Composite Scheme of Comprehensive Improvement for Urban Rivers

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Abstract: The work of comprehensive improvement for urban rivers has been put on the daily agenda. This paper introduces in detail a comprehensive treatment scheme integrating anti-pollution, treating-pollution and monitoring maintenance in views of both the perspective of technological process and the analysis of pollutant causes. The most important thing of pollution prevention is to prevent pollutants from entering the river again. Means such as low impact development technology and laying pipelines to collect wastewater for intercepting can be adopted. The most important process of pollution treatment is dredging sludge of rivers in time and repairing water body by using ecological principles. The process of monitoring and maintenance includes monitoring of water quality in real time, regular monitoring of water ecosystem, monitoring of normalized pollutants and timely cleaning of garbage and removal of various pollution sources, which could guarantee and maintain the river’s healthy state. The three steps of river improvement promote each other and form a circular relationship. According to this scheme, the comprehensive improvement for urban rivers needs the participation of government, enterprises, society and residents, which may achieve the ultimate goal of sound ecological balance of the ecosystem. In addition, this paper gives the simple operation process of river improvement and the simple idea of sludge treatment, which provides valuable reference for improving the water treatment system.

1. Introduction
Urban river flow generally includes natural river channels, ditches and other artificial water channels for flood control, drainage, sewage collection and navigation. At the beginning of China's reform and opening up, the rural population moved to the city, which made the scarce water resources of the city consumed. The domestic sewage was discharged into the river directly without any treatment, and the government regulators did not treat the sewage discharged from the enterprises. This is the first direct cause of river pollution. The second factor is from two major pollution sources, one of which is the direct damage from the residents who do not have the concept of caring for the river and often throw the domestic garbage directly into the river, another of which is the sewage that is used to clean and wash the streets and flows into the river with the low-lying land. The urban daily environmental sanitation has a great damage to the water quality of rivers, and it is difficult for aquatic plants and aquatic organisms to survive, so that the urban rivers lose their self-purification function. With the increasing deposition of waste from natural organisms and human beings, the silt at the bottom of river bed becomes thicker and thicker, which accumulates a large amount of nutrients. The nutrients result in eutrophication of water body. The pressure on the rivers is increasing with the invasion of more and more pollutants, which leads to more and more serious problems such as river pollution, siltation,
blockage and shrinkage. The water body has become black and smelly, which forces the public to avoid it.

The pollution of urban rivers not only brings serious trouble to people, but also becomes an important bottleneck of restricting the sustainable development of social economy. It is of great significance to formulate safe, economic and sustainable scheme to improve urban rivers. In view of the current situation of rivers improvement of Guangdong province, the principal part involved in the improvement is the government, but most of the rivers need to be taken into account the ecological security and economic benefits. If there is no participation of social organizations, enterprises and the public, the government's strength will be inadequate.

In this paper, we propose a comprehensive improvement scheme which combining pollution prevention, pollution treatment and monitoring maintenance, which could further implement the concept of green development, maintain the healthy life of rivers, promote the construction of ecological civilization, improve the water management system, and thoroughly implement Xi Jinping's ecological civilization thought[1]. We believe that the way of improving urban rivers should at least include both pollution prevention and treatment, in addition to monitoring and maintenance. Anti-pollution process should be carried out before pollution treatment. The focus of anti-pollution process is to intercept liquid waste and solid waste into the rivers. Only after intercepting the input of pollutants into the river and cutting off the pollution sources, could the existing pollution of the rivers be handled better, otherwise, the pollution treatment becomes meaningless. Pollution treatment mainly includes dredging of river sludge and restoration of water body. The monitoring process is to monitor the water quality in real time and regularly monitor the ecosystem and normal pollutants, which leads to safeguard them and ensure the health of the rivers.

2. Composite scheme for river improvement
The composite scheme of comprehensive improvement for urban rivers is shown in figure 1. The contents of river improvement include three steps of anti-pollution, treatment of pollution and monitoring and maintenance. Their relations constitute a cycle of mutual promotion, mutual restriction and mutual supplement, which are indispensable.

2.1 Anti-pollution process
The first step of river improvement is to prevent pollutants which mainly include liquid and solid from entering the rivers. As shown in Figure 2, the anti-pollution process is divided into three parts according to the pollution sources. The first part is to prevent the inflow of non-point source pollutants. The non-point source sewage includes the rain from the sky, urban greening irrigation, ice and snow melting water and livestock breeding sewage. The solid pollutants of non-point source come from the surface solid waste, the loss of soil and green fertilizer, livestock breeding emissions, etc. The interception of these pollutants could be combined with the construction idea of sponge city[2-3]. The various low impact development (LID) technologies[3-4] could be used to collect and purify these non-point source sewage, such as the establishment of natural drainage system, vegetation filter belt, ecological tree pool, etc., and the regular collection of solid waste. The ecological protection of riverbank is established and separation from the polluted places is adopted in case of the permission of
geographical environment. Therefore, the rainfall runoff and other non-point source sewage could be prevented into the urban rivers.

Figure 2. Schematic diagram of anti-pollution process.

The second part of anti-pollution process is to prevent the sewage of life and industry from discharging into the river. The sewage could flow into the pipeline. Therefore, the collecting and intercepting pipelines for sewage are laid along the rivers, and the sewage intercepting is incorporated into the urban sewage collection and treatment systems. The overflow control device and backflow preventer could be set up in the original devices where the rainwater pipes are combined with the sewage ones in some urban areas. If it is impossible to lay intercepting pipes along the rivers due to the geographical location of the rivers, the sewage should be treated in site because it could not be discharged to the rivers. The on-site treatment of sewage means that the sewage is discharged after the pollutants in the sewage are removed locally through the sewage treatment device using physical, chemical or biochemical treatment methods. After sewage interception, the water within the rivers becomes less and the flow velocity of water decreases, therefore sometimes necessary water replenishment processes are taken. The being intercepted sewage is delivered to the sewage treatment plant. However, the bypass treatment of the sewage should be set up if the existing urban sewage systems and the sewage treatment plants are unbearable due to more processing capacity of sewage. So the non-sewage pipeline will be directly discharged into the rivers, and the sewage generated on both sides of the rivers will be transmitted to the sewage plant for centralized treatment through the sewage collection system through the completion of the final complete separation system of rain and sewage, which could basically solve the problem of river anti-pollution.

The third part of the anti-pollution process is to prevent solid waste from entering rivers, such as people's domestic trash. The water in rivers will be polluted if the solid waste along the rivers is stored for long time, so they should be cleaned up in time.

2.2 Pollution treatment process

The second step of river improvement is to treat the existing pollutants in the rivers. These pollutants belong to endogenous ones. Figure 3 shows four aspects for treatment process of pollution. The first aspect of pollution treatment is to clean up the existing garbage, including both the garbage on two sides of the river and the trash, biological residues and floating objects such as aquatic plants, coastal plants and fallen leaves in the river. After the basic solid waste of the river is cleaned, the most important process of pollution treatment could be started. The river is first dredged by means of mechanical or hydraulic dredging in the process of sludge improvement, which is an important and effective means of eliminating endogenous pollution. The sludge then should be treated with resources, reduction and stabilization because there is a risk of secondary pollution during the transportation and treatment of sludge. The return water quality after treatment should meet the requirements of "no black odor". Finally, the sludge should be disposed safely to avoid secondary pollution. The dredging depth of river sludge needs to be well controlled because the aquatic ecology of river bottom is easily destroyed in case of too deep dredging and the sludge pollutants is not completely removed in case of
too shallow dredging. It is also necessary to avoid the appearance of black massive bleaching mud during dredging, which will pollute water again. The river dredging not only reduces the internal pollution, but also increases the cross-section of the flowing water that could improve the drainage capacity and dilute the original polluted water. The dredging also cuts off the nutrient source from the sludge, which reduces the amount of algae and microorganisms and reduces the subsequent pressure of water treatment.

![Diagram of pollution treatment process](image)

Figure 3. Schematic diagram of pollution treatment process.

The third aspect of the pollution treatment process is to improve the existing polluted water, which is a very important progress. There are five different improvement options in figure 3 which are applied using single or mixed choices for different cases of different water quality. At present, the most popular choice is to adopt the first option of ecological restoration technology[5], which means to plant aquatic plants or put some special microorganisms in rivers. The ecosystem cycle during the soil, microorganism and plant can effectively remove organic matter, nitrogen, phosphorus and other pollutants within water, which realizes the bioremediation of water, improves the water quality and recovers the self-purification function of rivers. The river bank needs to be repaired if it was hardened. The riverbank could be reconstructed by the form of grass planting ditch, ecological revetment or permeable brick, which restores natural purification function of shoreline and water to strengthen the treatment effect of water. This ecological restoration technology needs large engineering quantity, large amount of maintenance and high cost of harvesting and disposing ecological coastal plants. The second option of water treatment is artificial oxygenation. Artificial oxygenation refers to the use of water drop, fountain, jet and other forms of aeration, which effectively increases the dissolved oxygen level of water. This level reduces one of pollution factors[6] and maintains water quality. The third option is of by-pass treatment, which means to extract water from the seriously polluted section of river out of the river for purification by appropriate treatment facilities which are set up around water, and then discharge it to the other end of river. The by-pass treatment realizes the purification and circulation of water. It is necessary to select the bypass treatment choice in both cases of the heavy black and smelly water body where the sewage can not be completely intercepted and the enclosed water body where there is no external water supplement. The fourth option is the circulation of living water, which improves water flow effectively and maintains water quality by setting up the lifting pump station, reasonable connecting between the water systems, and using wind or solar energy. The fifth option of water improvement is the replenishment of clear water, which means to add the supplementary water such as the urban reclaimed water, clean rainwater flood and clean surface water into river water to increase the liquidity and environmental capacity of the water body. When the water quality is not too bad and the water quantity of the river is insufficient, this simple choice could be selected.

The fourth aspect of pollution treatment process is the regular treatment of normalized pollutants
including regular dredging, garbage cleaning and water restoration.

2.3 Monitoring and maintenance process
The third step of river improvement is to monitor the water body and maintain the river's health at any time, as shown in figure 4. The state of water body at any time is known by real-time monitoring of water quality. Regular monitoring of aquatic biological ecosystem is helpful to maintain ecological balance of rivers. The normalized pollutants are also regularly monitored. Once it is found that the pollutant content reaches above a certain level, it is necessary to start the pollution treatment process of river improvement and strengthen the anti-pollution process, which advances the treatment effect of river improvement and ensures the normalized status of the river. Such operation is a kind of normal maintenance. Monitoring is of benefit to maintain water quality and river’s health. The usual safeguarding work includes regularly cleaning up the aquatic plants, coastal plants and fallen leaves before they are withered and rotten. The plastic bags, other domestic garbage and other substances are also cleaned up if they exist in river. Once the anti-pollution and pollution treatment processes are completed, the other strengthening process such as circulation of living water can be introduced from time to time in order to better maintain the ecological purification function of the river.

![Figure 4. Schematic diagram of monitoring and maintenance process.](image)

3. Operation process of river improvement
The completion of river improvement requires the joint support of the government, enterprises and social power according to the composite scheme detailed shown in figure 1 to 4. Anti-pollution, pollution treatment, monitoring and maintenance are indispensable. Without perfect anti-pollution process, the pollution treatment can only give a temporary effect, and the river will soon return to the polluted state, which results in a great failure of pollution treatment process. The anti-pollution is the premise and foundation of pollution treatment. In order to prevent pollution, we need to add some elementary construction systems, lay pipelines and other sewage interception projects, and need the cooperation of the government providing funds and policies and the enterprises providing technology, as well as the good cooperation of residents' consciousness and environmental protection awareness. Some temporary sewage interception processes can be taken in the near future in order to implement the short-term and long-term treatment objectives respectively, such as that the sewage is transmitted to the urban sewage plant for treatment through the municipal main pipe. In the long term, the collecting and intercepting pipes for sewage can be gradually implemented in stages and sections according to the relevant sewage system engineering planning.

In the process of pollution treatment, the dredging and water restoration need to be carried out simultaneously, which can be designed and implemented by different engineering teams. The desilted sludge cannot be piled up directly, but needs to be treated and disposed safely. The bioremediation of water body should be also arranged based on the different biological species, planting and harvesting methods according to different water quality and different regions. After the assessment of treatment efficiency of pollution has been checked and passed by relevant departments, the river improvement is still not finished and needs to be monitored and maintained. Therefore, river improvement is a comprehensive, systematic and long-term project[7].
4. Sludge treatment effect in pollution treatment process

The dredging of river sludge not only cleans the river thoroughly, but also benefits the restoration and normal progress of river ecosystem. However, the bottom sludge needs further treatment of resources, reduction and stabilization after garbage sorting and sand stone separation for it. We take the river sludge of Tancun village in Chencun town of Foshan city as an example to deal with it. Through the analysis by instruments, the organic content of the river sludge is less than 10%. There are few extracellular polymers in the sludge. And its water content is between 75-80%. Before the sludge is mechanically dewatered by the belt dehydrator[8], some chemical reagents are added into it, such as poly aluminum ferric silicate and polyacrylamide, which can coagulate and flocculate the sludge. After the conditioning, the water content of the sludge decreased to less than 50% by mechanical dehydration. In this way, the purpose of reduction can be achieved, which makes transportation and storage of sludge become convenient. The separated sand from the sludge can be used as construction materials. According to the pollution level of the sludge, the sludge after dehydration can be disposed as building materials, backfill or landscape soil, etc., so as to maximize the resources, stabilization and harmlessness.

5. Summarization

This paper introduces in detail a comprehensive treatment scheme which integrates the processes of anti-pollution, pollution treatment and monitoring maintenance. Pollution prevention is the foundation, pollution treatment is the key, and monitoring as well as maintenance are the guarantee. The most important thing for pollution prevention is to prevent pollutants from entering the river again. The most important thing for pollution treatment is dredging and repairing water body. The guarantee progress includes real-time monitoring of water quality and regular monitoring of water ecosystem and normalized pollutants, which keeps the river healthy. The prevention, treatment, monitoring and maintenance of river improvement are mutually promoting and restricting each other. Only effective and reasonable implementation can promote river recuperation, give full play to the ecological benefits of rivers, and achieve the ultimate goal of good ecological balance of the healthy ecosystem.

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