# Comparison and Selection of Water Restoration Techniques for Artificial Landscape Lakes in Nantong City

**Shengrong YAN[1,2], Yuyue MA[1], Yi'an CHEN[1], Jiafeng SUN[1], Mingqing CHEN[2]***

1. College of Environmental and Biological Engineering, Nantong College of Science and Technology, Nantong 226007, China; 2. School of Chemical and Material Engineering, Jiangnan University, Wuxi 214122, China

**Abstract** As an important part of urban infrastructure, urban water system is of great and far-reaching significance for ensuring urban flood control and waterlogging safety, protecting ecological environment and building livable homes. Taking the urban water system of Nantong as an example, Nantong Water Resources Bureau issued R*evision of Nantong Urban Water System Planning* in 2017, and put forward the construction of the "two circles, eight lakes and nine veins" water system layout, giving new vitality to the urban water system. In view of problems existing in newly excavated artificial landscape lakes, such as fragile water ecosystem, strong eutrophication trend, poor environmental sensory effect and unsatisfactory water landscape effect, it is urgent to study the in-situ water ecological restoration technique of "algae-controlling zooplankton + submerged plant community" to build a "grass-type clear water" ecosystem for artificial landscape lakes, so as to improve the water sensory index and self-purification ability and finally realize the double improvement of "sensory effect and water quality" of artificial landscape lakes.

**Key words** Water body remediation technique; Artificial landscape lake; Comparison and selection; Nantong City
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## General Situation of Artificial Landscape Lake Construction in Nantong City

As an important part of urban infrastructure, urban water system is of great significance for ensuring the safety of urban flood control and waterlogging elimination, protecting the ecological environment and building a livable home. Although the basic water system conditions in Nantong City are good, due to the rapid urban construction in recent years, the area of Nantong's main city has increased rapidly, and some water systems have been occupied and filled in the process of development and construction, and the water surface ratio has been declining. Meanwhile, the impervious area of the city has increased, and the underlying surface of the city has undergone great changes. Several factors have combined to cause the water level of river channels to rise rapidly in the event of torrential rain, and the drainage capacity of the rainwater pipe network is limited, which is easy to cause flooding in low-lying areas. Based on this, on the basis of investigation, according to the characteristics of Nantong plain river network, a Nantong urban rain and flood model and a plain river network model were established. After model calibration and verification, Nantong Water Resources Bureau issued *Revision of Nantong Urban Water System Planning* in 2017, relying on the overall urban planning of Nantong and combining with urban green space planning and landscape construction, and put forward the construction of the "two circles, eight lakes and nine veins" water system layout, aiming to improve the drainage capacity of the city through "combination blow".

Nantong has always been the only city in Jiangsu Province with no reservoirs and natural lakes. Therefore, the construction of the "eight lakes" water system layout in a suitable location is to fill the "short board" of water ecology and give new vitality to the urban water system. The planned eight lakes have a total construction area of more than 267 $hm^2$, and their reservoir capacity is more than 4 million $m^3$, which is equivalent to the area and reservoir capacity of four Haohe rivers. It can increase the storage capacity by more than 1 million $m^3$, effectively expand the storage capacity, and reduce the peak flow and the risk of waterlogging. Moreover, the "eight lakes" can enhance the capacity of the water environment and the self-purification capacity of water bodies, and improve the water environment, as well as regulating the surrounding microclimate and reducing the "heat island effect". They can also beautify the urban water landscape and improve the living environment.

## Problems in the Construction of Artificial Landscape Lakes in Nantong City

According to *Bulletin on the Ecological Environment of China in 2020* issued by the Ministry of Ecology and Environment of the People's Republic of China on May 26, 2021, the water environment quality of national surface water assessment sections in 30

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Shengrong YAN (1981 - ), female, P. R. China, associate professor, PhD, devoted to research about ecological restoration of water environment.
* Corresponding author. E-mail: mqchen@jiangnan.edu.cn.

cities, such as Liuzhou, Guilin and Zhangye, was relatively good, while the water environment quality of national surface water assessment sections in 30 cities, such as Tongchuan, Cangzhou and Xingtai, was relatively poor, and the main pollution indicators were chemical oxygen demand, total phosphorus and permanganate, in 2020. Meanwhile, the eutrophication of lakes (reservoirs) could not be ignored. Among the 110 important lakes (reservoirs) that were monitored for nutritional status, the proportions of mesotrophic status, light eutrophication status and medium eutrophication were 61.8%, 23.6% and 4.5% respectively. Because the water bodies of the "eight lakes" are newly excavated lake bodies, they have simple ecosystem structure, small environmental capacity, low biodiversity, fragile water ecosystem and poor water body self-purification ability, so the overall water ecosystem needs to be optimized. Because the planned "eight lakes" have the landscape function, they can be called artificial landscape lakes. The surrounding green landscape is rich and has a large area. Daily green tail water flows into the lakes directly or with rainfall runoff, which brings more nutrients, which cannot be absorbed by the ecosystem in time, forming eutrophication, which is beneficial to the growth of alga. There is an algae outbreak trend in the water bodies, which makes the water quality worse and destroys the original underwater ecosystem, resulting in a vicious circle of the whole ecosystem, high turbidity and low transparency. In other words, the environmental sensory effect is not good, and the landscape effect is poor, which has a certain gap with the traditional small bridges and flowing water, and with the requirements of citizens and tourists[3]. In view of this, it is urgent to restore these artificial landscape lakes with fragile water ecosystem, strong eutrophication trend, poor environmental sensory effect and unsatisfactory water landscape effect.

# Comparison and Selection of Restoration Techniques for Artificial Landscape Lakes in Nantong City

## Common techniques for water body restoration of artificial landscape lakes

At present, commonly used techniques for the restoration of artificial landscape lakes at home and abroad are physical restoration, chemical restoration, biological restoration and ecological restoration.

**Physical restoration techniques** Physical restoration mainly includes artificial aeration, sediment dredging, in-situ treatment of sediment, hydrodynamic circulation, water diversion and water exchange, mechanical algae removal and other measures. However, through research and analysis, it has been found that the restoration methods have a single effect, but high construction and maintenance costs, and thus cannot fundamentally solve the problem of landscape water pollution. In recent years, with the introduction of foreign techniques, artificial aeration technique has gradually been used and explored in landscape water bodies in China, and experiments have been carried out in small watersheds and landscape water bodies, and good restoration results have been achieved. The polluted water bodies, such as West Lake in Hangzhou and Dianchi Lake in Kunming, were restored through the technical exploration of sediment dredging, and the pollutants such as total phosphorus, total nitrogen and heavy metals in the water bodies were significantly reduced. Physical remediation techniques, such as sediment disposal and artificial aeration and reoxygenation, were adopted in the United Kingdom for the water pollution of Thames, finally achieving the effect of improving the water quality and landscape[4].

**Chemical restoration techniques** Chemical restoration mainly includes chemical algae removal, flocculation and precipitation, chemical fixation of heavy metals, dosing air flotation and other measures. Although the restoration effect is obvious in a short time, there are some shortcomings such as high cost and secondary pollution to water. In recent years, scholars have been conducting research on chemical restoration techniques, and some companies have carried out research on new algae removal and precipitation agents. Some cities in China have also begun to deal with the pollution of landscape water and the treatment of black and odorous water by chemical methods. For example, the landscape water of Xuanwu Lake in Nanjing was treated by chemical methods. After analysis and observation, although the growth of cyanobacteria in the lake was suppressed in a short time, it did not fundamentally solve the problem of water eutrophication, but produced secondary pollution caused by chemical agents in some waters[5].

**Biological restoration techniques** Biological restoration mainly includes measures such as bacteria input technique, aquatic animal restoration technique and biofilm technique. Through practice, it has been found that although biological methods have the advantages of low cost and little pollution, they have some shortcomings, such as out of control of ecology, out of control of selection, excessive reproduction and long cycle. In recent years, most landscape water bodies at home and abroad began to be improved and treated by biological restoration techniques, and the most important measure was to put a large number of fish or microbial agents into the water, but it was later found that the effect of water body restoration was not significant[6]. These provide a reference for later research, so a single biological method cannot be used for water body restoration, and the selection and allocation of aquatic animals should also be optimized.

**Ecological restoration techniques** Ecological restoration mainly includes measures such as plant restoration, constructed wetlands and artificial ecological floating islands. As the mainstream techniques of water management in recent years, ecological restoration techniques have been favored by scholars and have been used in a large area. Very good results have been achieved on Jinji Lake in Suzhou, West Lake in Hangzhou, Living Water Park in Chengdu and Yunlong Lake in Xuzhou through ecological restoration and management[7]. However, through comparative study, it has been found that the problems of too-large area and high maintenance cost in the later period are gradually highlighted. Therefore, exploring suitable water ecological restoration techniques has become a hot research in urban landscape water treatment.

**Comprehensive evaluation of water restoration techniques for artificial landscape lakes**

Through the analysis and summary of above mainstream techniques, we can get following conclusions: physical restoration is suitable for water bodies with serious sediment pollution or low oxygen content; chemical restoration techniques are suitable for water bodies with serious heavy metal pollution, algae overgrowth or rapid effect; biological restoration is only suitable for general eutrophic water bodies; and ecological restoration techniques are suitable for comprehensive polluted water bodies with serious eutrophication. Physical and chemical techniques can get quick results, but the effects are temporary, and there are some shortcomings such as secondary pollution in the later stage and high input cost in the later stage. Biological restoration techniques are too slow to take effect and uncontrollable. Although ecological restoration techniques are also slow to take effect, they can basically solve the problem of water pollution and have great application prospects. In the later stage, they can maximize the effect with perfect maintenance scheme (Fig. 1). In view of this, it is urgent to carry out in-situ ecological restoration of artificial landscape lakes with fragile aquatic ecosystem, eutrophication trend, poor environmental sensory effect and unsatisfactory water landscape effect, and construct a "grass-type clear water state" system by using "algae-controlling zooplankton + submerged plant community", which is a low-consumption, efficient and environmentally safe water ecological restoration technique.

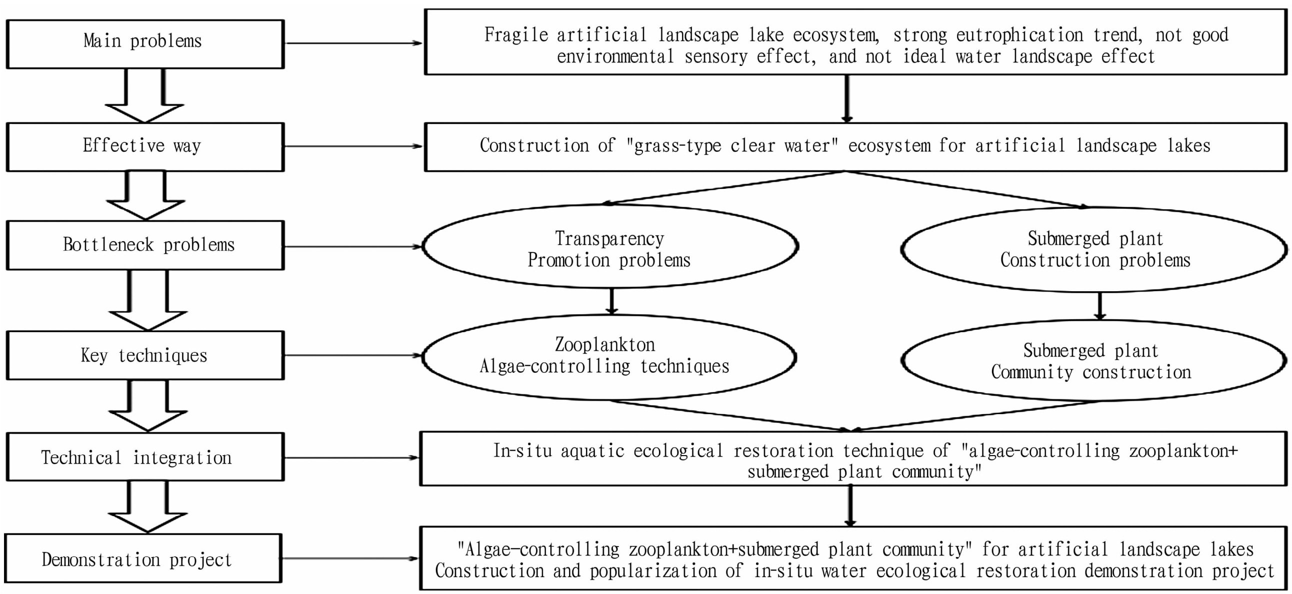


**Fig. 1 Construction and popularization of in-situ water ecological restoration demonstration project of "algae-controlling zooplankton + submerged plant community" in artificial landscape lakes**

## Conclusions

The clean water ecosystem of artificial landscape lake constructed relying on the in-situ water ecological restoration technique of "algae-controlling zooplankton + submerged plant community" can connect the food chain of "zooplankton controlling algae-fish eating zooplankton-human catching fish", and transfer nutrients such as nitrogen and phosphorus from the water to the shore, thereby completely reducing the eutrophication of artificial landscape lakes and maintaining the water quality for a long time. It can not only realize ecological balance, but also make rich nutrients become resources, revitalize water resources and develop aquaculture, thus optimizing water economy and generating economic benefits. It will play a good exemplary role in the realization of "Clear waters and lush mountains are invaluable assets", and also provide new possibilities for exploring the road of harnessing water and promoting water, and benefiting the people and strengthening the country in the new period.

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the statistical information system will automatically upload and display the homework completion ratio of the whole class and the score of each student. This evaluation method allows teachers to observe students' learning situation in time and adjust the teaching plan in time. It can also help students to "check and fill in the gaps", consolidate what they have learned in class in time, and grasp the important and difficult contents of each chapter more clearly. In 2022, we used the Learning Link to publish online homework for students majoring in biotechnology for 13 times, including 173 questions. The results showed that the students' homework completion rate was 100%, and the score was highest at 100 points and lowest at 64 points, with an average of 95.37 points[11]. Hence, this method realized the synchronous evaluation of teaching effect.

## Conclusions

In the era of networked information education, offline teaching must be deeply integrated with online teaching software to improve teaching quality and teaching effect[12]. In this paper, the teaching practice reform of the *Modern Instrumental Analysis* course for biotechnology majors was carried out from teaching content, teaching methods, teaching demonstration to teaching effect, and the traditional single offline teaching mode was been transformed into a diversified and interactive "online + offline" mixed multielement teaching mode, making the teaching activities of the course more interactive, interesting, enlightening and practical[13]. This reform not only greatly enriches the teaching resources for students, enhances the subjective initiative of learning, and effectively improves the overall quality of theoretical course teaching, but also provides reference for cultivating high-quality applied talents[14-15].

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