The Necessity Analysis and Idea Discussion of Sponge City Construction in North China

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ABSTRACT

With the continuous advancement of urbanization in China, the area of forests, fields and lakes have been decreasing. Some cities face two problems which are waterlogging and water shortage. How to deal with water ecological problems? Experts and scholars have proposed to build “sponge city” and make full use of rivers, lakes, buildings, roads, green spaces to form a complete sponge which has good flexibility in responding to environmental changes and natural disasters. This paper analyzes the successful cases of sponge city construction in Potsdamer Platz in Berlin, Germany and Pingxiang City. It analyzes the necessity of building a sponge city in the northern region from alleviating water shortage, preventing flood disasters, strengthening water ecological civilization construction and improving urban drainage infrastructure. It also proposed "zoning management, system construction, policy support."

INTRODUCTION

With the acceleration of urbanization and industrialization in developed countries, the concept of “urban rainwater management” appeared. Some western developed countries began to practice and study the theory in the 1970s. Australian population research scholar Budge first used "sponge" to express the adsorption effect of cities on the surrounding population. Ignacio F. Bunster-Ossa describes the city as a sponge with functions like water retention, filtration and purification and the flexibility to deal with rain and floods natural events [1]. Yu Kongjian and Li
Dihua used “sponge” to describe the ability of native wetlands and rivers to regulate urban drought and flooding in 2003[2]. Dong Shuqiu first proposed the concept of constructing an “ecological sponge city” from the perspective of urban planning in theoretical research in 2011[3]. The Urban Construction Department of the Ministry of Housing and Urban-Rural Development clearly proposed the sponge-type urban concept as a key work in February 2014. Xi Jinping proposed the new ideas for water control and emphasize again “building a sponge home and a sponge city”[4].

THE CONNOTATION ANALYSIS OF SPONGE CITY

In December 2013, Xi Jinping clearly pointed out the concept of sponge city, which is to make cities have absorbing and releasing rainwater functions like “sponges”, and can flexibly adapt to environmental changes natural disasters through original topography and geomorphology, natural ecological background, vegetation soil to accumulate, infiltrate, refine rainwater. The Ministry of Housing and Urban-Rural Development says a city should absorb water, retain water, seep water, and purify water when it rains, and release as well as use the accumulation of water when needed in October 2014. The author think the sponge city should have the function of absorbing and releasing rainwater, it could combines the artificial measures and natural ecosystems of grasslands, mud, forests and lakes to store rainwater when it rains, and release and use the accumulation of water when needed, which can effectively alleviate these problems such as waterlogging, seeper, water shortage, heat island [5].

CASE STUDIES OF SPONGE CITY CONSTRUCTION

Foreign Construction Case

The Potsdamer Platz is a mild humid continental climate with hot summers and cold winters, the annual precipitation is 525~665mm. The river network is dense, there are many lakes and swamps, and floods are flooding in spring.

The Potsdamer Platz takes many actions to build the sponge city. First, the main water storage system of the square is divided into two parts. The first part can accommodate 2600m$^3$ of water by setting 5 underground storage tanks, 900m$^3$ of which is used for emergency rainfall. The second part retains the water depth of 15mm above the constant water level of the main water surface. This provides a buffer volume of 1300m$^3$, which increases the emergency response capacity of the water storage system. Second, the roofs of 19 buildings around the square use the “green roof” rainwater utilization system, the water storage system of the landscape reservoir and the basement forms a circulating water pump. There is an automatic water quality monitoring system in front of the pumping station. If the water quality is up to standard after filtration, it can directly enter the rainwater circulation system.
for secondary use. The green roof can retention or reduction up to 85% of the rainfall and reduce the pressure on urban underground drainage pipes. Third the rain flows along the road to the ditches on both sides when it rains, the paths in the ditch are uniformly flowing to the reservoir sedimentation system. The open ditch reduces the accumulation of rainwater and it effectively prevents the occurrence of flood disasters.

**Domestic Construction Case**

Ping Xiang is a subtropical humid monsoon climate. The rainfall is abundant, the average annual rainfall is about 1600mm, and there is more rainfall in the second quarter of the year.

In order to build the sponge city, Ping Xiang takes many actions. Firstly, for the buildings and communities in the new urban area, facilities such as permeable pavement and green roof will be added during construction to promote the absorption, penetration and purification of rainwater through the technical systems of seepage, seepage, stagnation, storage, discharge, and use. Second, Ping Xiang transformed the park and the green space into the rain garden and low elevation greenbelt, and the new vegetation buffer zone and ecological wetland will adjust the rainwater. All the hard pavements of park including the original and new road were paved with permeable materials to increase the infiltration of rainwater. Then the water pollutants are cleaned regularly and the sewage is discharged to the special sewage pool. At the same time Ping Xiang build construct the manual storage area and drainage pump station to enhance the drainage capacity. Finally, the whole urban roads including the original and new road were paved with permeable materials, even including sidewalk. The low-concave green belts and decentralized rainwater gardens were built on both sides of the road, it aims to collect and utilize rainwater.

![Figure 1. PM2.5 data from the past three years.](image)
The new urban district formed the contiguous effect through the construction of major projects, and enhanced the drainage and flood control capacity effectively. The old urban area has withstood many heavy rainstorms through the transform of park and roads. The traditional waterlogging area including Wan Long Bay and Wu Feng River Basin were not waterlogging in 2017. More than 40 sponge industries have brought over 2 billion annual output values for Ping Xiang, and promoted the economic development and industrial structure optimization. The air quality of Ping Xiang became better and better since the construction of the sponge city, the PM2.5 data from the past three years are shown in Figure 1.

RESEARCH ON THE CONSTRUCTION OF SPONGE CITY IN THE NORTH

Urgency Analysis of Building Sponge City

The annual precipitation in the northern region is usually 400-800mm, and mainly happed in July and August so that flood appeared easily. However, the spring is short of rain and the drought appeared easily. The main water systems include Liao River, Songhua and Black Wusuli River in the northeastern region, the water volume is small and the water level changes greatly. The main water system is the Yellow River which has a large seasonal change in North China, the river surges in summer and autumn, and the flood appeared easily.

A lot of water evaporated in the spring, the advanced industry and agriculture industry need a lot of water resources and the water pollution further increases the shortage of water resources, the water pollution of 2016 years was shown in Figure 2. The concentrated rainfall, the ice run of the Yellow River and the old urban drainage facilities are easily affected by flood. Heavy rainfall occurred in northeast China in 2017, and the urban waterlogging happened in some areas. Due to ice run, the branch of Yellow River appeared the largest flood since the 1970s. Meanwhile, if the rainwater could not be utilized efficiently, it will be a big waste for water resource shortage in northern China. Sponge city can not only control river pollution, but also promote the recycling of rainwater, and alleviate water shortage effectively.

Analysis on the Construction of Sponge City in Northern Region

The author proposes zoning management, system construction and policy support for sponge city construction in northern China based on successful cases at home and abroad.
Figure 2. Water quality of major river sections in the north in 2016.

（1）Partition management

Combined with the natural ecosystems of the two major river basins and branches, the two divisions of the Northeast Plain and the North China Plain are divided based on the construction of the Liaohe-Songhua River Basin and the cities along the Yellow River Basin, and the suitable policy framework for the construction of sponge cities is formulated in each district. Each district establishes the comprehensive rainwater utilization system from Buildings and Communities, Urban Roads, Urban Water Systems, Urban Green Spaces and Squares, and improve the underground drainage infrastructure to promote the recycling of rainwater.

（2）System construction

Select the low-impact development technologies for urban functional zoning according to local conditions and economic efficiency, technical measures are shown in Table 1. The water pollution was controlled at source for Liaohe River, the Songhua River, and the Yellow River with its tributaries. On the one hand, the high-polluting industrial enterprises should be banned, the domestic garbage should be classified and recycled, and the sewage is discharged to the special sewage pool; On the other hand, the water pollution monitoring station should be established to monitors and record the locations and pollution sources of water pollution, so as to treat the polluted river sections timely and accurately.

（3）Policy Support

Formulate and improve the suitable, harmonious and unified policy framework for sponge city construction in the northern region. Government set goals implementation strategy to guide and supervise the construction of sponge city.
### TABLE I. TECHNICAL MEASURES.

<table>
<thead>
<tr>
<th>Functional Division</th>
<th>Technical measures</th>
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<tbody>
<tr>
<td>Building and community</td>
<td>Permeable brick paving, green roof, sunken green space, Biological retention facility, infiltration pond, seepage well, wet pond, rainwater wetland, rainwater tank, grass swale, vegetation buffer zone</td>
</tr>
<tr>
<td>City road</td>
<td>Permeable brick paving, sunken green space, Biological retention facility, rainwater wetland, grass swale, vegetation buffer zone</td>
</tr>
<tr>
<td>Green space and square</td>
<td>Permeable brick paving, sunken green space, Biological retention facility, infiltration pond, seepage well, wet pond, rainwater wetland, grass swale, vegetation buffer zone</td>
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<tr>
<td>Urban water system</td>
<td>Wet pond, rainwater wetland, vegetation buffer zone</td>
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### REFERENCES