Ecological Restoration for Mitigating Black-Smelling Sediment Pollution in Urban Rivers: A Case Study in Hangzhou

Liqin Du*

2482516799@qq.com*

University of Birmingham, Birmingham, UK*

Abstract. This study focuses on the ecological restoration of black-smelling sediment in urban rivers, using two demonstration projects in Hangzhou, China, as case studies. Urban rivers play critical roles in drainage, flood control, and providing cultural and recreational spaces. However, these water bodies often suffer from pollution due to urbanization and human activities. The research investigates the significance of improving water quality and ecosystem health in Hangzhou's urban rivers, which are essential for the city's identity and sustainability. The study employs a case study methodology, comparing different ecological restoration methods used in the Houyonggang and Danonggang rivers. The ecological restoration techniques involve bioremediation, aeration, submerged plant restoration, and more. The results demonstrate significant improvements in water quality indicators, including reduced ammonia and total phosphorus concentrations, indicating successful black-smelling sediment treatment. The findings highlight the importance of implementing sustainable restoration strategies to enhance urban river ecosystems and contribute to the overall well-being of the city.

Keywords. Ecological restoration, Black-smelling sediment, Urban rivers Urban rivers

1. Introduction

Urban rivers play a crucial role in the functioning and aesthetics of cities, serving various purposes such as drainage, water supply, and recreational spaces. However, due to urbanization and human activities, these rivers often face pollution challenges, threatening both their ecological health and their contribution to the urban landscape. Hangzhou, a city in southern China renowned for its water bodies, has experienced similar issues. Despite efforts towards improvement, urban rivers in Hangzhou have suffered from pollution, especially black-smelling sediment contamination. To combat black-smelling sediment pollution and restore the health of urban rivers, ecological treatment methods are being explored. This study focuses on two demonstration projects in Hangzhou: The Houyonggang and Danonggang rivers. These projects employ various ecological restoration techniques, including bioremediation with alga-eating worms, oxygen aeration, chemical treatments, and submerged plant restoration. The goal is to enhance the river's self-purification ability and improve water quality[1].

In this study, we investigate the effectiveness of these ecological restoration techniques in improving water quality and reducing black-smelling sediment pollution. We analyze the

IDEE 2023, November 24-26, Zhengzhou, People's Republic of China

DOI 10.4108/eai.24-11-2023.2343422

before-and-after results of these demonstration projects, considering parameters such as ammonia and phosphorus concentrations. By evaluating the success of these projects, we aim to contribute to a better understanding of ecological approaches to address urban river pollution.

2. Background and significance of the study

2.1 Background

Improvement of the water environment of river channels has been carried out continuously. Urban watercourses are bodies of water between natural watercourses and man-made ditches, which are usually shallow in depth and small in width, They are usually shallow, small in width, slow-flowing and straight. Urban rivers carry out many functions such as flooding and drainage, water replenishment and water supply, and climate regulation. They are also the carriers of cityscape, history, and culture, important places for people to relax and enjoy themselves, and important components of the city. It is an important part of the city. At the same time, urban rivers are strongly disturbed by human activities, and rainwater becomes surface runoff. Concentration of rainwater into surface runoff, and discharge of point source pollution along the river are very likely to lead to water pollution and ecosystem damage. In addition, the accumulation of pollutants formed by long-term accumulation of sediment in the river channel, it is very easy to cause water pollution and ecosystem damage in the river channel. Under certain conditions Under certain conditions, the pollutants will be released to pollute the river water. In the past few years In the past few years, most of the banks and bottoms of the river channels were constructed with concrete, with few aquatic plants and animals, and the capacity of the river environment was small and the self-purification ability was weak. The environmental capacity of the river is small and its self-purification ability is weak. Hangzhou, a water town in the south of the Yangtze River, is not only surrounded by famous water bodies in China and abroad, such as the Canal, the Qiantang River, the West Lake and the Xixi Wetland, but also surrounded by hundreds of water bodies. Hangzhou is not only surrounded by famous water bodies in China and abroad such as the Canal, the Qian Tong River, the West Lake and the Xixi Wetland, but also has hundreds of large and small inner river systems running through the city. These water bodies are the main sources of Hangzhou, a city of southern China's specialties. These water bodies are one of the most precious assets that Hangzhou, a city of southern color, possesses. These water bodies are one of the most precious assets of Hangzhou, a city of southern China's characteristics, and have become the city's reputation. In recent decades Due to the rapid socio-economic development and urban population growth, the discharge of pollutants in Hangzhou has been increasing, but the city infrastructure has not kept pace with it, and a large amount of pollutants have been discharged into the city rivers without treatment, causing great damage to the water ecological environment. In 2012, only 20% of the more than 470 urban rivers within Hangzhou's roundabout highway were in Class II of surface water, with more than 50% in Class V. Some of the rivers are black smelly, and some of them are in poor condition. Some of the rivers are black smelling, which has a negative impact on people's life and city image, and there is an urgent need for river management. The main sources of pollution analyzed are point source pollution caused by incomplete interception of sewage or mixed flow of rainwater and sewage in some areas, surface pollution caused by surface runoff from initial rainwater, and

endogenous pollution caused by long-term sedimentation of river bottom mud. Excessive discharge of external pollutants and release of internal pollutants cause low dissolved oxygen low transparency of river water, and massive algal growth, thus inhibiting the development of aquatic animals and plants[2].

This inhibits the growth of aquatic plants and animals, so that the water body gradually loses its self-purification ability and the river ecosystem is seriously damaged.

2.2 Research Significance

Hangzhou, like most cities in China, started the comprehensive improvement and protection and development project of urban rivers in 2007, and at that time, in view of the context of water environment management, it prepared the Planning of Comprehensive Improvement and Protection and Development of Urban Water System [3], the Planning of Water Transportation and Shipping of Urban Rivers (including tourism), the Planning of Urban River Landscape System, the Planning of Hangzhou Urban Master Plan, the Planning of Urban Water System Comprehensive Improvement and Protection and Development, the Planning of Water Transportation and Shipping of Urban Rivers (including tourism), and the Planning of Urban River Landscape System. Comprehensive Improvement and Protection and Development Planning of Urban Water System", "Urban River Water Transportation and Shipping Planning (Including Tourism Specialization), Urban River Landscape System Planning "Hangzhou Urban Master Plan" and a series of guiding plans and documents. However, as Hangzhou's water environment management for 10 years, the population to urbanization of concentration, around the large municipal supporting construction, urban village transformation, land development, government funding operation, and other reasons, often resulting in the construction of the river can only be "ripe for a section of the implementation of a section", and some of the river even failed to fully implemented according to the standards or planning in place, the existence of broken and unimproved river, the river is the only one that is not improved. The existence of disconnected and unimproved river, the river cannot form a large area of thorough water network; surrounding municipal supporting facilities are not perfect, due to a large number of outsiders to the city to concentrate, especially in urban villages is more prominent in a large number of sewage is not sewage trunks and branch pipe collection, sewage is discharged directly into the river, polluting the water body; the government departments are subject to the demolition and relocation of various government departments, land concessions, urban villages, such as transformation of the discrepancies and investment and other factors The influence of various government departments is restricted by the differences in demolition and relocation, land grant, urban village renovation and investment, which makes some boundary rivers and land parcels fail to coordinate development and management, and there are several construction subjects, construction timetables and standards of the same river, which result in the upstream polluting the downstream, and the opposite bank polluting the other bank. Therefore, it is especially important to classify the pollution control at source and analyze and summarize the different pollution source treatment technologies.

2.3 Research methodology

Case study method, with relevant cases to do analysis and comparison, to the advantages and disadvantages of urban river water environment management system as a guide, with actual

cases and the original management mode to do a comparative analysis, to determine the original management system in the development of the advantages of shortcomings in the continuous improvement of the feasibility and practicability of the management system. Through field sampling, the current status of black smelly sediment contamination of typical urban rivers in Hangzhou, which are mainly polluted by urban surface and domestic sewage, was investigated. The current status of black smelly sediment pollution in urban rivers in Hangzhou. In this study, two demonstration projects of in-situ remediation of black smelly sediment were selected, namely Houyonggang and Danonggang. In this study, two demonstration projects of in-situ remediation of black smelly sediment, Houyonggang, and Danonggang, were selected, and ecological treatment methods such as oxygen aeration, microbial agents, in-situ solidification, and submerged plant restoration were used. The in-situ remediation of black smelly sediment in a typical river channel was carried out collectively with a combination of aerators, microbial agents, in-situ solidification, and rejuvenation of submerged vegetation[4].

3. Diagnosis of Black-smelling Mud Pollution in Urban Rivers in Hangzhou

Equations According to the results of the survey on water quality and sediment pollution of typical urban rivers in Hangzhou conducted by Tu Yenan et al. According to the results of the survey on water quality and sediment pollution of urban rivers in Hangzhou conducted by Tu Yenan et al, the sediment pollution of urban rivers in Hangzhou is still serious, with generally high concentrations of nitrogen and phosphorus. Some of the river sediments have high organic matter content and are prone to black odor [5]. The concentration of nitrogen and phosphorus is generally high. Meanwhile, the higher concentration of pollutants may also lead to the development of black odor [6]. At the same time, the higher concentration of pollutants can easily cause the release of pollutants from the sediment to the river channel, which is the main source of endogenous pollution in the river channel. Therefore, the treatment of black smelly substrate is particularly important. Therefore, the treatment of black smelly sediment in rivers is particularly necessary. In order to deal with the black smelly substrate pollution in water bodies, the traditional engineering methods mainly rely on physical removal such as dredging and siltation to improve the substrate. The traditional engineering methods mainly rely on physical removal, such as dredging and desludging, to improve the condition of the contaminated substrate. With manual or mechanical means, the sludge is removed from the water body. A certain A certain thickness of contaminated surface A certain thickness of contaminated surface sediment in the water body is removed by manual or mechanical means, leaving a cleaner substrate and thus improving the condition of the water body's sediment. Although the technique of dredging and desludging has a low threshold, is relatively simple and quick, it still faces problems in practical application. However, in the process of practical application, it still faces the following problems [7].

However, there are still a series of problems in the practical application. The thickness of siltation is difficult to be calculated and controlled accurately, which will lead to the difference between the cost of siltation and the effectiveness of siltation. It is difficult to achieve the best balance between the cost and the effect of siltation; the sludge after sludge removal needs to be deposited in a special place. Nowadays, vacant land resources are becoming more and more

scarce, which greatly raises the threshold of siltation; siltation may cause damage to the benthic ecosystem of the river. Siltation may have a destructive effect on the benthic ecosystem of the river, which is also detrimental to the health of the river ecosystem; Although siltation can have a significant effect in a short period of time, if the subsequent ecosystem is not restored in time, the water quality and sedimentation will be reduced. However, if the ecosystem is not restored in time, the water quality and sediment condition will be further deteriorated. Further deterioration at the same time, the desilting work may also affect the daily life of the neighboring residents. At the same time, the desludging work may also affect the daily life of the neighboring residents.

4. Basic Information of the Demonstration Project on Ecological Treatment of Black-smelling Substrate

The demonstration project on ecological management of the Houyokang River is divided into two phases. Phase I Phase I starts from the canal mouth gate in the east and ends at Wengang Bridge in the west. It is about 300 meters with a water body area of about 6,400 square meters. Phase II is about 760 meters from Wengang Bridge to the west with a water body area of about 1,510 square meters. The second phase of the project is about 760 m west from the Wengang Bridge with a water area of about 1,510 m^2, and a total of about 2.15 million m^2 have been treated in total. A total of about 21.5 million square meters have been treated. Specific treatment measures: Adoption of bioremediation (alga-eating worms) to control algae and guide water ecological restoration techniques, with the addition of oxygen aeration and chemical treatment. On the basis of oxygen aeration and pharmaceuticals, an aquatic ecosystem is constructed by alga-eating worms, and the worms control the algae, The food chain is formed by worm-controlled algae and fish-feeding worms to gradually restore the submerged plants, which absorb and purify the nutrients from the black smelly mud at the bottom of the river. Through the absorption and purification of nutrients from the black smelly sediment by the submerged plants, the whole ecosystem will be restored in a chain reaction to enhance the self-purification ability of the water body and improve the watercourses. This will lead to a chain reaction of slow restoration of the whole ecosystem, enhance the self-purification ability of the water body, and improve the water quality of the river as well as its landscape.

Danong Harbor Fan Project mainly uses the method of desludging + aeration + pharmaceutical dosing + submerged plant restoration + biological manipulation + pretreatment at the discharge outlet for ecological restoration of the river, among which desludging, aeration and submerged plant restoration are the measures to treat the black smelly substrate [8].

Siltation, aeration and restoration of submerged vegetation are all measures for the treatment of black smelly sediment.

In terms of the specific amount of work, the total amount of desludging is about 23234.4 kilograms. The total amount of work was 23234.34 million cubic meters, 5551 cubic meters, 5 submerged aerators with a total length of 300 meters, 18 fountain aerators, 21492 square meters of submerged plants were restored, mainly using Verticillium, Bitter Grass, and Illicium, and 38 cubic meters of suspension filler was used for the pretreatment of the outfalls.

5. Demonstration Project Governance Results

The treatment results of the two demonstration projects at Hengkang and Danonggang are shown in Figure 1-3. The treatment of black smelly mud is ultimately to improve the water quality of the river. The treatment of black smelly substrate is ultimately to improve the water quality of the river, so the evaluation index of the project for the demonstration projects is still based on the change of the water quality of the river. The pre-treatment data of Hau Yokang Harbor used the average annual water quality monitoring data of Hangzhou City River Supervision Center in 2011 (Danong Harbor in 2013), while the post-treatment data used the average annual water quality monitoring value of the river after the demonstration project was operated in 2013 (Danong Harbor in 2015).

From the results in Figures 1-4, it can be seen that the water quality conditions of the two demonstration projects improved significantly before and after the treatment. In terms of ammonia, the water quality of Houyang Harbor and Danong Harbor improved from 5.9 mg/L and 8.5 mg/L before the treatment respectively. Ammonia nitrogen in Houyonggang and Danonggang decreased from 5.9 mg/L and 8.8 mg/L before treatment respectively. 8 mg/L before treatment to 1.47 mg/L and 3 mg/L respectively. The levels of ammonia were reduced from 5.9 mg/L and 8.8 mg/L before treatment to 1.47 mg/L and 3.2 mg/L respectively. 2 mg/L. The concentration of ammonia nitrogen in Houyong Harbour was reduced from Class DV to Class IV, while that in Danong Harbour was reduced to Class IV due to the higher concentration of ammonia nitrogen in the pre-treatment period. Before the treatment, the concentration of ammonia and nitrogen was higher, and the interception of the surrounding external pollution was not complete, the annual average concentration of ammonia and nitrogen was still at the level of Class IV. However, compared with the pre-treatment level, the annual concentration of ammonia nitrogen still dropped by more than 60%, and the requirement of Class V water could be met in some months. The water requirement of Class V was also met in some months. In terms of total phosphorus, the concentrations in Houyang Harbour and Danong Harbour were reduced from the pre-treatment levels of 0.72% and 1.75% respectively. Total phosphorus was reduced from 0.72 mg/L before treatment to 1.48 mg/L in Houyonggang and Danonggang respectively. The total phosphorus level decreased from 0.72 mg/L and 1.48 mg/L in the pre-treatment period to 0.75 mg/L in the post-treatment period. Total Phosphorus The total amount of phosphorus in the two harbors decreased from 0.72 mg/L before treatment to 0.23 mg/L after treatment. The average annual total phosphorus concentration in Houyong Harbor decreased from 0.72 mg/L before treatment to 0.23 mg/L after treatment. The annual average total phosphorus concentration in Houyong Harbour met the Class IV water quality standard and was even better than the Class III water quality standard for some periods of time. The average annual concentration of total phosphorus in Danong Harbour was found to be better than the water quality standard of Class III, while the average annual concentration of total phosphorus in Danong Harbour decreased by 66%. The average annual concentration of total phosphorus in Danong Harbour has decreased by 66%, with the average annual concentration of total phosphorus in Danong Harbour has decreased by 66%, and the water quality standard of Class V can be achieved at mid-year. The average annual concentration of total phosphorus in Danong Harbour has decreased by 66% and the water quality level of Class V can be achieved for part of the year. The levels of Manganese in both rivers were basically in the range of Class IV water before treatment but have increased

to III water after treatment. After the treatment, the levels were raised to the range of class III water.

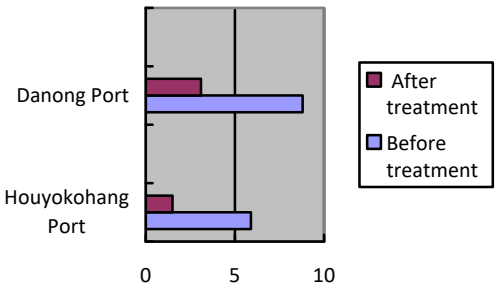

Figure 1 Comparison of ammoniacal nitrogen between Houyokang and Danonggang demonstration projects

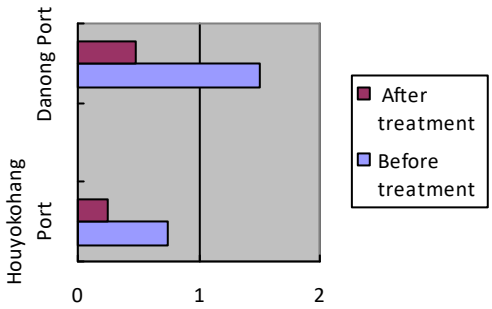

Figure 2 Comparison of total phosphorus between Houyokang and Danonggang demonstration projects

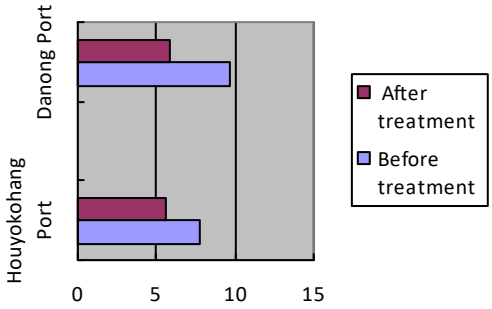

Figure 3 Comparison of manganese peroxide index between Houyokang and Danonggang demonstration projects

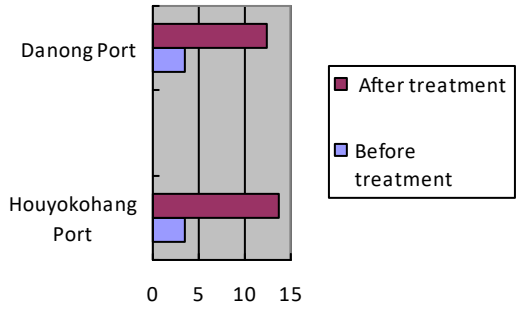

Figure 4 Comparison of dissolved oxygen between Houyokang and Danonggang demonstration projects

6. Conclusion

In conclusion, the study focuses on the ecological management of black-smelling sediment pollution in urban rivers, with specific emphasis on two demonstration projects in Hangzhou: The Houyonggang and Danonggang projects. These projects aimed to address the significant challenges posed by pollution in urban water bodies, which are crucial for the overall well-being of the city and its residents. Moreover, he study's findings demonstrated the effectiveness of the ecological management approach in improving water quality and mitigating black-smelling sediment pollution. The treatment results from the Houyonggang and Danonggang projects showed significant reductions in ammonia and nitrogen levels, as well as total phosphorus concentrations, bringing the water quality closer to acceptable standards. Moreover, the implementation of these strategies facilitated the restoration of aquatic ecosystems and enhanced the visual appeal of urban rivers.

References

[1] Klaus, Valentin H., and Kathrin Kiehl. "A conceptual framework for urban ecological restoration and rehabilitation." Basic and Applied Ecology 52 (2021): 82-94.

[2] Prach, Karel, et al. "A primer on choosing goals and indicators to evaluate ecological restoration success." Restoration Ecology 27.5 (2019): 917-923.

[3] Carlucci, Marcos B., et al. "Functional traits and ecosystem services in ecological restoration." Restoration Ecology 28.6 (2020): 1372-1383.

[4] Hua, Junyi, and Wendy Y. Chen. "Prioritizing urban rivers' ecosystem services: An importance-performance analysis." Cities 94 (2019): 11-23.

[5] Zhang, Wangshou, et al. "Urban rivers are hotspots of riverine greenhouse gas (N2O, CH4, CO2) emissions in the mixed-landscape chaohu lake basin." Water Research 189 (2021): 116624.

[6] Heymans, Angela, et al. "Ecological urban planning and design: A systematic literature review." Sustainability 11.13 (2019): 3723.

[7] Gann, George D., et al. "International principles and standards for the practice of ecological restoration." Restoration Ecology 27.S1 (2019): S1-S46.

[8] Holl, Karen. Primer of ecological restoration. Island Press, 2020.