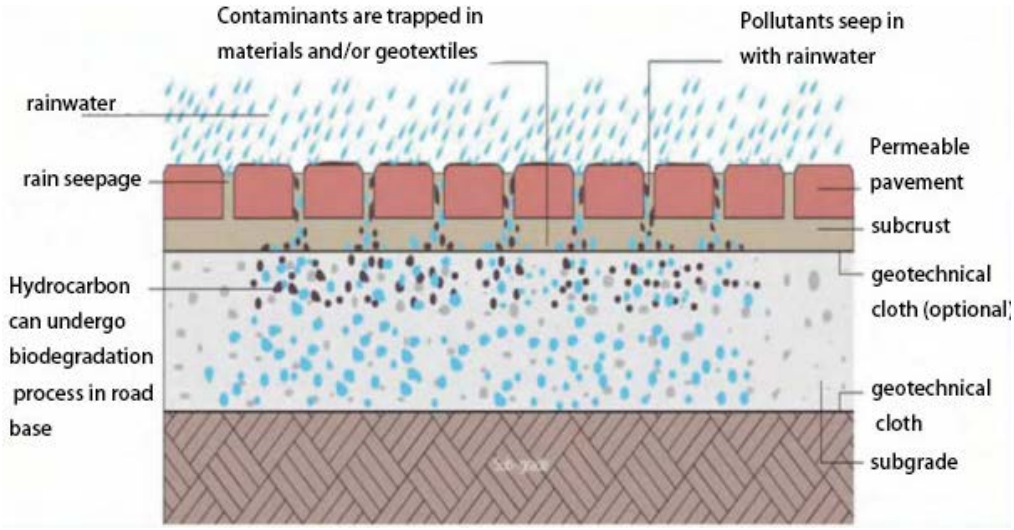

Figure 3. Control of Rainwater Runoff and Pollutants on Permeable Pavement

Figure 4. Green Space and Depression on Hardened Pavement

4. Problems and Countermeasures of Sponge City in Current Urban Development

4.1 Problems encountered by sponge cities in current urban development

4.1.1 Complexity of rainwater management

Rainwater management should not only meet the drainage requirements of cities, but also combine water and environment related to urban development, restore or maintain natural watersheds, deal with pollution, maintain ecosystems, store and transform rainwater, filter and channel, etc. Each of the above is a challenging requirement at present, not to mention achieving comprehensive development. Secondly, climate change and regional climate differences will greatly improve the difficulty of rainwater management. [12]

4.1.2 Challenges of late operation and maintenance of sponge city

Compared with the traditional rainwater management system with gray infrastructure as the main body, sponge city will be maintained more frequently. Although the design and construction costs of its projects can be estimated more clearly, it is not known if the operation and maintenance are included. After some extreme weather and unexpected accidents, the life of some projects in Sponge City will even produce many uncertainties, and there are often insufficient funds to maintain the later operation and maintenance. [13]

4.2 Countermeasures encountered by sponge cities in current urban development

4.2.1 Adhere to the idea of holistic and system development

The essence of sponge city is to change the traditional "grey" infrastructure-based rain and flood management system and realize the coordinated development with resources and environment [14]. This ideal can only be achieved by combining a systematic approach with ecological technology and the idea of harmonious coexistence between man and water. A good way to build sponge city is to change the single goal of flood control into multiple goals such as urban flood control, environmental improvement, ecological water demand and rainwater reuse [15]. How to build a sponge city needs systematic thinking? For the design, it is necessary to break the independence of various professional designs in the "traditional" gray infrastructure system, green infrastructure, ecosystem and urban construction system, and carry out top-level design based on the overall development concept of the city, instead of only pursuing the construction results of a single project and preventing the fragmentation of sponge city construction. [12]

4.2.2 Quantitative monitoring and evaluation

From the current situation of rain and flood management and sponge city construction, monitoring and evaluation is necessary, which can quantitatively evaluate the effect of sponge city construction and provide support for promoting the maintenance of sponge city. The degree and scope of monitoring are judged according to the purpose. For example, when evaluating the construction effect of sponge city, representative drainage areas, projects or facilities should be selected for water quality and quantity monitoring; Detailed monitoring should be carried out when evaluating and studying the permeability and purification functions of typical facilities, and the permeability coefficient of soil or artificial medium should be monitored; When evaluating the operation and maintenance of drainage system, select important pipe network nodes and pumping stations to monitor water quality and quantity.

a) Sponge city monitoring is an important means to evaluate its effect, and the content, scope and method of monitoring plan must be determined according to different monitoring purposes.

b) Sponge city construction monitoring should make monitoring plans and carry out monitoring with districts as units, so as to achieve hierarchical and system-wide monitoring objectives.

c) The monitoring of sponge city construction should cover the city's own conditions, drainage system and related receiving water bodies, involving various types such as season, water quantity and water quality, and make full use of information systems such as big data to maximize the benefits of monitoring work. [16].

5. Conclusion

In the process of urbanization in our country for nearly one hundred years, the government has been based on the construction of perfect municipal infrastructure. Therefore, the traditional "grey" infrastructure does not mean that it is wrong and backward. With the development of the times, the "grey" infrastructure has almost monopolized the whole rainwater management system, and even become the only way to manage urban rainwater. When meeting water, it will guide = without using, which makes more and more fresh water resources pass away without using it. The reasonable way to change this situation which seek the balance between the old management system and the new ideas, and change the single-function drainage into multi-dimensional and multi-functional absorption utilization, which would make full use of the self-repairing power of nature to store and purify rainwater. The artificial scientific and technological achievements included in the "grey" infrastructure-hydrocarbons are used to control and filter pollutants. The two modes respectively control and improve the water on the accumulated water and runoff pavement reasonably and effectively.

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