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# Case study on the Chinese polluted river and lake restoration under the sponge city construction

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**Abstract:** In order to improve the urban ecological environment, the central government has developed a series of water pollution control policies and measures since April 2015, and required local governments to complete the work of the polluted river and lake restoration within specified period. Moreover, the polluted river and lake restoration has been selected as a key evaluation indicator of achievements of the sponge city construction implemented since April 2015. This paper describes how to apply the sponge city construction technology to rehabilitate the polluted rivers and lakes through the polluted water treatment project in Xinghan New Area, Hanzhong and the polluted Huaguping River restoration project in Pingshan District, Shenzhen. The experience and lessons of the polluted river and lake restoration are summed up. Some measures to solve existing problems are put forward.

**Key words:** sponge city, polluted river and lake, restoration, ecological environment, case study

## 1. INTRODUCTION

With the rapid development and urbanization, the problems of the polluted rivers and lakes in the China have gradually become the fatalities of urban ecological environment construction <sup>[1]</sup>. Waterlogging often occurs in the Chinese cities, and the water environment pollution and the loss of rainwater resources have become obstacles to the sustainable urban development. 11,000 sudden water environment events have occurred in the whole country since 1995, which seriously affect the people's lives and physical & mental health <sup>[2]</sup>. The governmental departments neglect the environmental carrying capacity in the economic development, it causes serious environmental problems and huge economic losses. Therefore, it is urgent to treat the polluted rivers and lakes as soon as possible.

On April 16, 2015, the State Council issued the *water pollution control action plan*, which requires that the quality of the water environment in the whole country will be improved in stages by 2020, and efforts will be made to improve the overall quality of the water environment by 2030. In order to achieve these objectives, the *water pollution control action plan* provides 238 measures in 10 aspects, which is the China's water pollution prevention work guide during the current and future period <sup>[3]</sup>.

On August 28, 2015, the Ministry of Housing and Urban-Rural Development, the Ministry of Environmental Protection, the Ministry of Water Resources and the Ministry of Agriculture jointly formulated the *guidelines for the remediation of urban black and smelly water*. This guidelines require that water quality investigation should be completed in the built-up areas of the prefecture-level cities by the end of 2015; the black and smelly water should be basically eliminated in the built-up areas of directly administrated municipalities, provincial capitals or specific plan oriented cities by the end

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of 2017; 90% of the black and smelly water in the built-up areas of the prefecture-level cities shall be controlled at the end of 2020; the black and smelly water in the urban built-up areas shall be eliminated by 2030<sup>[4]</sup>.

On December 11, 2016, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council jointly issued the *opinions on the overall implementation of the river chiefs*. The river chiefs should be fully established at the end of 2018, and the heads of local governments are fully responsible for the environmental improvement work of rivers in their respective regions<sup>[5]</sup>.

On April 9, 2015, the Ministry of Finance and the Ministry of Environmental Protection jointly formulated the *opinions on the promotion of public and private partnership in the field of water pollution control*<sup>[6]</sup>. Social capitals are encouraged to take part in water environmental treatment actively.

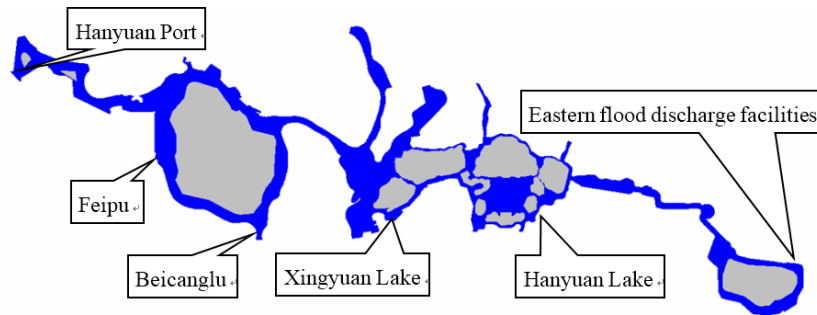
According to the *guiding opinions on promoting the construction of the sponge city* issued by the General Office of the State Council in October 2015, the sponge city construction should give full play of vegetation and soil to infiltration of rainwater, and give full play of wetlands, water basins to natural purification of water quality for realizing the natural circulation of urban water. Giving full part to the natural ecological functions and artificial intervention, the implementation of source reduction, process control, system management, is conducive to restore urban water ecology, conservation of water resources, enhance the urban waterlogging control ability, expand effective investment of public goods, improve the quality of new urbanization and promote the harmonious development of human beings and nature. Through the sponge city construction, the comprehensive infiltration, detention, storage, purification, utilization, drainage measures are used to minimize the impact of urban development and construction on the ecological environment. By 2020, more than 20% of the urban built-up areas will meet the requirements that 70% rainfall will be consumed and utilized locally; and more than 80% of the urban built-up areas will meet the target requirements by 2030<sup>[7]</sup>. It should re-examine the traditional gutter - rainwater inlet – drainage pipeline - river system storm water drainage system. The guiding opinions pointed out that promotion of the sponge city type road construction by means of low impact development techniques, changing traditional fast and rapid drainage mode, enhancing absorptive function of the green belts, constructing permeable pavement in the non-motor vehicle lanes, sidewalks, and parking lots, collection, purification and use of road rainwater to reduce the municipal drainage system pressure and gradually achieve mitigation goals such as no ponding during small rain, no waterlogging during heavy storm, clean water and heat island reduction.

Under the background of vigorously promoting the of sponge city construction, the effects of sponge city construction are closely related to the polluted river and lake restoration because the polluted river and lake restoration is an important part of the sponge city construction. This paper introduces two polluted river and lake treatment projects in Xinghan New Area, Hanzhong, Shaanxi Province, and Pingshan District, Shenzhen, Guangdong Province to discuss how the sponge city construction technology to treat the black and smelly water. The problems in polluted river and lake restoration are analyzed, and some improvement measures and the successful experiences are put forward and summed up.

## **2. THE POLLUTED RIVER AND LAKE RESTORATION IN XINGHAN NEW AREA**

The Xinghan New Area, Hanzhong, Shaanxi Province, consists of the Mazhai, Xingyuan Lake and Lijiawan areas. The total area is 27.7 km<sup>2</sup>, north to Class 1 Chengbao Highway and 108 National

Highway, south to the Yangan Railway, west to the interchange of 108 National Highway and Yangan Railway, and east to the interchange of Class 1 Chengbao Highway and Yangan Railway. The Xinghan New Area is developed by means of the Han culture tourism and five A scenic spot<sup>[8]</sup>. A new water system with an area of 2.08km<sup>2</sup> is created by connecting 7 existing reservoirs. The length is 8km from east to west, the maximum width is about 1.8km from north to south, and navigable water depth is 3m (see Fig. 1). The water quality flowing into the new area is unqualified, and most of them are Class V or worse (see Fig. 2).

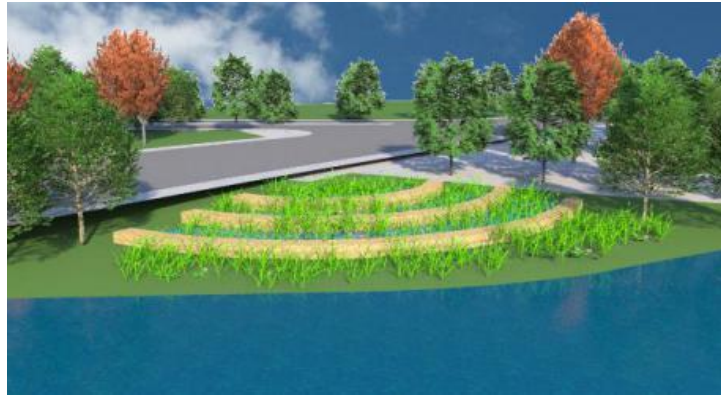


**Fig.1.** New river system in Xinghan New Area

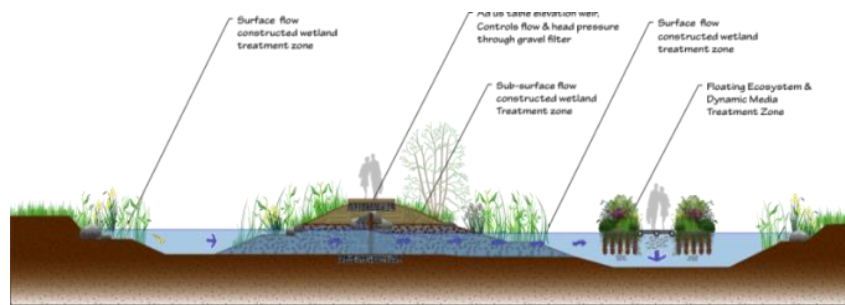


**Fig.2.** Inferior Class V water quality in Huangbayuan reservoir

In order to treat the polluted water in the Xinghan New Area, the Developer used the sponge city facilities such as rainwater gardens, permeable pavement, ecological sewage and rainwater treatment system to deal with the non-point source pollution (see Fig. 3). The water quality channel technology was used to deal with the inflow river water quality. Therefore, the water quality of the inflows and new reservoir can meet Class IV requirements. The water channel technology employs the natural purification ability to treat the river water and the reservoir water. The main facilities include gravel contact oxidation systems, active floating island reactors and wetlands. These facilities were designed in combination with the topography, reservoir profile and the surrounding landscape. Water is purified through biofilm formation of gravel layers, the plant absorption and consumption of active floating island reactors and wetlands, and aeration function of active floating island reactors (see Fig. 4).



**Fig.3.** Image of biological wastewater treatment System in Xinghan New Area



**Fig.4.** Schematic diagram of gravel contact oxidation system and active floating island reactor

### 3. THE POLLUTED HUAGUPING RIVER TREATMENT

The Huaguping River is a tributary of the Longgang River, and it located in the boundary between Shenzhen and Huizhou. The Huaguping River originates from the Huaguping Reservoir, and flows into the Longgang River at the Xiapo Road. The river basin area is 1.934km<sup>2</sup>, the average gradient of the river bed is 0.0801, and the river length is 1.405km (see Fig. 5). The average rainfall is 1719.1mm in the Huaguping River basin, 85% of rainfall occurs during the rainy season from April to September, and 15% of rainfall distributes in the dry season from October to March. The main water supply source is from rainfall, the Huaguping reservoir and sewage along the river. There is no sewage flowing into the Huaguping River upstream of the Longxing North Road, and the river water quality is good. The water quality of the Huaguping River downstream of the Longxing North Road is very bad because of sewage discharging into the river, non-point source pollution and secondary pollution of the deposits of the Huaguping River<sup>[8]</sup>

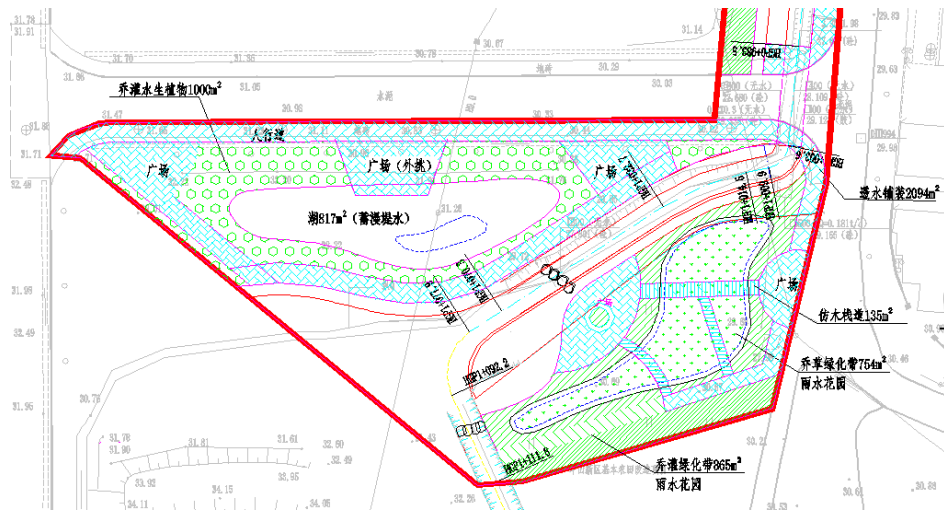


**Fig.5.** The Huaguping River

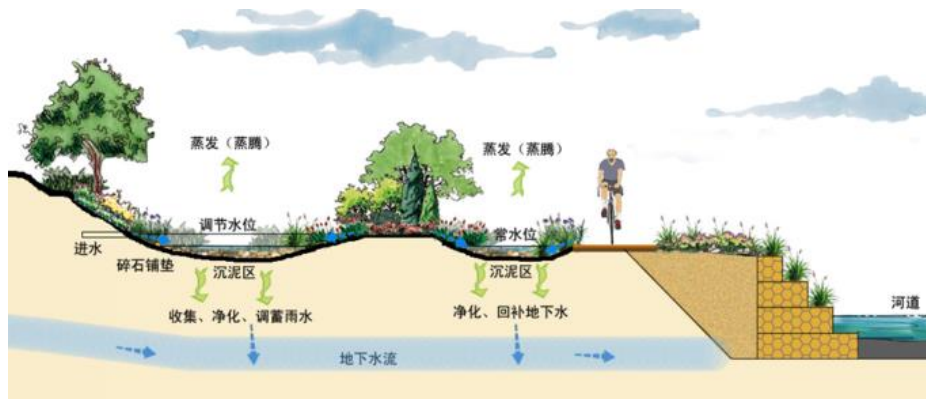
Based on the comprehensive analysis of the current situation of water pollution, water quality testing and polluted causes, the river restoration measures, including taking sewage into sewage pipeline, reducing non-point source pollution by sponge city facilities, removing the river bed deposits, recharging clean water and ecological restoration, are proposed. The treatment goal is to restore the ecological and landscaping functions of the Huaguping River by using the sponge city construction techniques and other river restoration technology. The main projects for the Huaguping River restoration are described as follows:

### **3.1. Raingardens on the upstream reaches**

Some natural wetlands are reformed into raingardens on the upper reaches to reduce the peak discharge, and the green belts with an area of 1619m<sup>2</sup> are constructed along the Huaguping River to reducing the non-point source pollution. The raingardens with a catchment area of 7453m<sup>2</sup> are located at the junction of the Huaguping River and a tributary which is the discharging channel of the Huaguping Reservoir (see Fig. 6 & Fig. 7). A flood control pond with an area of 817m<sup>2</sup> is constructed on the left bank to collect the runoff from a nearby mountain, and some small waterfalls are designed to create the river landscape. The area of the permeable pavement on platform and sidewalks is 2229m<sup>2</sup>.



**Fig.6.** Raingardens on the upstream reaches



**Fig.7.** Cross-section of the raingardens on the upstream reaches

### 3.2. Sediment removal and pollutant source control

The deposits of the Huaguping River will be dredged to reduce the secondary pollution. The sewage pipelines with diameters of 400-600mm are installed along the two banks. The length of the sewage pipeline on the left bank is 827m, and the length of the sewage pipeline on the right bank is 819m.

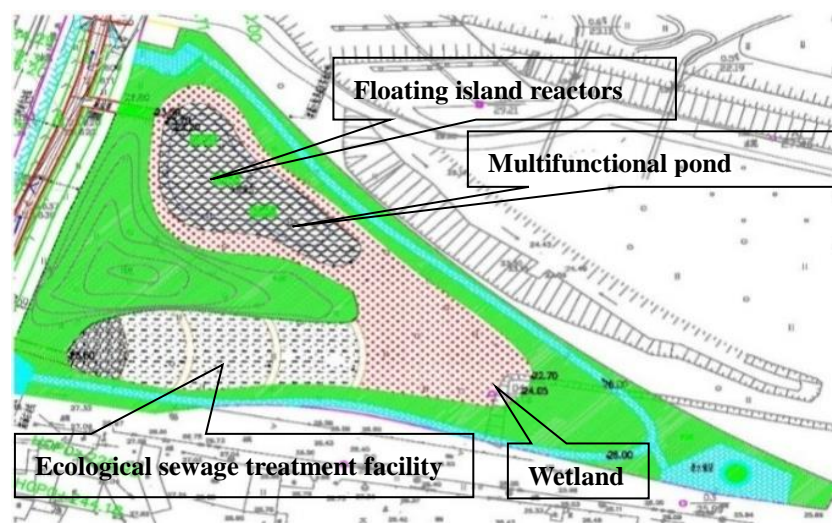
### 3.3. Sunken greenbelts on the middle reaches

The sunken greenbelts along the Huaguping River on the middle reaches are arranged to reduce the non-point source pollution, create the river landscape and improve ecological environment.

### 3.4. Innovative sponge city facilities on the downstream reaches

Innovative sponge city facilities such as ecological sewage treatment facilities with an area of 934.1m<sup>2</sup>, constructed wetland with a surface area of 3212.4 m<sup>2</sup>, active floating island reactors with a total area of 95.2 m<sup>2</sup> and multifunctional pond with a surface area of 1910.6 m<sup>2</sup> are designed near the junction of the Huaguping River and the Longgang River. The river water quality treated by the innovative sponge city facilities could reach Class IV. The ecological sewage treatment facilities are made up of three raingardens, and the water flows into constructed wetlands and multifunctional pond to further purify the water quality. Shrubs, macrophanerophyte, water plants and aquatic plants are planted on the mixed soil of the ecological sewage treatment facilities. The permeability of the mixed

soil is greater than 25.4mm/min, and the organic matter content is controlled within the range of 8%-10%.



**Fig.8.** Layout of the innovative sponge city facilities

#### **4. EXPERIENCE AND LESSONS IN THE TREATMENT OF THE POLLUTED RIVERS AND LAKES IN CHINA**

Since April 2015, the central government has recognized the bottleneck of the urban environment and economic development, formulated a series of policies and measures for water pollution control, carried out some large-scale water pollution control projects, and achieved some results. For the water pollution control, local governments are encouraged to plan, design and manage the black and smelly water treatment projects according to their own characteristics and adopting the innovative technology, ecological techniques and sponge city construction technology. On the other hand, local governments are required to adopt the Public-Private Partnership (PPP) to restore the polluted rivers and lakes, which are helpful to private capital to participate in the construction of urban public facilities and stimulate local economic development. The main successful experiences of the polluted river and lake treatment can be summarized as follows:

- 1) The central government attaches great importance to the prevention and control of water pollution. Under the unified leadership of the central government, local governments should formulate specific work objectives and implementation plans, and accomplish tasks within the prescribed period.
- 2) The party and government leaders take charge of the river chief in the areas under their jurisdiction, which is conducive to overall treatment work.
- 3) Water pollution control projects are fully open to the community, rather than by government investment alone; Introduction of PPP is helpful to stimulate local economic development.
- 4) The central government encourages innovation in treating the polluted rivers and lakes, and requires local governments to formulate treatment plans and carry out project construction in light of regional characteristics and pollution conditions.
- 5) The introduction of ecological treatment technology and sponge city construction technology into the polluted water treatment projects is helpful to solve the problems of non-point pollution and point pollution.

Although the successful experience has been achieved in treating the polluted water, there are still some problems that need to be improved.

- 1) Tight construction period. The construction periods of the polluted water treatment projects

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are set as 2-3 years. They are suitable for small rivers, but they are too tight for large rivers, which leads to reduce project quality. The reasonable periods for large rivers are 5 years.

2) Bad project quality. The polluted water treatment projects are comprehensive systems involved in a wide range of technical requirements. However, because the construction periods are too short, the designers and construction personnel did not receive proper training, resulting in many reasonable design drawings, construction without following the drawings, and part of the project quality not meeting the design requirements.

3) Lack of Innovation. Although the central government requires the use of innovative technology, because tight period, many polluted water treatment projects are still using the traditional technology, and innovative and ecological treatment techniques are not adopted in consideration of the local conditions and pollution situations.

4) Poor landscape effects. The river landscapes are stereotyped, and do not reflect local characteristics.

The central government and local governments should take the following measures to improve the problems mentioned above.

1) Local enterprises and residents should take part in water pollution control projects, and reasonable project periods shall be made according to the local conditions;

2) The training for professionals and administrator should be strengthened;

3) The innovative work should be enhanced according to the actual situations;

4) Technical standards should be worked out and promoted;

5) The experience in the treatment of the polluted water should be exchanged, and pilot city campaign for treating the polluted rivers and lakes should be implemented as soon as possible;

6) Residents supervision and expert consultation system shall be formulated;

7) The acceptance and management of the treatment of black and smelly water should be strengthened.

## 5. CONCLUSIONS

How to apply the sponge city construction technology to treating the polluted rivers and lakes are introduced through the new river system treatment in Xinghan New Area, Hanzhong and the Huaguping River restoration project in Pingshan District, Shenzhen. The two projects use the water channel technology, raingarden and innovative sponge city construction technology such as ecological sewage treatment system, gravel contact oxidation system and active floating island reactor. The traditional treatment technology such as installing sewage pipelines and constructed wetlands are also used. Therefore, the polluted treatment projects are the results of the comprehensive application of many technologies.

Lessons learned from the treating the polluted rivers and lakes are that local governments neglected the environmental protection and destroyed the original ecology during developing the economy, resulting in a large amount of investment in the environmental restoration at present, which causes a great waste of resources.

The treatment work of the polluted rivers and lakes is led by the central government, and implemented by local governments. Technology innovation and PPP are required in treating polluted rivers and lakes, which can not only improve the urban water environment, but also can enhance the local enterprises and resident's participation.

Technological innovation is the driving force for social development. Scholars, experts, technical and management personnel with innovative capacity should fully participate in water environment



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control projects. The polluted river and lake restoration by introducing PPP is a major innovation system, and this successful experience can be used to the emerging market countries and developing countries.

The policies and measures for treating the polluted water should be performed in consideration of local meteorological, geological, hydrological, water quality, economic and environmental conditions. Priority should be given to ecological technology and technological innovation. The reasonable construction period should not shorten for the completion of political tasks.

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