Eutrophication Evaluation and Influencing Factors of Daheiting Reservoir

Lihui Cao[1,2][a], Xubo Lv[2][b], Kun Lei[2][c], Libiao Yang[2,*][d] and Dianwu Wang[1,*][e]
[1]*College of resources and Environmental Sciences, Hebei Agricultural University, Baoding, Hebei, 071000, China*
[2]*Chinese Academy of Environmental Sciences, Beijing, 100012, China*

Keywords: Eutrophication, Evaluate, Factors, Daheiting Reservoir.

Abstract: Taking Daheiting Reservoir as an example, the water quality changes were studied by investigation and field sampling, and the water eutrophication and the main influencing factors were evaluated and analyzed in view of the gradually serious eutrophication of the water body in China. And the results were shown as below: DO concentration did not reach class II water standards only in the dry season. TN was inferior to class V in dry and normal season, and class IV in wet season; TP water quality was inferior to class V in dry and normal season, class III in July in wet season and not exceed the standard in August in wet season. COD_{Mn} exceeded the standard only during normal and wet water periods in August, and the water quality was class III. In dry season, the water body was slightly eutrophic; in normal water period, the water body was slightly to moderately eutrophic; in the wet season, the water body was slightly eutrophic in July and moderately eutrophic in August. Principal component analysis showed that temperature, nitrogen and phosphorus nutrients were the main influencing factors and do, pH and COD_{Mn} were the main manifestation factors of water eutrophication.

1 INTRODUCTION

Reservoirs were one of the important sources of urban drinking water in China. However, most reservoirs have a series of problems, such as short water exchange cycle, high basin erosion intensity and anti seasonal fluctuation, which lead to great instability of reservoir water quality and potential risks of water environment (Da, 2020; Wang,2010). The problem of water eutrophication was preliminarily explored in the early 20th century (Poikane, 2014), now it has become the focus of attention. Water eutrophication destroys aquatic ecosystems all over the world, foreign countries began to investigate lake eutrophication in the 1960s, and established relevant evaluation and prediction models. Due to its complex mechanism, wide range and difficult treatment, it has become a hot spot of water ecological security (Qin, 2010, Lu, 2003). The intensification of water eutrophication not only has an adverse impact on social harmony and stability, but also does serious harm to people's production and life. Therefore, scientific and reasonable water quality evaluation and determination of water eutrophication status were of great practical significance for water pollution control and water environment management planning (Meyer-Reil, 2000, Liu, 2020).

In November 2016, April, July and August 2017, this paper monitored 10 indicators including water temperature, total nitrogen, total phosphorus, active phosphate and Chl.a, evaluated water eutrophication, and clarified the main influencing factors of water eutrophication, in order to provide a theoretical basis for water pollution control of Daheiting reservoir.

[a] https://orcid.org/0000-0003-0903-4621
[b] https://orcid.org/0000-0002-5392-5897
[c] https://orcid.org/0000-0001-8343-3087
[d] https://orcid.org/0000-0002-7444-5112
[e] https://orcid.org/0000-0003-3408-6992

Cao, L., Lv, X., Lei, K., Yang, L. and Wang, D.
Eutrophication Evaluation and Influencing Factors of Daheiting Reservoir.
DOI: 10.5220/0011197700003443
In *Proceedings of the 4th International Conference on Biomedical Engineering and Bioinformatics (ICBEB 2022)*, pages 244-248
ISBN: 978-989-758-595-1

2 MATERIALS AND METHODS

2.1 Overview of the Study Werea

Daheiting reservoir, located in Qianxi County, Tangshan City, is one of the backbone projects of Luanhe River Diversion Project Group. The inflow rivers mainly include Luanhe main stream, Sahe River, etc. The region has a warm temperate continental semi humid monsoon climate with four distinct seasons and obvious dry and wet seasons. The average annual temperature is 10.1 ℃, the average annual precipitation is 804.2mm, the total storage capacity is 337 million m3 and the effective storage capacity is 224 million m3. The normal pool level is 133.0m and the dead water level is 121.5m. It is a large type II annual regulation reservoir. 15 sampling points were evenly arranged in the water werea from dam front to reservoir tail in Daheiting reservoir werea, as shown in Figure 1. The water quality sampling time is November 2016 (dry season), April 2017 (normal season), July and August 2017 (wet season).

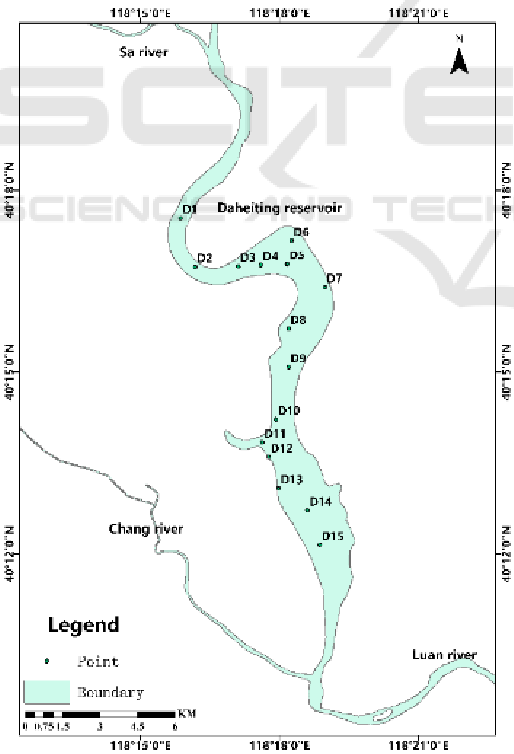

Figure 1: Schematic diagram of sampling points in Daheiting reservoir.

2.2 Evaluation and Analysis Method

2.2.1 Water Sample Collection and Monitoring

The water sample is collected with a 2L stainless steel water collector, put into a 500ml Brown reagent bottle, and immediately add concentrated H_2SO_4 for acidification and preservation. The water temperature and dissolved oxygen are measured by YSI multi parameter water quality detector, the transparency is measured by plug plate, the pH is measured by portable water quality analyzer, and the temperature, transparency and pH value are recorded on site. Other indexes shall be determined according to the fourth edition of monitoring and analysis methods for water and wastewater (P A, 2002).

2.2.2 Evaluation Method

Carlson comprehensive nutritional status index (TLI) method is used for evaluation, and the calculation formula is:

$$\mathrm{TLI}(\sum) = \sum_{j=1}^{n} Wj \cdot TLI(j)$$

Where, TLI (∑) is the comprehensive nutritional status index, WJ is the relevant weight of the nutritional status index of the j-th parameter, TLI (J) is the nutritional status index of the j-th parameter, and N is the number of evaluation parameters.

The comprehensive nutritional index TLI < 30 is poor nutrition, 30 ≤ TLI ≤ 50 is medium nutrition, 50 < TLI ≤ 60 is mild eutrophication, 60 < TLI ≤ 70 is moderate eutrophication, and TLI > 70 is severe eutrophication.

3 RESULTS & DISCUSSION

3.1 Water Quality Analysis of Daheiting Reservoir

The water quality was evaluated according to the environmental quality standard for surface water (GB3838-2002). In November 2016, the average concentration of do was 4.805 mg/L, which was class IV water, and did not exceed the standard in other periods; The average concentration of PO_4^{3}-P was 0.288 mg/L at the beginning of the study period, and gradually decreased to 0.005 mg/L at the end of the study period. The mean values of TN concentrations in the four periods were 2.541, 3.508, 1.184 and 1.374 mg/L respectively, exceeding the standard by 5.08, 7.02, 2.36 and 2.74 times respectively; In November 2016, April 2017 and July 2017, the average TP concentration was 0.268, 0.217 and 0.047 mg/L respectively, exceeding the standard by 10.72, 8.68 and 0.88 times respectively. In August, TP did not exceed the standard, and the water quality was upgraded from inferior class V to class II water; NH3-N concentration did not exceed the standard in four periods. In April and August 2017, the average COD_{Mn} concentration was 5.308 and 5.639 mg/L respectively, exceeding the standard by 1.33 and 1.41 times respectively. In other periods, it did not exceed the standard, and the water quality was class III water.

3.2 Eutrophication Evaluation of Daheiting Reservoir

The eutrophication state of Daheiting reservoir in dry season is shown in Figure 2, the comprehensive trophic state index ranges from 47.46 to 58.49, with an average of 51.58. 25% of the water bodies belong to mesotrophic state, 75% of the water bodies were slightly eutrophic, and the comprehensive trophic state is evaluated as slightly eutrophic. The normal water period can be seen from Figure 3, the comprehensive nutritional status index ranges from 54.80 to 63.01, with an average of 58.33. 100% of the water body reaches the degree of eutrophication, and the comprehensive nutritional status is evaluated as mild to moderate eutrophication. In the wet season in July, the comprehensive nutritional status index ranges from 47.32 to 54.80, with an average of 51.17. 37.5% of the water bodies belong to mesotrophic status, 62.5% of the water bodies belong to mild eutrophication, and the comprehensive nutritional status is evaluated as mild eutrophication; In August, the comprehensive nutritional status index ranged from 43.93 to 58.51, with an average of 46.47. 66.7% of the water bodies were in mesotrophic status, 33.3% of the water bodies were in mild eutrophication, and the comprehensive nutritional status was evaluated as mesotrophic. Xue et al. (Yun, 2020) found that the eutrophication degree of Dongting Lake decreased successively in summer, autumn, spring and winter, and Dongting Lake was mainly in medium trophic state. In the study on eutrophication evaluation of dajinzhong reservoir, Wang et al. (Wang, 2019) found that the overall water quality of the reservoir is in a slightly eutrophic state, and individual wereas were in a moderately eutrophic state, and the comprehensive nutritional state index is related to the wet season and dry season, and the comprehensive nutritional state index is high in the wet season. In this study, It may be that the tributary pollutants enter the reservoir werea, resulting in the accumulation of pollutants, and the concentration of TN and TP exceeds the standard seriously, resulting in the aggravation of the degree of eutrophication. With the continuous discharge of water from the reservoir and the influence of rainfall, the concentration of TN and TP gradually decreases until the TP concentration does not exceed the standard in the wet season, and the comprehensive nutritional state of the reservoir water is medium nutrition.

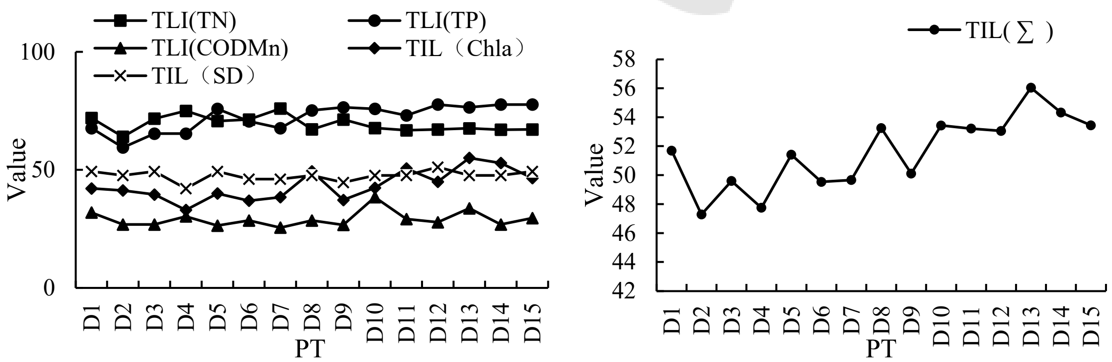

Figure 2: Eutrophication status of Daheiting reservoir in November 2016.

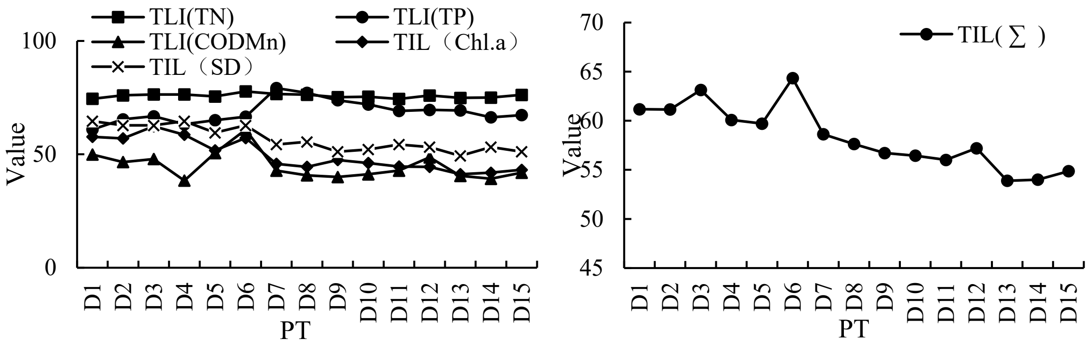

Figure 3: Eutrophication status of Daheiting reservoir in April 2017.

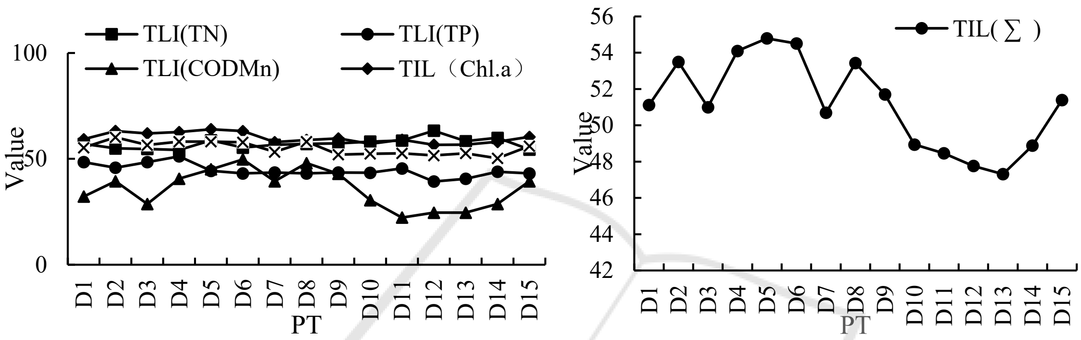

Figure 4: Eutrophication status of Daheiting reservoir in July 2017.

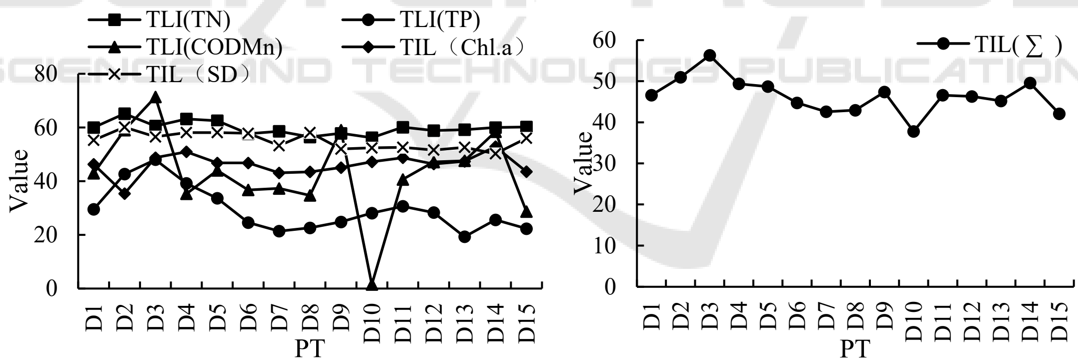

Figure 5: Eutrophication status of Daheiting reservoir in August 2017.

3.3 Analysis on Influencing Factors of Water Eutrophication in Daheiting Reservoir

Chl. a is a representative indicator of planktonic algae biomass, so we focus on the correlation between Chl. a concentration and other environmental factors. According to the order of correlation degree, it is DO, SD, PO_4^{3}-P, temperature, pH, TN, TP and COD_{Mn}. Chl. a has a very significant correlation with do, SD, PO_4^{3}-P, temperature, pH, TN and TP, indicating that TN, TP and PO_4^{3}-P were the main nutritional factors for the growth of planktonic algae, and DO, SD, temperature and pH were the main environmental factors for the growth of planktonic algae. Tab 1 shows,the cumulative contribution rate of the three principal components is 86.193%, the contribution rate of F1 is 39.435%, the contribution rate of F2 is 34.279%, and the contribution rate of F3 is 12.479%. Tab 2 shows, the load values of temperature, TN, TP and PO_4^{3}-P on F1 were large, so F1 can be characterized by temperature and nitrogen and phosphorus content. The load values of do and pH on

F2 were large, and only the load value of COD_{Mn} on F3 is greater than 0.80. It is inferred that temperature, nitrogen and phosphorus nutrients were the main influencing factors of eutrophication, and DO, pH and COD_{Mn} were the main manifestation factors of water eutrophication.

Table 1: Factor eigenvalues and contribution rate of water environmental indicators after rotation.

Factor	Eigenvalue	Contribution Rate %	Total Cumulative %
F1	3.549	39.435	39.435
F2	3.085	34.279	73.714
F3	1.123	12.479	86.193

Table 2: Factor load value after rotation of water environment index.

Factor	Chl.a	T	pH	SD	DO	PO_4^{3-}-P	TN	TP	COD_{Mn}
F1	-0.366	-0.972	-0.013	0.289	0.008	0.849	0.925	0.893	-0.117
F2	0.657	0.097	0.883	-0.79	0.963	-0.386	0.173	-0.243	0.272
F3	-0.425	0.057	0.226	-0.24	0.125	-0.166	0.194	-0.153	0.853

4 CONCLUSIONS

Based on the results and discussions presented above, the conclusions are obtained as below:

(1) In dry season, TN and TP exceeded the standard by 5.08 and 10.72 times respectively, DO does not meet class II standard, COD_{Mn} up to standard; TN, TP and COD_{Mn} exceeded the standard by 7.06, 8.68 and 1.33 times respectively in normal water period, DO up to standard; in the wet season in July, TN and TP exceeded the standard by 2.36 and 0.88 times respectively, and COD_{Mn} and DO did not exceed the standard. In the wet season in August, TN and COD_{Mn} exceeded the standard by 2.74 and 1.41 times respectively, and TP and DO did not exceed the standard.

(2) The water body is slightly eutrophic in dry season, slightly to moderately eutrophic in normal season, slightly eutrophic in July and moderately eutrophic in August in wet season.

(3) The main influencing factors of eutrophication in Daheiting reservoir were temperature and nitrogen and phosphorus nutrients, and the main performance factors were DO, pH and COD_{Mn}.

ACKNOWLEDGMENTS

Key special project of "global change and response" of national key R&D plan (2016YFA0600902); National major special project of water pollution control and treatment science and Technology (2018ZX07111002).

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