Research on Treatment Measures and Treatment Effects of Black and Smelly Water Body in Shenyang Area

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Abstract. Taking Shenyang City as an example, the current situation and progress of the treatment of black and smelly water bodies in the built-up area of Shenyang City are summarized from three aspects: the distribution of black and smelly water bodies, completed renovation measures, and problem identification and diagnosis. Aims. Based on the analysis results of the pollution load of the black and smelly water body catchment unit, the remediation plan and measures for the black and smelly water body in the built-up area of Shenyang City are clarified, and the experience and effectiveness of the black and smelly water body treatment are summarized and analyzed.

Keywords: Black and odorous water body, sediment, ORP, early warning system, Shenyang city, environmental quality.

1. Introduction
Urban rivers, lakes and other water bodies, as necessities for residents’ lives, can not only provide water sources, supplement groundwater, regulate flow and temperature, but also maintain ecological balance, maintain urban climate, and improve the living environment. However, with the continuous expansion of the scale of cities, the acceleration of industrial development and urbanization, the discharge of industrial wastewater and domestic sewage is gradually greater than that of sewage treatment plants, and more and more sewage is discharged directly into rivers and lakes without treatment. It far exceeds the self-purification capacity of the water body, causing the eutrophication of the water body, and even the black and odor phenomenon of the water body. Urban black and odorous water bodies have occurred with the country’s industrialization and urbanization. For example, water bodies such as the Thames in London, the Ruhremsc River in Germany, and the Danube in Vienna, Austria have all been black and odorous. Improve.

Shenyang is located in the central part of Liaoning Province, in the centre of the Northeast Asian Economic Circle and the Bohai Rim Economic Circle. It is an old industrial base and the only megacity in the Northeast. In recent years, with the rapid economic development and continuous expansion of the city scale, Shenyang’s urban environmental infrastructure has become increasingly inadequate, and urban sewage discharge has increased day by day. A large number of pollutants entering the River have caused serious river water pollution and seasonal or year-round black odors. Phenomenon. In 2015, in accordance with the requirements of the Ministry of Housing and Urban-
Rural Development, the Shenyang Municipal Government reported 5 black and odorous water bodies in the "National Urban Black and Odorous Water Remediation and Supervision Platform Information Reporting System". In addition, during the treatment of black and odorous water bodies, five black and odorous water bodies were newly discovered and reported [1]. Focusing on the comprehensive improvement of black and smelly water bodies in the built-up areas of the city, Shenyang has carried out a series of work and achieved obvious results. Up to now, 3 black and odorous water bodies have been comprehensively rectified, basically eliminating black and odor; the other 7 black and odorous water bodies have been comprehensively treated, and the water quality of the water bodies has been significantly improved, and they have become mildly black and odourless, or even no black and odor. This study summarizes the status quo of black and smelly water bodies in the built-up area of Shenyang City and the completed measures for the treatment of black and smelly water bodies, identifies and diagnoses the main problems that still exist in the treatment of black and smelly water bodies, and proposes short-term goals for the treatment of black and smelly water bodies. Based on the analysis results of the pollution load of the black and smelly water body catchment unit, the plan and measures for further comprehensive improvement of the black and smelly water body in the built-up area of Shenyang City are clarified, and the experience and effectiveness of the treatment of black and smelly water bodies are analyzed, with a view to improving the black and smelly water bodies in the seasonally cold northern regions. Provide reference for water treatment.【The data and standards involved in this research are as of December 2018】

2. The characteristics of the Heixou River Basin in Shenyang City and its governance status

2.1. Distribution of black and odorous water bodies

The central urban water system of Shenyang mainly includes Hun River, Pu River, South Canal, Xinkai River, Weigong Open Channel, Huishan Open Channel and Mantang River. Among them: Hun River and Pu River are large rivers; South Canal, Xinkai River and Weigong Open Channel constitute the water system around the city of Hunbei main urban area, collectively known as "Baili Canal". According to the investigation and verified by the National Urban Black and Smelly Water Body Remediation Special Action Supervision Team, there are currently 10 black and smelly water bodies in the built-up area of Shenyang City, namely Xinkai River, South Canal, Weigong Open Channel, Xi River and Huishan. Open Channel, Mantang River, Shanli River, Nanxiao River, Baitabao River and Hunnan Main Hunan. The black and smelly section is about 106.58 km long and involves 8 administrative districts including Heping District, Shenhe District, Huanggu District, Dadong District, Tiexi District, Hunnan District, Yuhong District and Shenbei New District. Among them: Xinkai River, South Canal, and Weigong Open Channel mainly source water from the Hun River; Xi River, Huishan Open Channel, Mantang River, Shanli River, and Nanxiao River mainly source water from sewage treatment plant tail water; Huishan Open Channel and Mantang River and Baitabao River are seasonal rivers; the main trunk of Hunnan is used for irrigation. According to the requirements of "Shenyang Environmental Monitoring Plan and Task Decomposition in 2019", in 2019, monthly monitoring will be carried out on the Liao River (Shenyang Section), the Hun River Shellbie (Shenyang Section) and its main tributaries, with 26 monitoring items. There are 28 monthly surveys in Wolong Lake [2]. There are 23 groundwater monitoring indicators in Shenyang in 2019: pH, total hardness, sulfate, chloride, iron, manganese, copper, zinc, volatile phenol, anionic synthetic detergent, permanganate index, nitrate nitrogen, Nitrite nitrogen, ammonia nitrogen, fluoride, cyanide, mercury, arsenic, selenium, cadmium, hexavalent chromium, lead, total coliforms.

2.2. Monitoring results

2.2.1. Xi River. First. The three large-scale sewage treatment plants in the north, west, and Xiannv River still implement the secondary discharge standards, and the treatment standards are low, and the upgrading and renovation projects have not been completed. Second, there is still a mixed flow of rain
and sewage in the North Canal, and the rainy season will affect the water quality of the downstream Weigong River and Xi River. Third, the operation load of the expansion project of the Western Sewage Treatment Plant is relatively low. At present, the main body of the expansion project of the Western Sewage Treatment Plant (Phase II) has been put into operation, and the sewage from the chemical park and other areas has been collected, but the supporting pipeline network of the sewage treatment plant needs to be further improved. Influent water quality is not stable yet. Fourth, the municipal infrastructure in Zhangyi, Dapan, and Changtan townships in the lower reaches of the Xi River is not complete, and the environment along the River is poor, and the township sewage cannot be effectively treated [3]. Fifth, the main function of Xi River was to receive pollution in the city, lack of ecological water supply, and poor water self-purification ability. Sixth, environmental risks such as illegal discharge and dumping have caused environmental risks.

2.2.2. Baitabao River. One is the low standards of sewage treatment plants. Second, there is no separation of rain and pollution along the line. The third is the imperfect interception pipeline. Fourth, sewage treatment facilities in towns and villages failed to operate effectively. Fifth, there is agricultural non-point source pollution.

2.2.3. Beisha River. One is that part of the domestic sewage in the built-up area of Sujiatun is still directly discharged. The sewage treatment plant in Sujiatun District with a daily processing capacity of 50,000 tons has reached the upper limit of its treatment capacity, and the expansion of the sewage treatment plant has not been completed. Urban sewage is drained into Beisha River through Xiujiang. The second is the sewage discharge from the mining areas and living areas of industrial and mining enterprises such as Hongyang No. 3 Mine, Linsheng, and Hongling, which has an impact on the water quality of the River, especially the water quality of the Dongyangjiao section downstream. The third is the stable and effective operation of sewage treatment facilities in 12 villages and towns in the region, and there are hidden dangers in meeting discharge standards. Fourth, the environment along the River is poor. The Beisha River and its tributaries flowing through towns and villages have rubbish accumulation channels, which will affect the water quality of the River. Fifth, there is a lack of ecological replenishment, and there is a certain impact on the upstream water [4].

2.2.4. Pu River. First. The expansion project of the ecological sewage treatment plant in Liaozhong County has not yet been completed. Second, the Qipanshan Sishui Sewage Treatment Plant, the Liaozhong Offshore Economic Zone Sewage Treatment Plant, and the Yuhong Yongan New City Sewage Treatment Plant were mainly completed, but due to the imperfect supporting pipe network, the number of enterprises in the catchment area and the drainage volume were small, which was not realized. Stable operation. The third is that the sewage pipe network of some real estate projects developed in the Huanggu North Economic Zone and Pu River New City area is imperfect, and some sewage discharged from the project is mixed into Pu River through the rainwater main pipe. Fourth, Nanxiao River in Dadong District, Huangni River in Pu River New Town, North Drain (Xiaohun River) in Yuhong District, Huangni River in Shenbei New District, Jiulong River flowing through Shenbei New District and Yuhong District, and Wubo in Liaozhong District The water quality of the Pu River tributaries such as Steak Gan, etc. has exceeded the standard in varying degrees, which has affected the water quality of the Pu River. Fifth, the prevention and control of water pollution in agriculture-related areas still needs to be strengthened. Pollution discharge in some towns has not yet been effectively controlled. Livestock and poultry breeding along the route and agricultural non-point source pollution have a greater impact on the water quality of Pu River. Sixth, the whole section of Pu River lacks environmental supplemental water. Especially in the dry season in winter, the downstream rivers of Pu River are all about 144,000 tons of tail water discharged daily by 12 sewage treatment plants along the line. Although the treatment has reached the standard, it still has a large gap with the national assessment standard, that is, the quality of surface water class V.
3. Technical analysis of black and smelly water treatment model

3.1. Parallel factor analysis black and smelly river DOM

Parallel factor analysis (PARAFAC) is based on Stedmon's tutorial through MATLAB9.0 for EM-PARAFAC modeling. The model arranges the EEM data set into a set of three rows and three columns and a residual matrix, and decomposes different fluorophore groups by minimizing the sum of the squares of the residual matrix to interpret the entire EEM data set. The matrix model is expressed as:

\[
X_{ijk} = \sum_{f=1}^{F} a_{if} b_{jf} c_{kf} + \varepsilon_{ijk}
\]

\[i = 1, \ldots, I; j = 1, \ldots, J; k = 1, \ldots, K\]  

In the formula, F represents the number of model components, \(X_{ijk}\) represents the fluorescence intensity of sample 1 at emission wavelength J and excitation wavelength k; \(a_{if}\) is the concentration ratio of the f-th fluorescent component in the i-th sample (defined Is the score); \(b_{jf}\) and \(c_{kf}\) are the model parameters in the f component; \(\varepsilon_{ijk}\) is the sum of squares of the residual matrix that is minimized in the model.

Use Milli-Q water as a blank to calibrate the sample for scattering. The Raman unit is converted according to the Raman peak area of ultrapure water at the excitation wavelength of 275nm. By diluting the water sample to make the ultraviolet absorbance value at a wavelength of 254nm less than 0.1, the internal filtering effect of fluorescence measurement is reduced. The DOM Four toolbox of the MATLAB software package was used to model the EEM data set PARAFAC. The data sample is randomly divided into two arrays of the same size through the method of dividing into two, as shown in Figure 1, to ensure that the sum of squares of the load of \(E_x, E_y\) is basically similar, so as to prove the reliability of the analysis results, and verify that the 2-6 components The effective component number of, among which 3 and 4 components are effective, calculate the central continuity coefficient of the effective component number model to determine the most appropriate three-factor model. Finally, the positions of the maximum excitation and emission wavelengths and the relative fluorescence intensity of the three components are obtained. The abundance of each component is represented by the maximum fluorescence intensity \(F_{max} (R.U.)\).

![Figure 1](image_url)
3.2. Inherent optical quantity of water body

The inherent optical quantity of a water body is a parameter that does not change with the distribution and intensity of the incident light field. Different water bodies exhibit different spectral characteristics due to the influence of changes in the concentration of their components, mainly including spectral absorption coefficient \( a(\lambda) \), scattering coefficient \( b(\lambda) \), and scattering phase function \( P \) and the beam attenuation coefficient \( c(\lambda) \). And \( c(\lambda) = a(\lambda) + b(\lambda) \).

The intrinsic optical quantity is an important link connecting the water quality parameters and the physical quantity. Water bodies with different pollution levels show different spectral characteristics due to the influence of changes in the concentration of their components. There are 4 kinds of optically active substances in natural water bodies that affect the inherent optical quantity of water bodies, namely pure water, non-pigment particles, phytoplankton and coloured soluble organic matter. Phytoplankton is the primary producer in the water body, and the cells contain different types of pigments, such as chlorophyll a, etc.; non-pigmented particles mainly include the residues of phytoplankton death, organic debris and inorganic suspended particles produced by resuspension of sediment; Coloured soluble organic matter (CDOM) is mainly a soluble organic matter composed of fulvic acid and humid acid released by decaying substances [5]. This article mainly studies the relationship between CDOM and \( a_p \) humid the amount of tourism.

3.2.1. Absorption coefficient of total suspended solids. Pass a sufficient volume of water sample \( V_f \) (about 0.5-SL) through a GF/F glass fiber filter membrane with a diameter of 47mm and a pore size of 0.7 μm, and place the filtered total suspended particulate matter filter membrane under a spectrophotometer to measure the optical density. The absorbance value obtained is recorded as \( OD_f \). According to the quantitative filter technology (QFT), the formula for the spectral absorption coefficient of total suspended particles can be obtained as follows:

\[
a_p(\lambda) = 2.303 \frac{s_r}{V_f} \left( 0.378OD_f + 0.523OD_f^2 \right)
\]

3.2.2. Coloured soluble organic matter (CDOM) absorption coefficient. CDOM value the part of the organic matter with colour in the soluble organic matter has a significant impact on the colour change of black and odorous water. Filter the water sample with a Millipore filter membrane with 0.2μm pore size and place it in a quartz cuvette with a light path of 5 cm. Measure the absorbance \( D(\lambda) \) of the solution under a visible light-ultraviolet spectrophotometer, and then calculate the CDOM after scattering correction according to the following formula. The absorption coefficient:

\[
a_{CDOM}(\lambda) = 2.303 \frac{D(\lambda)}{r} - a(\lambda_{null})
\]

In the formula: \( D(\lambda) \) is the measured absorbance value; \( r=0.5m \) is the optical path; \( a(\lambda_{null}) \) is the scatter correction item, which is the minimum value of the average value of \( a_{CDOM}(\lambda) \) for every continuous 10nm.
4. Analysis of governance measures

4.1. Key technologies for source pollution control and treatment

Pollution source control and treatment are mainly aimed at point sources, non-point sources and internal sources that cause black and odorous water bodies. Appropriate treatment technologies should be adopted to reduce the target pollutant load and meet the requirements of water body environmental capacity control.

First, the construction of rain and sewage pipe networks. For the treatment of urban black and odorous water bodies, we should first coordinate the formulation of a drainage system suitable for local natural and climatic conditions. The planning and construction of the drainage system should comprehensively coordinate the planning and construction of urban sewage treatment plants and sponge cities. For point sources of pollution directly discharged into the water body, measures should be taken to intercept pollution, improve the sewage collection system, realize full collection and full treatment, and check for misconnections and omissions in the pipe network. For new urban areas with abundant rainfall, a split drainage system should be implemented; the overflow combined drainage system should be gradually transformed into a fully combined drainage system, and the overflow outlets that directly discharge rivers should be gradually blocked. For cities that have adopted a diversion drainage system, storage facilities such as reservoirs and rainwater tanks can be gradually set up to collect, process, and use runoff rainwater to control pollution and rational use of rainwater under economic conditions. In arid and semi-arid areas, under the conditions of relatively complete construction of urban sewage pipe networks and sewage treatment plants, a confluence system can be adopted to make full use of pipelines and storage facilities to intercept sewage beyond the treatment capacity of the sewage treatment plant. After rainfall, the mixed sewage is treated in the sewage treatment. It is fully treated in the factory to reduce the pollution load in the rainy season [6]. Figure 2 shows the treatment method of urban black and odorous water.

![Figure 2. Treatment methods for urban black and odorous water bodies](image)

Second, point source pollution control technology. The point source pollution that affects urban black and odorous water bodies mainly includes urban residents' domestic sewage, industrial sewage, and large-scale livestock and poultry breeding pollution. First, the domestic sewage of urban residents should be treated in a centralized manner, and the effluent should be stable and meet the standard and meet the control requirements of the water environment function zone and water environment capacity.
of the receiving water body; if the effluent water quality requirement is better than the level A standard, membrane biology Reactor (MBR), activated sludge method (secondary) + biological aerated filter, advanced treatment of constructed wetlands, etc. Second, the discharge standards of industrial parks and urban sewage should be gradually merged [7]. For difficult-to-degrade pollutants, advanced oxidation methods can be adopted; for high-salt wastewater, membrane separation (reverse osmosis, forward osmosis) + multi-effect evaporation and other combined processes can be adopted. Encourage enterprises to implement cleaner production and reuse of reclaimed water. If necessary, add advanced oxidation, adsorption, membrane technology and other enhanced treatment units to improve the quality of effluent water.

4.2. Water purification and ecological restoration technology
Water purification and ecological restoration in the water body mainly include the following aspects. First, for black and smelly water bodies with poor habitat conditions and difficult water ecological restoration, in-situ treatment techniques such as aeration and oxygenation, floating beds, floating wetlands, floating water purification plants, microbial agents, and biological carriers should be used; In areas where conditions permit, technologies such as biological ponds and constructed wetlands can be used as bypass processing systems. Improve water quality and bottom quality to create conditions for aquatic bioremediation. Second, on the basis of controlling pollution sources, carry out aquatic plant restoration, screen and identify local pioneer species for aquatic vegetation restoration, and use aquatic plant seedling cultivation, artificial hole drilling, sandbag throwing, turf production and other planting techniques to restore aquatic plant communities. And optimize the configuration. In the process of aquatic plant restoration, it is necessary to prevent the invasion of foreign species and secondary pollution of aquatic plants from decay, evaluate the biological safety when necessary, and encourage the resource utilization of large aquatic plants.

5. Conclusion
By actively carrying out comprehensive improvement work, Shenyang City has made good progress in the treatment of black and smelly water bodies, and the water quality has been significantly improved. How to ensure the long-term maintenance of good water quality is an important consideration in the follow-up remediation work. By strengthening the water quality monitoring, evaluation and identification capabilities of black and odorous water bodies, the establishment of a black and odorous water body information monitoring system and platform in the built-up area of Shenyang City will systematically improve the level of intelligent management of the water environment in the built-up area of Shenyang City, which can better monitor good water quality regulatory role.

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