Urban polluted water treatment based on landscape ecological construction technology

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Abstract. Since the reform and opening up in the last century, many cities in China have entered the rapid stage of development, at the same time, the problem of urban water environment pollution has become increasingly prominent. Good water environment is the basic guarantee of the healthy and harmonious development of the city, therefore, people begin to invest a lot of energy on how to control the polluted water of the city reasonably and efficiently. In this paper, the present situation of water environment in most cities of our country is summarized, and the main technical measures and their advantages and disadvantages of urban polluted water treatment in the past are briefly analysed. And it further expounds on how to integrate landscape ecological construction technology into the treatment of urban polluted water in details in order to provide reference for the future urban water environment management.

1. Introduction

The total amount of water resources in China is 2.81 trillion m³, ranking the sixth in the world. But the per capita water resources in China is only 2300 m³, which is 1/4 of the per capita water resources in the world, and is one of the 13 poor water countries in the world [1]. Of the more than 600 cities in the country, more than 400 cities have insufficient water supply, among which 110 cities are seriously short of water, and it is 6 billion m³ that the total annual water shortage in cities throughout the country amounts to [2]. As the source of life, water is an important part of urban natural environment and the support of urban development. With the rapid development of economy in China, the problems of water pollution in urban water system, urban waterlogging and shortage of water resources are becoming increasingly prominent.

In recent years, great progress has been made in urban water treatment in China. For example, from the single flood control to the construction of recreation space, from the improvement of water quality to the restoration of watershed ecosystem, and from small-scale to large-scale, from the emphasis on qualitative description to emphasis on quantitative analysis [3]. Water environment management technology has gradually transformed from physical and chemical technology to biological-ecological treatment technology. The comprehensive improvement of urban environmental infrastructure and river channels has improved the urban green coverage rate and strengthened the background of green development. However, the water eco-environmental quality is still a prominent deficiency affecting the overall development of the city, and the problem of water ecosystem
construction in water environment management has not yet been effectively solved. There is still a big gap compared with the growing environmental needs of citizens and the goal of building an eco-livable city.

In modern cities, we should strengthen the protection and construction of ecological environment, promote the green development, and carry out the research and application of water environment treatment technology suitable for urban polluted water treatment and landscape, so as to solve the problem of urban water pollution systematically. We will build a beautiful city and promote a green shift in the way of development in order to build a more livable ecological city. Urban polluted water treatment technology based on landscape ecological construction, which combines water ecological treatment technology with landscape construction technology, restores urban polluted water synergistically, and optimizes physical and chemical treatment technology. And it would also establish landscape spaces for citizens to relax, and provide new scientific and technological support for the treatment of urban polluted water.

2. Situation of water environment

In recent years, there has gradually increased the intensity of water pollution control in China, and the proportion of surface water quality section has been increasing. For example, the black and smelly water in built-up areas of 36 key cities have been basically eliminated. The quality of the water environment in the country has further improved, and the people are truly aware of the positive changes in the quality of the water environment. Overall, the water environmental quality has improved, but the polluted water have not been completely eliminated. From 2015 to 2017, the proportion of surface water quality (figure 1) of the III class and above showed an upward trend in China, but the increase was relatively slow, while the proportion of the IV class and below showed a downward trend, and it is about 30% that the total proportion of IV class and below amounts to, the quantity is still high [4].

At the same time, the situation of aquatic ecological environment in China is still urgent and complex. Incomplete construction of aquatic ecosystem and lack of systematic protection are the main problems. The water system lacks overall protection, and has not yet constructed the large-scale protection layout of the linkage between the water area and the land area, and between the coast and the river basin.

3. Technology of water treatment

As a result of unreasonable urban construction and expansion, rivers lakes and so on, have been polluted by municipal garbage and industrial sewage, and have become culverts for sewage discharge. With the deterioration of the ecological environment of water gradually appeared, government officials began to pay attention to the restoration of damaged water, and water restoration technology has also been developed. According to the volume of the damaged water, the source of pollution, the degree of damage and so on, the researchers put forward the corresponding solutions. It can be divided into three categories: physical methods, chemical methods (table 1) and biological-ecological...
methods.

**Table 1.** Physical and chemical techniques for water environment treatment.

| Technology of water purification | Principal | Specific technology | Shortcomings               |
|----------------------------------|-----------|--------------------|----------------------------|
| Chemical technology             | Application of chemical agents to remove algae and nutrients from waters | Flocculation sedimentation technology | Chemicals are liable to secondary pollution |
|                                  |           | Heavy metal immobilization technology |                             |
| Physical technology              | Direct displacement of pollutants to decontaminate | Water supply and exchange technology | Large water consumption |
|                                  |           | Sediment dredging technology | High cost |
|                                  |           | Circulating filtration technology | Poor removal of nutrients |
| Bio-ecological technology        | Application of food chain to control algae content and by the metabolism of organisms to transforme the pollution | Ecological wetland technology | Easy to plug |
|                                  |           | Aquatic ecosystem technology | Works slowly |

Bio-ecological methods include plant and microbial remediation technologies, such as ecological wetland technology [5], artificial floating bed technology [6], biofilm technology [7] and so on. It controls the algae content through the food chain, uses the organism metabolism to remove the water pollutant, thus to improve the water quality. The use of phytoremediation and microbial remediation technology to carry out ecological restoration of polluted and damaged water avoids the shortcomings of physical and chemical methods such as high cost and large water consumption, which is in line with the long-term goal of sustainable development.

4. Urban polluted water treatment based on landscape ecological construction technology

Biological-ecological restoration technology overcomes the shortcomings of physical and chemical technology, nevertheless, it doesn’t combine with the water landscape to create landscape space for citizens to relax. The construction of urban water landscape from the aspects of water culture, space and vision, and according to the conditions of different rivers, beautifies the urban water environment and provides places for people to entertain [8]. But there are some deficiencies in the ecological design, water landscape protection and maintenance and leisure space construction.

Urban polluted water treatment should consider comprehensively the source and current situation of water pollution, from external pollution interception to ecological restoration, carry out research and development of water environment treatment technology suitable to landscape. Taking technical measures of combining engineering, environment, ecology and landscape to reflect the regional culture. The construction of urban water landscape should naturalize urban river, adjust the structure and open space of waterfront area, establish green ecological corridors and ecological revetments, from the natural form of rivers, water system connectivity, vegetation allocation and other aspects of the natural waterfront construction, so that the river in the vertical, horizontal and deep three-dimensional direction of rich landscape heterogeneity, so that the city damaged river ecological restoration reflect the water ecological landscape [9].
4.1. Landscape ecological pollutant source control technology

The premise of ecological treatment of polluted water is pollutant source control. The external pollution of urban water mainly includes point source pollution and non-point source pollution, industrial waste water, domestic sewage and other point source pollution, which can be controlled by policies and regulations. The non-point source pollution is formed by rainfall and snow melting, etc. dispersion of no fixed discharge points, and it is difficult to interception, which resulted in water organic pollution, eutrophication or toxic and harmful pollution, and it places a serious impact on the water ecosystem, affecting the urban ecological environment.

According to different pollution types, there are four kinds of point source pollution control technologies.

4.1.1. Interception pipelines. To reduce pollutant discharge from the source, the interception combined drainage system uses overflow control devices along the riverbank, makes full use of the existing confluence pipes, and lays interception pipes along both sides of the river to collect sewage [10]. In order to avoid the overflow of sewage from the drainage system or the high water level leading to the river water entering the sewage pipe, the interception main pipe and the interception can be separated. Through reducing discharge and setting reasonable anti-backflow measures, sewage separation at the junction of confluence system and diversion system has to do well.

4.1.2. Rain water and sewage diversion. Some residents of the city discharge sewage, such as washing, into water risers. The drainage system of residential area is changed by reforming the construction of building drainage system to realize the effect of rain water diversion, to lighten the load of sewage interception pipe on municipal confluence system, and to combine vertical greening with water riser. Part of the rain and sewage drainage system in the city is mixed, and rain water discharges directly with the sewage to the receiving water body, so that causing water pollution. Through rebuilding the original confluence pipeline and reforming damaged or aged pipes, ensures proper operation of rain and sewage drainage system. The expansion of the diameter of the sewage pipe and the inspection of the original confluence pipe should be strengthened to avoid the blockage of the pipe. In the process of constructing new sewer pipe, we should make full use of the existing sewer network and the original sewer pipe, take the old drainage pipe as the sewer pipe, and add rain water pipeline system [11].

4.1.3. Rain water infiltration. To improve the infiltration rate of rain water, to reduce surface runoff and increase surface water content, we would choose permeable materials to replace impervious pavement. Digging ecological drainage ditches in the rigid square to infiltrate part of the rain and flood, so that it can guide surface runoff to sink green space or other collection point [12]. Using drainage ditch filler with certain porosity and colour and material in harmony with square paving stone to improve landscape, ensures confluence and infiltration rate. The large concave terrain could be transformed into wetlands, rain water gardens, and so on, which equipped with plants, landscape platforms to provide citizens with leisure places. Areas where the terrain is less undulating and where the soil has a certain infiltration capacity, we take measures such as sunken green space and biological retention green space to let rain water naturally infiltrate and store, and increase the rate of greening coverage.

4.1.4. Reducing the concentration of rainwater pollutants. Making use of the interception, adsorption, absorption and transformation of soil and plants, rain water was preliminarily purified, and the concentration of pollutants was reduced, then the pollution was reduced from the source. There are two specific treatment techniques.

Using green building to reduce the concentration of pollutants in rain water. Rain water erodes the roof of the building, bringing the soluble matter on the surface of the building into the receiving water, causing water pollution. We would collect, purify and use rain water in the manner of roof greening to
reduce non-point source pollution. Designing reasonable in all kinds of buildings, structures rooftops, balconies or large artificial rockery with different functional zones [13]. We would plant vegetation with good removal of pollutants and good landscape effect under the premise of satisfying roof load-bearing, the non-point source pollution would be reduced by plants and soil, and rain water would be utilized rationally. At the same time, we would equip with gallery, seats and other leisure sketches to meet the needs of people.

Combining ecological revetments with landscape to reduce pollutant concentration of rain water. On the premise of controlling flood and draining, we would repair and restoration the original revetments ecologically to built the natural slope. Constructing green ecological slope to replace the original hard revetment by artificial recommendation, hydraulic spraying grass planting and tiling turf. Planting on the slope, combining the ecological bank slope and the land vegetation community, restoring the landscape ecological self-purification system in the water-land ecotone. Applying the concept of landscape designing to restore ecologically and establishing hydrophilic public space, constructing ecological corridor and waterfront landscape of water-land ecological integration and human-water harmony, the integration of urban landscape and ecological landscape, and the construction of local characteristics.

4.2. Landscape eco-remediation technology of polluted water

Based on the principles of ecology and environmental science, aquatic plants and hygrophytes should be allocated scientifically and rationally, so as to establish diverse biological communities, improve the ability of self-purification and self-recovery of water, and improve the ecological service function of aquatic environment ecosystem. Giving full play to the role of the regional water system in the landscape, and considering to the coordination of the water ecosystem and the surrounding environment. Then, making full use of the natural elements of the site to build the water scene in the process of ecological treatment of the polluted water. We would achieve the regulation of sewage storage, purification and using of polluted water by soil, plants, animals, microorganisms and so on. Eventually, we can meet the unity of nature and humanity.

4.2.1. Construction technology of landscape ecotone. Pollutants and nutrients from non-point sources would be absorbed and transferred by ecotone, where it is between water and terrestrial ecosystems, so as to improve water quality and trap particulate matter to reduce sediment in water [14]. At the same time, ecotone would provide habitat for biological breeding and growth, which is of great significance for protecting biodiversity, reducing flood damage and conserving soil and water. There are two specific treatment techniques.

Construction of habitat diversity shoreline. By maintaining the natural form of the existing rivers to maintain the naturalization of the water. Creating natural zigzag shoreline by using the concept of landscape ecology to form habitats with fast and slow, deep and shallow, steep and gentle water flow, where animals and plants are easy to live. Using water shoreline near the natural to maintain the biodiversity of the water, slow down surface runoff during rainstorms and filter pollution from land.

Construction of plant community. In vertical structure, the combination of arbor, shrub and herbaceous plants in land area and the combination of emergent, floating and submerged plants in water area are adopted to form a reasonable vertical structure of vegetation and to construct a complete plant community [15]. While plants purifying sewage, the constructed habitat provides conditions for the survival of animals, which is conducive to biodiversity protection. And plant community would create leisure space for people. We have to give native tree species a priority, and combine plants reasonably by considering the seasonal characteristics, so that we have considerable scenery in the four seasons. Artificial seeding, seedling planting and tree planting are used to strengthen the life cycle of species, to speed up the restoration of vegetation in the water-land ecotone, so as to increase the diversity of plants and to construct a lovely water landscape, promote the realization of complete or semi-complete self-circulation of aquatic ecosystems.
4.2.2. Biological-ecological purify technology of wastewater in a landscape manner. In the treatment of polluted water, we would integrate a variety of environmental engineering technology and ecological technology to give full play to the advantages of different technologies in order to achieve collaborative results. With the combination of plants, animals and microorganisms, and applying the principle of landscape ecology, we construct the biological-ecological purify technology of wastewater in a landscape manner to purify wastewater with high efficiency and realize the utilization of wastewater.

The use of microbial technology to activate indigenous microorganisms in polluted water, and at the same time to release compound microorganisms into polluted water, so as to make toxic and harmful pollutants into non-toxic substances through microbial degradation or biotransformation under controllable environmental conditions to repair contaminated water. In the process of microbial remediation of polluted water and improvement of water quality, the dissolved oxygen content in the water plays an important role. Aeration is used to aerate the water to control the oxygen content and the oxygen content in the rhizosphere can be increased by the roots of aquatic plants to provide good living conditions for micro-organisms. The combination of plants and microbial strengthen the sewage purification capacity of the two.

Combining the classical and non-classical biological manipulation technology with the environmental and ecological engineering technology, we would protect and develop the large-scale herbivorous zooplankton by adjusting the structure of the fish swarms and make the food web suitable for zooplankton or fish to eat and consume algae, so as to control the excessive propagation of algae and improve the quality of the water environment.

We combine plants, animals, and micro-organisms to form a high-efficiency complex ecological purification system, which symbiosis aquatic plants, benthos, fish and microorganisms9 (figure 2), and we construct water ecosystem with aquatic animals and micro-organisms in a multi-level and multi-dimensional way for different functional lake areas. The allocation structure, space-time structure and nutrition structure of aquatic species should be constructed in accordance with local conditions, so that each species can coexist mutually and form food chains [15,16] to strengthen the function of ecological purification, to enhance the self-purification ability of water and to improve the structural stability of water ecosystem. It guarantees the stability of water quality, ecological system structure and incorporate landscape elements to create a place for the public to relax and entertain.

![Figure 2. Compound ecological purification system.](image)

5. Conclusion
Urban polluted water treatment based on landscape ecological construction technology plays an important role in improving polluted water quality, controlling pollution sources, eliminating black and smelly water, protecting environment and ecological restoration of water system and land-water interlaced zone. It also optimizes the urban landscape and ecological landscape as a whole, increases biodiversity and promotes the stability of the ecosystem to enrich habitats for animals and to create
ecological landscape with local characteristics. The technology of purifying polluted water has the value of the economy, the society, the ecology, the esthetics and the important significance. However, the technology needs further study to improvement for the following weaknesses, such as water purification capacity weakened while plants grow slowly in cold season, the method of removing aquatic plants in time, otherwise it will cause secondary pollution. For future works, urban polluted water treatment based on landscape ecological construction technology in this paper would build a beautiful ecological city, and further enhance the harmony between human and nature.

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