Genetic analysis of algae blooms in landscape water in the west section of Nanchuan River City, Xining City

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Abstract: The west section of Nanchuan River City is an important part of the water ecological environment of Xining city, known as the urban meeting room. In order to find out the possible causes of algal blooms in the summer of 2022, water quality detection, aquatic organism identification and sediment analysis were carried out in the main landscape ponds of the west section of Nanchuanhecheng. The results showed that 52 species of phytoplankton were identified, including 4 species of cyanobacteria, 29 species of diatoms, 14 species of green algae, 3 species of cryptophytes and 2 species of gymnophytes. There were 66 species of zooplankton, including 22 protozoa, 29 rotifers, 9 cladocerans and 6 copepods. There were 18 benthic animals, including 4 annelids, 3 molluscs and 11 arthropods. According to the detection results of aquatic organisms, water quality and sediment, the causes of algal blooms were analyzed and corresponding measures were proposed to provide reference for subsequent control work.

1. Introduction

Urban landscape water body refers to the water body formed naturally or constructed artificially with landscape function and can provide leisure places and other functions, such as park lake, urban river and so on. Urban landscape water bodies are of great value in tourism, entertainment, flood regulation and storage, drainage, climate regulation and urban ecological environment improvement, etc. Most of them are closed slow-flowing water bodies with static or poor mobility, and generally have the characteristics of Algae bloom is a phenomenon related to water ecological environment management. Nanchuan River is a first-class tributary of Huangshui River, located in the south of Xining city, with a total length of 49.2km, and flows into Huangshui River in Xining City, of which Chengxi section refers to the left bank section of Nanchuan River from Liuyi Bridge to Xiushui Bridge in Xining City, with a total length of 2.9km. The west section of Nanchuan River is a typical representative of Xining city's urban landscape water body with "clear water, green bank, smooth and beautiful scenery". It not only plays the role of the window of the city's external publicity and a beautiful business card, but also becomes the riverside support platform for the general public's leisure and entertainment. In recent years, with the rise of temperature and the control of water flow in the west section of Nanchuan River City, when there are appropriate biological, hydrological, meteorological and other conditions, algae will also occur explosive reproduction, forming a large area of bloom. Since 2005, Xining City has carried out construction projects such as "Xining Nanchuan River Control Project", "Xining Nanchuan River Clean Water into the City Project" and "Nanchuan River Municipal Sewage interception and management Project". Through the construction of comprehensive control projects of dikes, steel DAMS, drop weir and stepped storage area, as well as planting submerged water, rising water and floating water plants and releasing fish snails and shrimp, the circulation system has been constructed. The water ecological environment has been improved. In order to further consolidate the achievements of water ecological environment management in Nanchuan River and identify the possible causes of excessive algae growth in the summer of 2022, the main landscape pool in the west section of Nanchuan River was investigated and studied to reveal the possible relationship between water quality and algae outbreak, as well as sediment and aquatic organisms, the possible causes of algal bloom were analyzed, and corresponding control measures were proposed. To provide reference for the subsequent treatment work.

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2. Materials and methods

2.1 Layout of sample points

Nanchuan River is a first-class tributary of Huangshui River, with a total length of 49.2 km, of which the length of the urban section is about 8.0 km. Chengxi section refers to the left bank section of Nanchuan River from Liuyi Bridge to Xiushui Bridge in Chengxi District, Xining City, with a total length of 2.9 km. According to the actual situation of hydrology and water quality in the west section of Nanchuan Hecheng, a total of 11 sampling points are set up, as shown in Figure 1, #0 is the inlet of Jiefangqu Aqueduct. In order to understand the water quality of the inlet of landscape Pond, 2# and 4# are located in the upstream section from Jiefangqu aqueduct Section to Liuyi Bridge, and 6#, 8#, 10# and 12# are the middle reaches of the west section of Nanchuan Hecheng. 15#, 17#, 19# and 21# are the downstream part.

![Figure 1 Map of the distribution of sampling points](image)

2.2 Sample collection and processing

Water quality samples shall be investigated, sampled and tested according to the Standard for Surface Water Environmental Quality (GB3838-2002) and Technical Specification for Surface Water Environmental Quality Monitoring (HJ 91.2-2022). Water temperature (WT), pH, dissolved oxygen (DO), transparency (SD), electrical conductivity and total suspended matter (TSS) shall be tested on-site. Total phosphorus (TP), total nitrogen (TN), ammonia nitrogen (NH3-N), five-day biochemical oxygen demand (BOD5), chemical oxygen demand (CODCr), permanganate index (IMN), chlorophyll a (Chla) were brought back to the laboratory for testing; HJ 710.12-2016 “Technical Guidelines for Biodiversity Observation of Aquatic Vascular Plants (Release Draft)” was used to identify phytoplankton species and phytoplankton cell density. The indicators of sediment were color, bulk density, density, water content, mechanical composition, REDOX potential (observed in the field), pH, organic matter, chlorophyll a (Chla), total nitrogen, total phosphorus, available nitrogen, available phosphorus, ammonia nitrogen, mercury, arsenic, hexavalent chromium.

3. Results And Analysis

3.1 Aquatic organism identification

As shown in FIG. 2 and FIG. 3, 52 species of phytoplankton were found in the main landscape pools of Nanchuanhe River (from pool #0 to pool 21#), including 4 species of cyanobacteria, 29 species of diatom, 14 species of green algae, 3 species of cryptophytes and 2 species of gymnosperms. The density of phytoplankton at various points ranged from $25.8 \times 10^5$ /L to $324.7 / L$. With an average of $163.7 \times 10^5$ phytoplankton / L. The dominant group of phytoplankton in this survey was diatoms. In terms of density, diatoms were the absolute dominant group, accounting for 94.83% of the total density. The first dominant species is Cyclotella with 64.30% dominance, followed by Pseudanabaena with 6.51% dominance.
A total of 66 species of zooplankton were found in the main landscape pool, including 22 protozoa, 29 rotifers, 9 cladocerans and 6 copepods, as shown in Fig. 3. The density of zooplankton at various sites ranged from 531 to 3416 ind./L, with an average value of 1506 ind./L. Pools 2 and 1 had the highest density, while pools 4 and 19 had the lowest. Among all groups, protozoa was the highest and copepods the lowest. In terms of biomass, the biomass of zooplankton at various points ranged from 0.145 to 2.21 mg/L, with an average of 0.626 mg/L. Pool 4 and pool 6 had the highest biomass, and cladocera had the highest biomass. The dominant group was protozoa. In terms of density, protozoa is the absolute dominant group, accounting for 80.18% of the total density. The first dominant species was Vorticella sp. with 25.69% dominance, followed by Ciliate. The degree of dominance was 18.87%.

A total of 18 species of benthic animals were found, including 4 annelids, 3 mollusks and 11 arthropods. The density of benthic animals at various points ranged from 285.71 to 3,809.23 ind./m², with an average value of 4749.78 ind./m². The potential group was annelids, which were the absolute dominant group in terms of density. The proportion of the total density was 88.08%; The first dominant species was Hofuensis species with 87.53% dominance, followed by Chironomid species with 5.9% dominance.

**Fig. 2** Phytoplankton dominant species at various points in the sampling pool

**Fig. 3.** Number of zooplankton species at various points in the sampling pool
There are seven main types of submerged plants, i.e., floating algae, Caltrop, Caltrop, Caltrop, spiropteris, black chlorophyta and cattails. There was little difference in the dominant submerged plant species in each landscape pool, but there was a big difference in biomass.

3.2 Relationship between water quality and environmental factors

The correlation analysis of water quality indexes and environmental factors of 11 pools that have been sampled is shown in FIG. 4. The results show that the correlation between all environmental factors and BOD is weak, and the correlation between water volume and ratio and BOD is strong. The length, area and volume of water in the pool were positively correlated with dissolved oxygen. Water temperature and total suspended solids showed a significant negative correlation. Elevation and total phosphorus and total nitrogen showed a significant positive correlation, transparency and total phosphorus showed a significant negative correlation, water temperature and total nitrogen showed a significant negative correlation. The correlation coefficients between all environmental factors and COD were less than 0.6, indicating a weak correlation, in which the correlation between specific gradient and COD was the largest. The correlation between altitude and permanganate index was strong, and the correlation between specific gradient and permanganate index was significant; Elevation, water depth, water temperature and PH showed a significant correlation, among which elevation and PH showed a negative correlation, water depth, water temperature and PH showed a positive correlation, transparency and PH showed a significant positive correlation.

![Fig. 4 Correlation diagram between water quality and environmental factors in the sampling pool](image)

3.3 Correlation between water quality and sediment

The correlation analysis between the water quality index and the bottom mud (substrate) is shown in Figure 5. According to the analysis results, it can be seen that the clay content, organic matter and total phosphorus of the bottom mud show a significant negative correlation with the REDOX potential of surface water, while the correlation between each bottom mud index and the conductivity reflecting water quality is weak. Sediment depth, sediment PH and surface water BOD showed a significant positive correlation, sediment density and BOD showed a significant positive correlation, while organic matter and BOD showed a significant negative correlation. There was a significant negative correlation between ammonia nitrogen and dissolved oxygen in surface water. The correlation between all sediment indexes and total suspended solids was weak, and the biggest correlation was between total phosphorus and total suspended solids. The volume of sediment, hexavalent chromium and total phosphorus content of surface water showed a weak positive correlation, while the clay content of sediment, organic matter, available nitrogen and total phosphorus content of surface water showed a weak positive correlation. The content of total phosphorus and mercury in bottom mud showed a weak positive correlation with total phosphorus in surface water.
was a strong positive correlation between hexavalent chromium and surface water chemical oxygen demand and permanganate index. There was a strong negative correlation between total phosphorus and surface water pH.

![Fig. 5](image)

**Fig. 5** Correlation between water quality and sediment in the sampling pool

3.4 Genetic analysis of algae blooms

Hydrological characteristics and hydrodynamic conditions (such as water velocity, water exchange rate and river slope) are the primary factors affecting water quality. The survey shows that the elevation of each landscape pond of Nanchuan River from 0# pond (Jiefangqu Aqueduct) to 21# pond at the upstream inlet drops from 2228.36m to 2180.29m, as shown in Figure 6. The river reach is about 3.4km long, with an average gradient of about 14‰, which is more than double that of the natural channel gradient of Nanchuan River, which is 36‰. In the west section of the river, the water body is released by the gate, the flow rate is very small, basically in a state of stagnant water (flow rate < 0.001m/s), resulting in insufficient flow power in the river, hydrodynamic conditions have become the main limiting conditions affecting the growth of algae, the mobility is reduced, resulting in the decline of water reoxygenation capacity, and the local water area or water layer oxygen deficit problem is serious. The formation of suitable algae bloom rapid growth of hydrodynamic conditions\[12\], the flow rate of small also stimulate the growth\[13, 14\] of algae, increase the risk of outbreak, there are also research results show that the flow rate of algae growth between \[15,16\]. In addition, most of the groundwater depth in the west section of the city is greater than 10m, and there is almost no exchange between landscape pool water and groundwater, resulting in extremely weak water body renewal and self-purification ability, and extremely limited water environment capacity in landscape pool, which is the primary reason that algal blooms are easily triggered in this section.
A closed or poorly flowing water body with high water temperature (20-25℃, as determined by air temperature and light conditions) and suitable water depth (20-80cm for most phytoplankton and 50-200cm for most submerged plants) creates a suitable and stable hydraulic environment for algae growth. Therefore, water bodies with these conditions are often prone to algal blooms. Temperature is the most basic environmental factor for algae growth, which is the necessary condition for algae to carry out photosynthesis. Summer is the growth season of planktic algae, and buoyant algae will rise to the surface of the water to get more light, resulting in a large number of planktic algae, and buoyant algae will rise to the surface to carry out photosynthesis. Summer is the growth season of planktic algae, which is the necessary condition for algae to carry out photosynthesis. Summer is the growth season of planktic algae, and buoyant algae will rise to the surface of the water to get more light, resulting in a large number of planktic algae, and buoyant algae will rise to the surface to carry out photosynthesis.

The upstream water and the sediment it carries may be the main cause of sediment deposition in landscape ponds and the excess of total nitrogen in water quality. In the water environment system, sediment directly affects the occurrence state of pollutants in the water-solid phase through adsorption and desorption of pollutants. Meanwhile, along with the movement of sediment in the water body, the occurrence state of pollutants between the water body and the bottom mud also changes. Sediment and water flow together become the main carrier of pollutants, affecting the migration and transformation process of pollutants in the water body, and ultimately affecting the quality of the water ecological environment. The survey shows that the depth of the sediment in 11 pools has reached 20cm, except for the #1 pool (Jiefangquan aqueduct inlet) and the #21 pool (because of lush plants can not be measured by boat), the average sediment thickness of the remaining pools has reached 17.5cm, accounting for about 27% of the average water depth of each pool. From the results of the classification of sediment, the powder particles with a grain size between 0.002-0.02mm are the main components of the sediment, accounting for about 58.3% of the volume of the sediment. The second is the sand with the grain size of 0.02-0.02mm, accounting for 37.4%. Clay with grain size <0.02mm is the least, accounting for about 4.3%. It can be concluded that the sediment of landscape pools in the west section of Hecheng in Nanchuan has the obvious characteristics of fast sedimentation rate and fine sediment texture. From the correlation analysis results between the water quality index and the sediment index, it is found that the depth and the particle size composition of the sediment volume have great influence on the content of total nitrogen, total phosphorus and total suspended matter in the water body. Phosphorus in water provides a rich material basis for algae growth. Algae growth plays an important role in addition to the supply of phosphorus in water, and the ratio between the concentration of total nitrogen and total phosphorus in water also has an important impact on algae growth. The eutrophication results of many water bodies prove that as long as the phosphorus in the water body is strictly controlled, it can play a very good role. International scholars believe that the control standard of phosphorus content is: The total phosphorus concentration is 0.03mg/L, if the water nutrient concentration exceeds the standard, algal bloom has occurred, and the total phosphorus concentration is greater than 0.03mg/L, that is, algal bloom has occurred in the main landscape pool of the west section of Nanchuan River City.

The survey results of submerged plants showed that except floating algae and cattails, the most suitable habitat for the other 5 species of plants (Caltrop caltrop, Caltrop Caltrop, Caltrop Caltrop, Bristelecone paniculata and nigrophylla verticillata) was eutrophication water at a depth of 80-
200cm, and the water depth of all landscape pools in the west section of the city was within this range. Therefore, the eutrophication degree of the water body of the landscape pool in the western part of the city was more serious. Benthic animals also play an important role in water purification, especially mollusks with filter feeding function. However, there are very few mollusks in the main landscape pool in the west section of Nanchuan River, which also leads to the outbreak of algae blooms in landscape water.

4. Conclusion and management measures

4.1 Conclusion

(1) Based on the algae density, the risk area of bloom in the west section of Hecheng in Nanchuan is judged. Except for 0#, the risk of bloom exists in several other pools, and the algae density is \( \geq 5.0 \times 10^7 \) L\(^{-1}\). According to the evaluation and classification criteria of bloom, the bloom degree belongs to moderate bloom.

(2) According to the identification of aquatic organisms, several kinds of bloom algae were detected in the west section of Nanchuan Hecheng, mainly chlorophyta and diatomata. The main environmental factor was temperature. Except for pools 0#, 2# and 12#, the temperature of all other pools was \( > 20^\circ C \). The total phosphorus concentrations in the main landscape ponds were all \( > 0.03 \text{mg/L} \). There were 66 species of zooplankton, including 22 protozoa, 29 rotifers, 9 cladoceras and 6 copepods. Due to the species diversity of zooplankton, algal bloom growth was also promoted to some extent.

4.2 Prevention and Control Measures

(1) Rationally regulate water flow rate and renewal cycle, improve hydrodynamic conditions and improve water self-purification capacity. Water environmental capacity, as a critical control condition for water pollutant discharge, is the basis for achieving water quality standards. Water characteristics, especially hydrodynamic conditions, determine to a large extent the dilution and diffusion capacity of water for pollutants. Some measures should be taken to keep the water flow rate and water renewal cycle in the west section of Nanchuan River in a reasonable range.

(2) Strengthen the dynamic monitoring and early warning of the water temperature and algae in the landscape pool in the west section of Nanchuan River City during the highly sensitive period, issue early warning signals in time to prevent the occurrence of algae blooms, control the change trend in the high-risk period of bloom outbreak in real time, and issue early warning information to the management department in time.

(3) To explore the research and development of environmentally friendly algae inhibitors, and provide emergency technologies for coping with extreme situations. In order to ensure the rapid and efficient removal of algal bloom during the outbreak period of Nanchuan River in Xining city, it is necessary to consider the development of rapid and efficient emergency cyanobacteria inhibitors suitable for algal bloom management in river channels. According to the survey results of phytoplankton, the dominant algae in the scenic pool of the western section of the city is diatom, which is also the dominant species of algae blooms in China at present. Therefore, there are many kinds of algae inhibitors on the market. However, even if the same algae is affected by meteorological and hydrological conditions and the primary environment, its growth-propagation-eruption-death succession conditions may be different. Therefore, several existing ecological algal inhibitors with good algal inhibition effect (such as chitosan modified clay, barley straw, etc.) were selected to conduct experiments on this algal species, so as to find the best concentration of different inhibitors to inhibit or remove algal bloom, and thus provide technical support for emergency management.

(4) To carry out the investigation of water ecology and water environment before and after desilting, to provide a basis for sediment desilting and treatment projects. In the One river one policy managed by the west section of Nanchuan River, it is required to desilting once every two years, and carry out a comprehensive investigation and monitoring of the water ecological environment of each landscape pool before and after the next desilting, so as to provide a basis for the sediment desilting and treatment project. Research on the spatial optimal allocation of sediment transport and soil and water conservation measures in the whole basin is carried out to provide scientific basis for the continuous realization of the goal of "clean water and green bank". Since sediment carried in the upper reaches is the main source of sediment in the west section of Nanchuan River, and the river body has natural hydraulic connections between main and tributaries, upstream and downstream, and left and right banks, it is necessary to conduct a systematic investigation and study on sediment production and sediment transport from the perspective of the whole basin in order to control sediment deposition and sediment pollution in the landscape pool of the west section of Nanchuan River. To avoid the long-term loss caused by fragmented management.

References

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