E3S Web of Conferences **267**, 01026 (2021)
ICESCE 2021

https://doi.org/10.1051/e3sconf/202126701026

Relationship between water quality assessment and phytoplankton community structure of M River in Shijiazhuang City

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Abstract. On the basis of the "Environmental quality standard for surface water" (GB 3838-2002) in China, eight water quality indexes were measured in M River, including pH, water temperature (T), transparency (SD), dissolved oxygen (DO), chemical needs Oxygen (COD), ammonia nitrogen (NH_3-N), total nitrogen (TN), total phosphorus (TP). Using the single factor index method, it is concluded that the water pollution of M River is serious and the water quality is beyond Grade V of water environment standard. Moreover some indexes of the water quality meet with the standard level, including COD, NH_3-N, TN and TP. The Pearson correlation analysis is conducted between water quality indexes and phytoplankton community parameters. 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). H' and TN was a significant positive correlation (r = 0.923, P <0.05); J and COD was a significant positive correlation (r = 0.918, P <0.05); There was a very significant negative correlation between d and water temperature (T), COD, NH_3-N, TN (r =-0.881, P <0.01; r =-0.983, P <0.01; r =-0.893, P <0.01; r=-0.962, P<0.01). The result of the research indicates that T, COD, NH_3-N and TN are main water quality indexes affecting phytoplankton community structure.

1 Introduction

At present, most physical and chemical indexes and biological indexes are used to evaluate surface water quality at home and abroad. 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 (Herong et al., 2016). Phytoplankton taking as an important component of aquatic ecosystem plays an important role in regulating the structure and function of ecosystems by participating in material circulation and energy flow in lake, and plays a direct role in lake pollution and purification (Lijin et al., 2014).

To understand the phytoplankton community structure and the water quality state in Huaihe River Basin, phytoplankton samples were collected in the basin in May 2013, the result showed that the phytoplankton diversity index was low and most sites were in a medium-heavy pollution state (Zhu Weiju et al., 2017). Suikkanen investigated relationships between the late summer biomass of different phytoplankton taxa and environmental factors in two areas of the Baltic Sea, the northern Baltic proper and the Gulf of Finland, the result

indicated that summer temperature and winter dissolved inorganic nitrogen concentration were the most important factors with respect to changes in the phytoplankton community structure (Suikkanen S et al. 2007). 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.
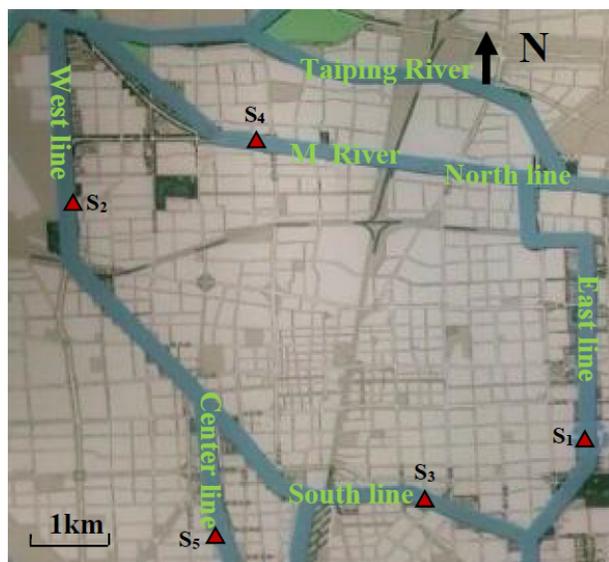
2 Materials and Methods

2.1 Overview of the study area

M River is located in Shijiazhuang City, Hebei Province, a total length of 56.9 kilo meters. It is divided into the east, west, south, north and centre 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, centre line for Bin-he 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

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River. Therefore, it is necessary to know the water quality of the M River to understand the growth of phytoplankton. In December 2019, samples were collected and analyzed in the S1, S2, S3, S4, S5 (Fig.1).

Fig.1 Sampling sites in M River
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 Water quality indicators

According to the basic indexes in "Environmental quality standard for surface water"(GB 3838-2002) and taking into account the water quality monitoring data, eight water quality indexes were measured, including pH, water temperature (T), transparency (SD), dissolved oxygen (DO), chemical needs Oxygen (COD), ammonia nitrogen (NH$_3$-N), total nitrogen (TN), total phosphorus (TP). The collection and analysis of samples refer to the relevant requirements for the Technical Specifications for Monitoring Surface Water and Wastewater (HJ/T 91-2002) and the State Environmental Protection Administration Water and Wastewater Monitoring and Analysis Method (Fourth Edition). In this paper, the single factor index method was used to evaluate the water quality and pollution degree (Baixue, 2014). According to Grade V of water environment standard, exceed multiple was calculated (Wei Jingchi, 2014). The standard value was showed in Tab.1. Single factor index method was calculated by the following formula:

$$I_i = \frac{C_i}{S_i} \qquad (1)$$

Where: I_i is single factor index; C_i is the observed value of the i-Th evaluation factor in the exceeded, $I_i < 1$ meet the standard.

Tab.1 The standard value of eight water quality indexes

indexes	pH	T (°C)	SD (cm)	DO (mg/L)	COD (mg/L)	NH$_3$-N (mg/L)	TN (mg/L)	TP (mg/L)
value	6-9	-	-	2	40	2.0	2.0	0.4

3 Results and discussion

3.1 Results of water quality indexes

The results of the water quality index in each sampling sites of the M River in December 2019 were showed in Tab.2.

Tab.2 The results of the water quality index in M River

Site	pH	T (°C)	SD (cm)	DO (mg/L)	COD (mg/L)	NH$_3$-N(mg/L)	TN (mg/L)	TP (mg/L)
S$_1$	8.00	7	88	9.39	27.53	0.83	1.26	0.37
S$_2$	8.02	6	68	8.12	25.91	1.08	1.34	0.24
S$_3$	7.77	8	57	6.27	54.01	2.31	2.84	0.64
S$_4$	7.51	7	76	8.34	43.88	1.76	2.12	0.52
S$_5$	7.47	8	83	7.45	38.82	1.12	1.69	0.32

Compared Tab.1 with Tab.2, we can see that the pH is within the acceptable limit of 7.47~8.02, T were between 6~8°C, SD were between 57 and 88cm. Among them, S3 transparency is the lowest. DO were in the range of 6.27~9.39 mg/L, the values of DO is within the acceptable limit. COD in S3 and S4 exceeds the "Environmental quality standard for surface water" Grade V, exceed multiple are 0.35 and 0.10, respectively. NH$_3$-N in S3 is

exceeded, exceed multiple are 0.16. TN in S3 and S4 is exceeded, exceed multiple are 0.42 and 0.06, respectively. TP in S3 and S4 exceeded, exceed multiple are 0.60 and 0.30. In general, NH$_3$-N, TN, COD and TP in S3 are all beyond permissible limits. TN, COD and TP in S4 are all beyond permissible limits. S3 and S4 is close to the public, there are domestic waste and sewage discharged into the M River. The above results showed that water quality is

beyond Grade V of water environment standard. Some indexes of the water quality are beyond the standard level, including COD, NH₃-N, TN and TP. This result is consistent with the research of other scholars. Such as the research of the structure of phytoplankton community and relationship between phytoplankton community and water quality in Taihu Lake (Lidi et al.2014). The results found that the principal pollutant was total nitrogen, secondly total phosphorus, thirdly chemical oxygen demand.

3.2 Pearson correlation analysis between eight water quality indexes and the phytoplankton community parameters

The Pearson correlations analysis between eight water quality indexes and phytoplankton community parameters of M River were showed in Tab.3.

From Tab.3 we can see that T, COD, NH₃-N and TN were significantly correlated with phytoplankton community parameters. Our study found that the density of Bacillariophyta was a very significant positive correlated with COD, NH₃-N and TN ($r = 0.902$, $P < 0.01$; $r = 0.960$, $P < 0.01$; $r = 0.969$, $P < 0.01$). The species numbers of Cyanophyta also were a very significant positive correlated with COD, NH₃-N and TN ($r = 0.956$, $P < 0.01$; $r = 0.971$, $P < 0.01$; $r = 0.965$, $P < 0.01$). The density of Chlorophyta was a significant positive correlated with COD, NH₃-N and TN ($r = 0.901$, $P < 0.05$; $r = 0.880$, $P < 0.05$; $r = 0.935$, $P < 0.05$). There was a very significant positive correlation between water temperature and the species number of Chlorophyta ($r = 0.963$, $P < 0.01$). H' and TN was a significant positive correlation ($r = 0.923$, $P < 0.05$). J and COD was a significant positive correlation ($r = 0.918$, $P < 0.05$). There was a very significant negative correlation between d and T, COD, NH₃-N, TN ($r = -0.881$, $P < 0.01$; $r = -0.983$, $P < 0.01$; $r = -0.893$, $P < 0.01$; $r = -0.962$, $P < 0.01$).

Tab.3 The results of Pearson correlation analysis between eight water quality indexes and phytoplankton community parameters

Indexes		pH	T	SD	DO	COD	NH₃-N	TN	TP
Bacillariophyta	density	-0.215	0.539	-0.834	-0.852	**0.902****	**0.960****	**0.969****	0.859
	species	-0.158	-0.105	-0.406	-0.693	0.504	0.678	0.571	0.715
Cyanophyta	density	0.072	0.516	-0.774	-0.756	0.746	0.812	0.839	0.783
	species	-0.554	0.519	-0.684	-0.757	**0.956****	**0.971****	**0.965****	0.858
Chlorophyta	density	-0.241	0.713	-0.703	-0.851	**0.901***	**0.880***	**0.935***	0.843
	species	-0.770	**0.963****	-0.150	-0.664	0.844	0.590	0.720	0.630
Euglenophyta	density	0.292	-0.134	-0.689	-0.610	0.012	0.164	0.131	-0.210
	species	-0.032	-0.218	0.082	-0.102	-0.442	-0.483	-0.471	-0.784
Chrysophyta	density	0.266	-0.200	0.654	0.819	-0.362	-0.388	-0.392	0.010
	species	-0.532	-0.134	0.073	0.206	0.280	0.314	0.232	0.355
Xanthophyta	density	0.309	-0.869	-0.255	0.203	-0.439	-0.157	-0.323	-0.442
	species	0.032	0.218	-0.082	0.102	0.442	0.483	0.471	0.784
H'		-0.240	0.756	-0.438	-0.590	0.857	0.787	**0.923***	0.859
J		0.622	-0.533	0.653	-0.775	**0.918***	-0.726	-0.754	-0.442
d		0.513	**-0.881****	0.561	-0.809	**-0.983****	**-0.893****	**-0.962****	0.812

Note: ***** indicates significant correlation, $P < 0.05$; ****** indicates very significant correlation, $P < 0.01$.

During the survey period, the weather in December was bright and the light was strong. Coupled with appropriate environmental conditions such as no precipitation and low water level, algae in dormancy quickly multiplied and a large number of phytoplankton gathered. COD can reflect the degree of organic pollution of water bodies, NH₃-N and TN content can indicate the state of eutrophication and pollution degree, and many species of algae have a greater correlation with T, COD, NH₃-N and TN, which has an impact on the distribution of algae. The above results showed that the distribution of phytoplankton is affected by environmental factors such as T, COD, NH₃-N and TN. This is also consistent with the previous researches. Through correlation analysis of phytoplankton community and water quality found that water temperature, transparency, total nitrogen, chemical oxygen demand were main factors that influenced phytoplankton community structure in Taihu Lake (Lidi et al.2014); The spatial distribution and assemblage structure of phytoplankton were carried out during August 2011 and May 2012 respectively in Jinzhou Bay, the analysis results indicated that nitrate concentrations and water temperature was the most important influencing factor in summer and spring respectively (Fu Mingzhu et al., 2014); San-men bay were studied based on the data-set of our field investigation in spring 2014 using multivariate statistical techniques, the controlling factors influencing the phytoplankton community were salinity, water temperature, dissolved oxygen, dissolved inorganic nitrogen and suspended solid in spring (Chen Danqin et al., 2017); The scholars were examine the community structure of phytoplankton and the associated environmental factors in Lake Changhu in the summer of 2012 (Chaiyi et al. 2014), correlation analysis suggested that the total nitrogen, total suspended solids, total phosphorus, dissolved oxygen and nitrite nitrogen were

the main environmental factors affecting the spatial distribution of phytoplankton community.

4 Conclusions

Water quality is beyond Grade V of water environment standard. Moreover, some indexes of the water quality meet with the standard level, such as COD, NH_3-N, TN and TP. Correlation analysis between water quality indexes and phytoplankton community parameters indicated that T, COD, NH_3-N and TN are the main water quality indexes affecting the phytoplankton community structure in M River.

Acknowledgments

References

1. Herong, Jiangli, Zheng Shuming, Zhou Yanling, Zou Shenjuan, Dingshan. Phytoplankton community structure and water quality assessment in Longtan River of Three-Gorges Reservoir [J]. Journal of Hydro ecology, 2016, (04):30-35.

2. Lijin, Ji Fenfen, Hua Jianghuan. Community structure of phytoplankton and the water quality assessment in spring in Lake Ci[J]. Journal of Hubei Normal University (Natural Science), 2014, (03):1-7.

3. Suikkanen S, Laamanen M, Huttunen M. Long-term changes in summer phytoplankton communities of the open northern Baltic Sea[J]. Estuarine Coastal & Shelf Science, 2007, 71(3-4):580-592.

4. Zhu Weiju, Pang Wanting, You Qingmin, Wang Quanxi. Phytoplankton community structure and the evaluation of water quality in spring, Huaihe River Basin[J]. Journal of Lake Sciences, 2017, 29 (3): 637-645.

5. Han M S. Freshwater plankton map[M]. Beijing: Agricultural Press, 1980.

6. Editorial board of water and wastewater monitor the analytical method, State Environmental Protection Administration. Water and wastewater monitor the analytical method (4th edition). Beijing: China Environmental Science Press, 2002.

7. Baixue. Evaluation of Surface Water Quality of Shijiazhuang City in 2013[J]. Journal of Hebei Engineering and Technical College, 2015, (01):10-14.

8. Wei Jingchi. Study of surface water and underground water pollution in Xiao River basin [J]. Hebei Journal of Industrial Science and Technology, 2014, 31(5): 407-411.

9. Li Di, Li Xuwen, Niu Zhichun, Wang Xia, Shi Wei, Yu Hongxia. Structure of Phytoplankton Community and Relationship between Phytoplankton Community and Water Quality in Taihu Lake [J]. Ecology and Environmental Sciences, 2014, 23(11): 1814-1820.

10. Fu M Z, Sun P, Sun X, Wei Q S, Zhang X L, Wang Z L, Phytoplankton community structure and its ecological responses to environmental changes in Jinzhou Bay, China. Acta Ecological Sinical, 2014, 34(13): 3650-3660.

11. Chen Danqin, Yeran, Wei Yongjie, Yu Haibo, Yangqing, Wang Yuchu, Liao Yougen. Correlation between phytoplankton community and environmental variables in Sanmen bay, East China Sea[J]. Marine Environmental Science, 2017,36(01):70-75+86.

12. Chaiyi, Pengting, Guokun, He Yongfeng, Yang Deguo, Luo Jingbo. Community characteristics of phytoplankton in Lake Changhu and relationships with environmental factors in the summer of 2012[J]. Chinese Journal of Plant Ecology, 2014, 38 (8): 857-867.