Application of computational fluid dynamics in the research on odorous-black water and physical treatment technology

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Abstract. As an extreme phenomenon of water pollution, odorous-black water not only cause ecological damage and threaten human health, but also severely restrict urban development. This paper mainly summarizes the main points, applicability, advantages and disadvantages of the current comprehensive treatment technology of odorous-black water, and analyzes the later development direction of odorous-black water treatment technology. It is considered that the treatment of odorous-black water is a systematic project, which involves many sources such as external source interception, water purification, quality assurance of living water, ecological restoration are the important technical means.

Keywords: Odorous-black water, comprehensive treatment, technical means.

1. Introduction
In recent years, due to the rapid development of industry, agriculture and urbanization, human production and living have intensified the total pollution of water resources. Not only natural lakes and reservoirs have been under great threat, but also artificial landscape lakes and reservoirs have been polluted to varying degrees [1]. A large amount of industrial, agricultural and domestic pollution discharge causes a series of water environment problems such as black and odorous water in the surrounding water, water quality deterioration, and even water bloom. Black and odorous water not only damages the river ecosystem, but also seriously affects the urban landscape and damages the urban living environment. The treatment of urban black and odorous water has always been a key problem in the research of domestic and foreign experts and scholars. At present, quite a few urban river sections in China are polluted to varying degrees [2]. At the same time, due to the lack of urban environmental infrastructure and the difficulties in the reconstruction of old urban areas, a large number of pollutants are discharged directly without treatment. In addition, More and more cities will use the tail water of sewage treatment plants that meet the Pollutant Discharge Standard for Urban...
Sewage Treatment Plants (GB 18918-2002) and the Water Standard for Landscape Environment of Urban Sewage Recycling (GB/T 18921-2002) as reclaimed water and serve as the water source for surface water such as lakes or wetlands [3]. The content of nitrogen and phosphorus pollutants (TN 15 mg/L, TP 0.5 mg/L) in the tail water of Grade A standard is relatively high, which does not meet the standard of Class V water quality (TN 2 mg/L, TP 0.4 mg/L) in The Environmental Quality Standard for Surface Water (GB 3838-2002). Moreover, it did not reach the internationally recognized critical value of eutrophication (TN 0.2mg /L, TP 0.2mg /L). As an extreme phenomenon of water pollution, black and odorous water not only cause ecological damage, have a serious impact on residents’ lives and the surrounding environment, but also seriously restrict urban development [4]. Therefore, the remediation of black and odorous water has become one of the hottest and most difficult environmental problems in water environmental protection and governance in China today [5].

2. Comprehensive remediation technology for black and smelly water
The primary task of urban black and smelly water remediation is to understand its causes and take effective measures to eliminate the "black and smelly" problem. The main causes of black and odorous water in urban inland rivers are the input of external pollutants (such as industrial wastewater, domestic sewage, garbage and non-point source pollution on both sides of the bank) and the input of internal source pollution from sediments. The environmental factors that cause black and odor mainly include: organic pollutants, nitrogen, phosphorus, iron, manganese, sulfide and other pollutants, water hypoxia, poor fluidity, etc. can further accelerate the black and odor of water. The treatment of black and odorous water should follow the technical route of "external source emission reduction, internal source dredging, water quality purification, clean water supply, and ecological restoration". External source emission reduction and internal source dredging are the foundation and prerequisite, water quality purification is a phased treatment method, and hydrodynamic improvement technology and ecological restoration are long-term guarantee measures. At present, there are many black and odorous water treatment technologies. According to different treatment methods and pollutant sources, the black and odorous water treatment technologies are divided into five categories, as shown in Table 1.

| Table 1. The treatment technology of urban odorous-black water |
|---------------------------------------------------------------|
| **Classification** | **Technology** | **Applicability** | **Advantage** | **Dis-advantage** |
| Point source pollution control | Complete pipe network, separate rain and sewage, centralized sewage treatment | It can be used in all kinds of rain, sewage treatment and cities and towns at all levels. | High processing efficiency and quick results. | A complete sewage pipe network and sewage treatment plant are required, and the construction and operation costs are high [6]. |
| High-efficiency first-level enhanced sewage treatment technology | It is suitable for large-scale sewage treatment, various industrial organic sewage and wastewater treatment. | It can reduce large pollution load, environmental water pollution, low construction and operation costs, high treatment efficiency, and quick results. | The treatment process is optimized and determined after a comprehensive technical and economic comparison based on the scale, water quality characteristics, environmental functions of the receiving water, and local actual conditions and requirements. |
| Policy strengthening | Applicable to cities and towns at all levels. | Has legal effect and compulsory. | Pollution discharge fee system is not perfect, pollution discharge permit system is problematic, environmental protection policies and regulations are lagging behind, and law enforcement supervision is weak [7]. |
|----------------------|---------------------------------------------|---------------------------------|----------------------------------------------------------------------------------|
| Non-point source pollution control | Urban low-impact development (such as sponge city) technology | It is suitable for areas with good water permeability and deep underground water depth, and it is not easy to affect surrounding buildings or structures. | Wide applicability, convenient construction, can replenish groundwater, small environmental impact, low cost [8]. |
|                     | Initial rainwater control technology | It is suitable for areas with serious initial runoff pollution [9]. | Source control, rainwater is treated on-site, and can be collected and reused later. |
|                     | Ecological Revetment | It is suitable for any rivers, lakes, reservoirs or the surrounding areas. | It can allow water and soil to penetrate each other, and has comprehensive effects such as flood control, ecology, landscape and self-purification of water. |
| Water purification technology | Constructed wetland | It is suitable for treating urban rainwater and sewage with little water volume, little water quality change, and low management level. | The treatment effect is good, the landscape value is high, and the energy consumption is low [11]. |
|                       | Ecological floating island | It is suitable for the initial stage of black and odorous water, and is mainly | The water purification effect is good, the water surface area of the water is directly |
|                       |                             |                                | The technology is not mature enough, and a large amount of experimental data is based on the laboratory. Some floating |
| Method                              | Suitable for                          |优点及影响                   |优点及影响                   |
|------------------------------------|---------------------------------------|----------------------------|----------------------------|
| Stabilization pond                  | It is suitable for rural domestic sewage treatment, and is often used in combination with constructed wetlands and ecological filters. | It has strong openness, high dynamics, convenient operation and maintenance, low cost, and no secondary pollution [14]. | It is easily affected by the outside world (rainfall, temperature, sewage, runoff) and internal plants, aquatic animals, and microorganisms. It requires regular tracking, recording, and processing by on-site personnel [7]. |
| Hydrodynamic improvement technology | It is suitable for lakes and reservoirs with high pollution load, insufficient hydropower, and low environmental capacity. | It can improve the utilization rate of water resources and the carrying capacity of the water environment. | The need for abundant water resources may lead to pollution transfer. |
| Black and smelly water improvement | Flowing water, water transfer technology | It is suitable for lakes and reservoirs with high pollution load, insufficient hydropower, and low environmental capacity. | It can improve the utilization rate of water resources and the carrying capacity of the water environment. | It is easily affected by the outside world (rainfall, temperature, sewage, runoff) and internal plants, aquatic animals, and microorganisms. It requires regular tracking, recording, and processing by on-site personnel [7]. |
| Ecological restoration technology   | Artificial control technology for algae growth | It is suitable for rivers, lakes and reservoirs where the release of phosphorus from sediments is high and the external source pollution is controlled. | The method and technology are mature, the algae control effect is good, and the effect is quick. | The manpower and power consumption are relatively high, and the cost is relatively high. |
| Improvement of black and smelly water and bottom mud | Water ecological restoration technology | Suitable for all kinds of rivers, lakes and reservoirs. | Low investment, low energy consumption, no secondary pollution, and beautify the river [15]. | The cycle is long and needs to be used in conjunction with other engineering techniques. |
| Biodiversity regulation technology | Suitable for all kinds of rivers, lakes and reservoirs. | Improve the self-purification capacity of the river and restore the ecological diversity of the river. | It has a long cycle and is often used as a later advanced treatment process [15]. |
2.1. External source blocking technology

Blocking pollution sources is the key to controlling black and odorous water. Urban pollution sources mainly include point source pollution and non-point source pollution. For the treatment of external pollutants, many cities have done a lot of effective work, which can basically be achieved by improving the sewage pipe network, improving the efficiency of rain and sewage diversion, and the centralized sewage treatment and external discharge. At the same time, it can strengthen the administrative management. For example, the upgrading or shutting down of the sewage of key sewage companies, and improving the efficiency of garbage removal and transportation, can further improve the processing capacity and level of external pollutants [5]. For sewage that has no conditions for interception and pipelining, high-efficiency first-level enhanced sewage treatment technology or technology can be used in situ to avoid pollution of water by direct sewage discharge [9]. Urban non-point source pollution is an important source of black and smelly water. In the summer of 2007, the tap water in Wuxi City produced a severe pungent smell, mainly due to non-point source pollution caused by a large amount of chemical fertilizers near Taihu Lake, which flowed into the rivers and lakes, resulting in eutrophication of the water and a large number of cyanobacteria. Pollution occurs almost every 3 years. Event [6],[15]. Non-point source pollution control technologies mainly include various urban low-impact development (such as sponge city) technologies, initial rainwater control technologies and ecological bank protection technologies. The low-impact development technology mainly uses the backfill soil layer with good permeability and pollutant adsorption performance to naturally purify the pollutants carried by rainfall runoff through physical, chemical, and biological effects such as filler adsorption, filtration, ion exchange, and microbial degradation, and then infiltration to replenish groundwater or collect and reuse it has the comprehensive functions of mitigating urban waterlogging, purifying water quality and conserving groundwater resources. The initial rainwater control technology mainly uses infiltration tanks, sedimentation tanks, permeable paving, green roofs and other facilities to dispose of rainwater with high pollutant content in the early stage of rainfall, and then reuse it, which is effective for urban non-point source pollution control. measure. Ecological bank protection mainly uses plants or a combination of plants and civil engineering to protect the slope of the river. It has comprehensive effects such as flood control, ecology, landscape and water self-purification. It has the best effect when combined with non-point source pollution source treatment facilities. [10].

2.2. Water purification technology

Water purification technology is an important means to remove black and odorous water and reduce black and smelly. Water purification technologies for urban black and odorous water mainly include: constructed wetland technology, ecological floating islands, stable ponds, etc. Constructed wetlands mainly use fillers with better adsorption performance and a complete microbial system to adsorb and degrade pollutants and reduce the content of pollutants in water. The ecological floating island technology mainly uses aquatic plants with better adsorption performance to absorb nutrients in the water and relieve the eutrophication of the water. It is generally used before the water is black and smelly. The ecological floating island has good landscape value and is an application for water quality restoration in rivers and lakes. More technical means [16]. Stabilization pond technology is similar to constructed wetland and ecological filter ditch technology, mainly using filler adsorption, plant absorption, microbial degradation and other methods to remove nitrogen and phosphorus nutrients in the water. Because of its convenient operation and maintenance, low cost, and no secondary pollution, it is a common technical method for rural domestic sewage treatment [14]. In addition, the use of artificial aeration, oxygenation, and flocculation sedimentation technology can remove the ammonia nitrogen in the black and odorous water, and the addition of flocculants can generate incompatible precipitation of certain phosphorus and heavy metals and fix them in the river bottom mud. The methods of aeration and aeration are used in the management of the Saar River in Germany, the Thames River in the United Kingdom, the Swan River in Australia, and the Suzhou River in China.
2.3. Hydrodynamic improvement technology
Hydrodynamic improvement technology adopts methods such as running water and water transfer to improve the water quality of water. This technology has obvious effects for lakes and reservoirs with high pollution load, insufficient hydropower, and low environmental capacity. However, to use clean water to improve river water quality, unconventional water sources should be used as much as possible, and at the same time, new sources of pollution should be prevented in the process of water transfer.

2.4. Ecological restoration technology
Ecological restoration technology is to rebuild river and lake ecosystems through physical, chemical, and biological methods under effective control of external pollution. It is an important measure to improve black and odorous water and black and odorous sediments and a key technology to restore river and lake ecosystems. Ecological restoration technology mainly includes artificial control technology for algae growth, water ecological restoration technology and biodiversity regulation technology. Artificial algae growth control technology is used in polluted water with high phosphorus release. Through artificial salvage, algae inhibition and other methods, the growth of blue and green algae is controlled, and the eutrophication of the water is reduced. Water ecological restoration and biodiversity regulation technologies are mainly used to regulate animals, plants, and microorganisms in rivers and lakes, protect biodiversity, and create a good ecosystem. Ecological restoration technology is an advanced treatment process for black and odorous water in the later stage.

3. Conclusions and Outlook
In the future, black and smelly water treatment technology will establish a technological system for urban inland river black and smelly water treatment with the scientific logic of "internal treatment-ecological restoration" under the premise of "external source interception". In terms of point source treatment, we will develop high-efficiency nitrogen and phosphorus source control technologies, such as nitrogen and phosphorus resource recycling technologies, refractory industrial wastewater, and high-efficiency redox technologies for waste residues. In terms of non-point source treatment, it is necessary to integrate comprehensive urban non-point source control technologies, such as initial rainwater, surface interception, and pollution control technologies. Regarding the treatment of endogenous black and odorous bottom sludge, starting from the development of new materials and new equipment models, we will research and develop high-efficiency, low-risk, and low-cost in-situ control technologies for urban black and odorous river bottom sludge pollution, such as oxidizers and covering agents, Algae inhibitors, environmentally friendly ecological covering agents, etc. In terms of ecological restoration, the application of in-situ water quality improvement and biological ecological restoration technologies, such as high-efficiency composite microbial agents, and indigenous microbial growth-promoting technologies, should be the main application. In addition, reorganizing, extending and developing a series of new technologies based on the existing physical, chemical and biological remediation technologies will fundamentally solve the difficulties and technical key points of the black and odor problem of urban rivers, and help pollution control.

Acknowledgments
This research was financially supported by the Key Search and Development Program of Shaanxi (2020SF-420), the project of Shaanxi Provence Land Engineering Construction Group (DJNY2020-27).

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