Systematic treatment of urban river pollution

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Abstract. Urban river pollution is one of the most prominent environmental problems in Chinese cities that have been trying to prevent and control. The aim of this paper is to propose an urban river governance framework from the perspective of systematic governance. The point source pollution control is the premise of river regulation. Increased impervious surface in urban areas due to urbanization continuously increases the concentration of stormwater runoff pollutants. Many low-impact development facilities such as sunken lawn and rain gardens can also effectively reduce non-point source pollution. Controlling the pollution source eliminates some pollutants in the river though it does not improve its own ecosystem. Since the self-purification ability of an unstable ecosystem is weak, the restoration of ecosystems is critical component of the water environment management. Urban river regulation should focus on sustainable management of river sources to meet the human needs, while ensuring the health and continuous development of river ecosystems, water ecology, water landscape and water culture.

1. Introduction
With rapid urbanization and industrialization in China, human demand for rivers has exceeded its own carrying capacity, leading to serious damages to the river ecosystem and pollution.[1-2] Urban river pollution is one of the most prominent environmental problems in several Chinese cities that have been trying to prevent and control the river pollution. Due to the increased capital investment but low efficiency, the pollution control measures do not significantly improve the environmental quality. Residents continue to complain about the problems caused by river pollution, and the situation of urban river pollution prevention and control is still grim.[3-4] In this context, the aim of this paper is to propose an urban river governance framework from the perspective of systematic governance.

2. Point source pollution control
The point source pollution control is the premise of river regulation. The pollution source is generally controlled by improving the sewage collection system, resulting in reduced direct discharge of sewage into the river. Sewage is intercepted in the sewage collection and treatment system by constructing and renovating sewage pipelines along the water body to reduce source pollutants. Meanwhile, the existing sewage interception pipeline should be thoroughly checked to ensure that the sewage pipeline has no leakage. Figure 1 shows one adjustable intercepting well. For sewage without conditional interception, it can be treated with first-stage enhanced sewage treatment equipment to avoid the pollution of water.
directly discharged into the water body. Sewage from catering industry and farmer's market along the river should be treated. The cleaning of garbage along the urban rivers is an important measure for pollution control. The cleaning of the temporary dumping point of the garbage is a one-off engineering measure and needs to be cleaned completely at one time.

**Figure 1.** One adjustable intercepting well

### 3. Non-point source pollution control

Though urban point source pollution is controlled, the proportion of urban non-point source pollution is on the rise. Especially, stormwater runoff pollution, which is an important part of urban non-point source pollution, is a main contributor to the flooding in urban areas and to urban river pollution in China. Pollutants to stormwater runoff pollution is contributed by a wide range of sources such as atmospheric dust, vehicle transportation and corrosion, urban surface erosion, plant debris corrosion, animal waste, and garbage. Increased impervious surface in urban areas due to urbanization continuously increases the concentration of stormwater runoff pollutants.

Additionally, the pollution load and composition of stormwater runoff vary greatly with time and space due to the randomness, suddenness and extensiveness of stormwater runoff. In particular, the initial stormwater runoff pollution is the most polluted since the pollutants carried by the surface runoff formed by rainfall are concentrated in the initial rainwater. The stormwater runoff is directly discharged into rivers causing serious pollution. Initial rainwater storage tank technology is widely used to intercept initial rainwater and reduce the amount of pollutants directly discharged into the water body. Rainwater collected in the tanks is slowly transported to the sewage treatment plant. Figure 2 shows one modular storage tank.

**Figure 2.** One modular storage tank

Many low-impact development facilities such as sunken lawn and rain gardens can also effectively reduce with non-point source pollution. Sunken lawn is characterized by a green space elevation lower than the road elevation, rainwater outlet in the green space, and the rainwater outlet higher than the green space. The sunken lawn regulates the pool and vegetation buffering such as supplementing groundwater, regulating runoff and reducing pollutants.
4. Environment dredging on river
Sediment of rivers is an important part of natural waters since it adsorbs pollutants in water and releases again under certain conditions to cause secondary pollution in water. Therefore, the removal of contaminated sediment could slow the eutrophication of water bodies and improve water quality. As river siltation directly affects the water storage function and drainage capacity of the river channel, dredging of river channel is important for drainage, flood control and irrigation.

The treatment of dredged sludge is subject to the following principles:

(1) Multiple disposal methods
As dredged sediment comes out in large quantity, it is necessary to dispose them effectively, and combine the local conditions to open up the disposal and disposal methods to solve the problem of land occupation and environmental pollution of dredged sludge. Commonly used disposal methods include wetlands, yard filling and ocean dumping and used in forest land, roads, foundations, embankment construction and bricks and haydite.

(2) Select technology based on the disposal route
The disposal technology should be chosen according to the end use to treat sludge to be suitable for that use and reduce any solid waste after treatment.

(3) Harmless treatment
The contaminated sediment should be stabilized and isolated during use to avoid secondary pollution of groundwater, surface water and landfill due to pollutant release.

(4) Resource utilization principle
The disposal methods should focus on converting the sediment into resources according to the physical and chemical properties of the sediment and the utilization of the soil resources of the surrounding sites. These methods include mechanical dewatering (plate frame dewatering, centrifugal dewatering, vibrating screen dewatering, etc.), chemical curing and heat treatment (burning bricks, ceramsite and cement).

(5) Cost-effective principle
Since the process produces large amount of mud, the disposal method should be economical through resource utilization and optimization of process combination.

5. Water ecological restoration
Controlling the pollution source eliminates some pollutants in the river though it does not improve its own ecosystem. Since the self-purification ability of an unstable ecosystem is weak, the restoration of ecosystems is critical component of the water environment management.[5-6]

In this context, aquatic plant restoration technology is preferred since it can comprehensively restore water quality and ecology, low treatment cost and can be used to beautify the environment through choosing ornamental plants. Constructed wetland is a complex and ecologically designed stratum ecological structure that is artificially designed to mimic natural wetlands. Artificially, the sewage is controlled to be allocated to the land with aquatic plants, and the effective residence time is controlled in different ways (Figure 3 shows). The biological treatment occurs in the constructed wetland via filtration, adsorption, precipitation, ion exchange, plant absorption and microbial decomposition under the combined action of physics, chemistry and biology. The constructed wetland sewage treatment technology has good treatment effect, stable effluent water quality, convenient operation and maintenance management, low engineering infrastructure and operation cost, and strong adaptability to load changes.
Ecological design and construction should follow the following principles:

1. Respect natural ecological diversity while meeting flood and water demands.
2. Protect existing natural ecological elements and further restore good water ecosystems.
3. Use ecological purification technology to improve the self-purification capacity and water quality of rivers.
4. Combine engineering measures with effective management measures. Provide longer maintenance time for the significant adaptation and self-improvement of ecosystems unlike conventional construction projects.
5. Incorporate environmental education, give play to the ecological and environmental protection propaganda role of ecological projects, and raise awareness about environmental protection.

6. Conclusion

Urban river regulation should focus on sustainable management of river sources to meet the human needs, while ensuring the health and continuous development of river ecosystems, water ecology, water landscape and water culture. Additionally, priority for interception, governance-based, open source and expenditure reduction, ecological restoration, and system governance should be considered. The river water quality improvement is for long-term and will fail if it is not properly managed. Therefore, it is necessary to promote the long-term management solutions, set up a professional management team, and adhere to long-term construction management.

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