Phytoplankton Community Investigation and Water Quality Assessment of M River in winter in Shijiazhuang City

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Abstract. An investigation of phytoplankton community and water quality for M River was conducted in December 2019. The results showed that 38 species of phytoplankton belonging to 6 phyla and 26 genera were collected. Among them, Bacillariophyta is the richest species, which accounted for 34.21%, followed by Cyanophyta with 26.32% and Chlorophyta with 28.95%. The density of phytoplankton was 63.0×10^6 inds/L which indicated as eutrophic water body. The highest density was Bacillariophyta, accounting for 51.03%. The Shannon-Wiener diversity index (H') varied from 1.34 to 2.24, the Margalef Species diversity index (d) varied from 2.71 to 3.85, and the Pielou evenness index (J) varied from 0.38 to 0.67. According to the integrative analysis results of H' , d and J , M River water quality belongs to oligo-polluted, but individual sites belong to meso-polluted.

1 Introduction

The survival of aquatic organisms is closely related to the water environment quality, and the composition of species and their proportion in the community can reflect the water quality^[1]. Phytoplankton forms the basic link in the food chain of an aquatic ecosystem and virtually all the dynamic features of lakes such as color, clarity, trophic state, zooplankton, and fish production depend to a large extent on the phytoplankton. Freshwater communities are very much sensitive to environmental variables^[2]. The number of species, dominant species and diversity index of phytoplankton community varied greatly in the water environment with different nutrition levels, which often become a biological index of water environmental monitoring and eutrophication^[3-4].

There have been many studies on phytoplankton community investigation and water quality evaluation on surface rivers and watersheds. An investigation was carried out in the Shanxi section of Xiaolangdi Reservoir from May 2014 to November 2015, the result showed that water body of Xiaolangdi Reservoir belongs to medium eutrophication level^[5]. Phytoplankton community investigation and water quality evaluated were conducted in the three typical waters of Baiyangdian Lake from April to November in 2013, the conclusion is phytoplankton distribution was significantly affected by three environment factors^[6]. However, there is little research on water quality evaluation for the M River. In this paper, the phytoplankton community constitute and water quality evaluation in M River were carried out in December 2019.

Results of phytoplankton composition together with water quality parameters are reported, which provided the basic data for the ecological environment management.

2 Material and method

2.1 Overview of the study area

M River is located in Shijiazhuang City, Hebei Province, a total length of 56.9 kilometers. It is divided into the east, west, south, north and center five rivers around the city, east line for Century Park, west line for Zhongshan Park, south line for the Ouyun Park, north line for Pearl Park, center line for Binhe Park. In turn named S1, S2, S3, S4, S5. The water system of this river is city landscape water body. In recent years, human activities have made a significant impact on the ecological environment of M River. Therefore, it is necessary to know the water quality of the M River to control and prevent water pollution. In December 2016, samples were collected and analyzed in the S1, S2, S3, S4, S5 (Fig.1).

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Fig.1 Sampling sites in M River

Tab.1 Latitude and longitude of sampling point

Point	Latitude	Longitude
S1	38.020753°N	114.533908°E
S2	38.067455°N	114.431105°E
S3	38.016171°N	114.504844°E
S4	38.083076°N	114.478397°E
S5	38.000818°N	114.463152°E

2.2 Phytoplankton samples

The samples for phytoplankton analysis were collected using 5L plexiglass water harvesting device at the depth of 0~0.5m. 4% formalin were then added to the phytoplankton samples for longer preservation^[7-8]. Before taxonomic analyses and species enumeration, the samples for phytoplankton analysis were stored in the dark in evacuated 4 L flasks and allowed to supernate for 48 h^[9]. According to “The Freshwater Algae of China: Systematics, Taxonomy and Ecology” and “Freshwater plankton map”, phytoplankton species were identified and counted^[10-11]. All phytoplankton samples were analyzed by the same investigator. The count was counted twice and the density of the phytoplankton was calculated by the following formula:

$$N(\text{inds}/L) = \frac{\text{average number}}{80} \times 400 \times 10^4 \times \frac{3}{50} \times 1000 \quad (1)$$

After phytoplankton qualitative and quantitative analysis, the phytoplankton community characteristics in Minxin River were analyzed by Dominance index (Y), Shannon-Wiener diversity index (H'), Margalef Species diversity index (d) and Pielou evenness index (J). Assessment criterion of each index were showed in Tab.2. The calculation formula is as follows:

$$Y = \frac{N_i}{N} \times f_i \quad (2)$$

$$H' = -\sum_i^s p_i \ln p_i \quad p_i = \frac{N_i}{N} \quad (3)$$

$$d = (S - 1) / \ln N \quad (4)$$

$$J = H' / \ln S \quad (5)$$

N_i ——the number of individuals of the i -th species;

N ——the total number of all species; f_i is the frequency of the i -th species at each sation;

S ——the total number of species.

The evaluation criteria of each index are shown in Tab.2.

Tab.2 Assessment criterion of each index

Index	Range	Criterion
Y	≥ 0.02	dominant species
H'	0	serious pollution
	0-1	heavy pollution
	1-2	meso-polluted
	2-3	oligo-polluted
	>3	clean
J	0-0.3	heavy pollution
	0.3-0.5	meso-polluted
	0.5-0.8	oligo-polluted
	>0.8	clean
d	0-1	serious pollution
	1-2	heavy pollution
	2-3	meso-polluted
	3-4	oligo-polluted
	>4	clean

3 Results and discussion

In December 2019, a total of 38 species, 26 genera and 6 phyla of phytoplankton in M River were identified. The composition and percentage of phytoplankton species are shown in Tab.3. Percent composition of different phytoplankton community density in Fig.2. The list of dominant species were showed in Tab.4. Statistical results of phytoplankton community density were showed in Tab.5. The results of Shannon-Wiener diversity index (H'), Margalef Species diversity index (d) and Pielou evenness index (J) were showed in Fig.3.

Tab.3 Phytoplankton species composition in M River

Phyla	Genus(inds)	Species	Percent
Bacillariophyta	8	13	34.21
Cyanophyta	7	10	26.32
Chlorophyta	7	11	28.95
Euglenophyta	2	2	5.26
Chrysophyta	1	1	2.63
Xanthophyta	1	1	2.63
Total	26	38	100

Fig.2 Percent composition of different phytoplankton community density**Tab.4** The list of dominant species

Site	Dominant species	Occurrence frequency(%)	Dominance index (Y)
S ₁	<i>Synedra sp</i>	79.2	0.042
S ₂	<i>Navicula sp</i>	74.3	0.039
S ₃	<i>Synedra sp</i>	81.4	0.043
	<i>Oscillatoria sp</i>	75.2	0.039
S ₄	<i>Nitzschia sp</i>	73.1	0.038
S ₅	<i>Ulothrix sp;</i>	76.3	0.040

Tab.5 Statistical results of phytoplankton community density in M River (Unit: inds /L)

Site	Total density	Bacillariophyta density	Cyanophyta density	Chlorophyta density	Euglenophyta density	Chrysophyta density	Xanthophyta density
S ₁	7.0×10^6	4.2×10^6	1.2×10^6	1.2×10^6	0	0.4×10^6	0
S ₂	7.1×10^6	5.1×10^6	0.8×10^6	0.6×10^6	0.4×10^6	0	0.2×10^6
S ₃	29.1×10^6	10.8×10^6	8.4×10^6	9.6×10^6	0.3×10^6	0	0
S ₄	10.5×10^6	6.6×10^6	0.9×10^6	2.7×10^6	0	0.2×10^6	0.1×10^6
S ₅	9.3×10^6	5.4×10^6	0.6×10^6	3.0×10^6	0.2×10^6	0	0.1×10^6
Total	63×10^6	32.1×10^6	11.9×10^6	17.1×10^6	0.9×10^6	0.6×10^6	0.4×10^6

It can be seen from Tab.4 that there are five kinds of dominant species, including *Bacillariophyta Synedra sp*, *Navicula sp* and *Nitzschia sp*, *Chlorophyta Ulothrix sp*, *Cyanophyta Oscillatoria sp*.

The composition of phytoplankton species mainly is Bacillariophyta, Cyanophyta and Chlorophyta. Bacillariophyta is the richest species of algae, which accounted for 34.21% (Tab.3). The percentage of Cyanophyta and Chlorophyta in the number of species was similar, accounted for 26.32% and 28.95% (Tab.3), respectively. It can be seen from Tab.5 that the density of Bacillariophyta was the largest at 32.1×10^6 , accounting for 50.95% of the total density of phytoplankton, followed by Chlorophyta (27.14%) (Fig.2). Bacillariophyta density was greatest at all sampling sites (Tab.5). Therefore, Bacillariophyta not only occupies an advantage in the number of species, but also occupies a certain advantage in density (Tab.3 and Fig.2). The phytoplankton density of S₃ is the largest, accounted for 46.19% of the total phytoplankton, followed by S₄ (16.67%) and S₅ (14.76%). The total density of phytoplankton was 63.0×10^6 inds/L. According to the evaluation criteria of lake eutrophication^[12], M River belongs to an eutrophic water body, there may be some influence on the composition and distribution of phytoplankton species. In recent years, a large amount of organic pollutants containing nitrogen and phosphorus are discharged into the M River, the degree of water quality eutrophication is aggravated, which directly affects the urban water quality. In general, there is a clear positive correlation between nutrient concentration and biomass in lakes. Algae have some indication effect on water quality^[13].

Fig.3 Diversity index of the phytoplankton in M River

As can be seen from Fig.3, Shannon-Wiener diversity index of all sites were between 1-2, which indicate that the water quality is meso-polluted. Pielou evenness index of S_1 and S_2 were between 0.5 and 0.8, which indicate that the river is oligo-polluted, but S_3 , S_4 and S_5 were meso-polluted whose index in the range of 0.3-0.5. Margalef Species diversity index of all sites were between 3-4, which indicate that the water quality is oligo-polluted, but S_3 were meso-polluted whose index were between 2 and 3. The change trend of Shannon-Wiener diversity index, Margalef Species diversity index and Pielou evenness index are basically consistent, all of which are the lowest in S_3 . This close relationship between them is reflected in ecological processes such as predation, competition and succession^[14]. Among all the sampling sites, S_3 is the most serious pollution. In summary, the M River water quality is meso-polluted.

4 Conclusions

The main types of phytoplankton in the M River include Bacillariophyta (34.21%), Cyanophyta (26.32%) and Chlorophyta (28.95%). The total density is 63.0×10^6 inds/L of phytoplankton, it is indicated that the M River belongs to eutrophic water body. According to the integrative analysis result of Shannon-Wiener diversity index, Margalef Species diversity index and Pielou evenness index, M River water quality belongs to meso-polluted, but individual sites belong to oligo-polluted.

Acknowledgments

This research was supported by National natural science foundation (41373096), National environmental protection issues (201509041-05), natural science foundation of Hebei Province (B2014208068), Hebei Provincial Environmental Protection Bureau of public issues, Hebei Province pharmaceutical molecular chemistry laboratory open fund and Hebei Province key discipline construction fund project funded.

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