Comprehensive Assessment and Simulation of Eutrophication of Hasu Sea Water Environment in Inner Mongolia

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Abstract: Hasuhai is situated in Hohhot's Tumet Left Banner. In recent years, due to tourism, some natural causes and human activities, the eutrophication of Hasuhai has gradually increased. Data from each Hasuhai monitoring point between May and July 2021 are first obtained for this paper，and analyzes the TP, TN, SD, CODmn and Chl in the data A Each element is analyzed, and then the comprehensive trophic state index method is used to evaluate the trophic state of the lake. The evaluation results of the comprehensive nutritional status index method showed that the scores in May and July were 58.18 (slight eutrophication) and 67.12 (moderate eutrophication), demonstrating that the eutrophication in the summer was more than that in the spring and that the process of interannual change had a tendency to gradually deteriorate, which calls for attention to better governance. Chlorophyll (Chl. a), transparency (SD), and total phosphorus (TP), which account for 23.94%, 23.05%, and 20.18% of the Hasu Sea's eutrophication, respectively, are found to have a significant impact on the process. Through comprehensive analysis, it is concluded that the Hasu sea water body is greatly affected by the surrounding canals.

Keywords: Hasuhai; Eutrophication; Comprehensive Trophic State Index Method; Factor

1.Introduction

Hasuhai is a significant area that contributes significantly to agricultural, animal husbandry, fisheries, tourism, and other fields and is situated in the Hohhot city neighborhood of Tumet Left Banner. The unique geographical setting and historical context have created a lake ecosystem that is unlike any other.[1]. However, due to humankind's rapid economic development, resources are being developed at an even faster rate, which results in nutrient pollutants entering lake water in a variety of ways, increasing, and accumulating in the lake, rapidly degrading the water environment, and exacerbating the characteristics of eutrophication.[2]. The sea was chosen as the research object in this study to clarify the primary pollutant types and distribution rules of the sea, and the assessment of eutrophication and its primary water environmental impact factors were analyzed to analyze algae species, total nitrogen (TN), total phosphorus (TP), and chlorophyll (Chl. A). Additionally, the Harbin Marine water environment is accurately assessed and analyzed using the spatial change law of transparency (SD), the comprehensive nutrient state index method, which offers a theoretical framework for managing eutrophication in lakes so that their resources can be better protected and used.

2.Materials and Methods

2.1 Overview of the Study Area

The interval of Hasu Sea is located in east longitude 110°56 '~111°01', 40°57 '~40°64', and is located in Tumet Left Banner of Hohhot city.

Hasu Sea has a maximum width of 9.5 km, a maximum width of 5.3 km, and an average width of 3.1 km. The lake's water surface area is around 32 km2, its shoreline is 24.1 km long, its depth ranges from 3 to 2.5 m, and its volume is 80 million m3. According to the survey, the annual average storage capacity is 34.5667 million m2. The lowest point of the embankment is at 988.5 meters, close to the lake's center, and it rises to 993 meters, a difference of 4.5 meters in elevation. The Hasu Sea's primary water supply support comes from a number of rivers and channels that merge in the basin, including the Yellow River, the Wanjiagou Valley, and the West Yibai Shizigou[3]. Monitoring sites in the study area are shown in Figure 1.

2.2 Data Source

The water quality monitoring data of Hasu Sea used in this paper is the monitoring data conducted by the water environment team of Inner Mongolia Agricultural University in May and July 2021, including the water quality factors TN, TP and CODmnAnd Chl-a concentration was determined by ultraviolet spectrophotometry, molybdenum and antimony resistance spectroscopic breadth method, ferriammonia sulfate titration and acetone extraction spectrophotometer, transparency, mud thickness and water depth were determined by plug plate method, rod and sonar respectively[4]. Data processing and figure drawing were mainly done by Excel 2016 and Arcgis 10.8.

2.3 Evaluation Method

The integrated nutritional status index method was used[5]To evaluate the water nutrient status, redundancy analysis was used to determine the main influencing factors of lake eutrophication. TN, TP, and COD were selectedmn、Chl . A As the benchmark parameter for evaluating lake eutrophication, the evaluation formula is as follows:

Formula: the total nitrogen nutrient index; the total phosphorus nutrient index; the permanganate nutrient index; the chlorophyll a nutrient index; the comprehensive nutrient state index; the weight of the nutritional state index of j parameter; the nutritional state index of j parameter; m is the number of evaluation parameters. The scoring criteria are shown in Table 1.

$$\mathrm{TLI(TN)} = 10 \times (5.453 + 1.694 \times \ln(\mathrm{TN}))\mathrm{TLI(TP)} = 10 \times (9.436 + 1.624 \times \ln(\mathrm{TP}))\mathrm{TLI(COD_{Mn})} = 10 \times (0.109 + 2.66 \times \ln(\mathrm{COD_{Mn}}))$$

$$\mathrm{TLI(Chl.a)} = 10 \times (2.5 + 1.086 \times \ln(\mathrm{Chl.a}))$$

$$\mathrm{TLI(SD)} = 10 \times (5.118 - 1.94) \times \ln(\mathrm{SD}))\mathrm{TLI}(\textstyle\sum) = \sum_{j=1}^{m} W_j \times \mathrm{TLI(j)}$$

$\mathrm{TLI(TN)TLI(TP)TLI(COD_{Mn})TLI(Chl.a)TLI(\textstyle\sum)W_jTLI(j)}$

use Chl. A as the benchmark parameter, the formula for the correlation weight of the j parameter is shown in formula 7, and the correlation coefficient is shown in Table 2.

$$W_j = \frac{r_{ij}^2}{\sum_{j=1}^{m} r_{ij}^2}$$

3.Results and Analysis

3.1 Analysis of Eutrophication Index of Hasosea

In accordance with Figures 3, 4, The surface water environmental quality standard (GB3838-2002) surface water class standards were exceeded in May by the permanganate to indexes of H1, H2, and H3. The six monitoring points' permanganate indexes in July were higher below the minimum value for the water type specified by the quality standard; point H1 had the highest P values in both May and July. The greatest reading was 0.43 mg/L. Over the surface water environmental quality standard's class V water standard value, The monitoring sites H2 and H6 recorded phosphorus concentrations that were higher than the water standard value required by the surface water health standard in May and July, respectively; Point H3 in May has the highest nitrogen content, and point H4 in July has the highest nitrogen concentration. H2 and H3's combined nitrogen concentration in May was higher than the class V water standard value required by the surface water environmental quality standard. The total nitrogen concentration of monitoring H3 was higher than the water class's recommended standard value in July, and H4 of the monitoring point

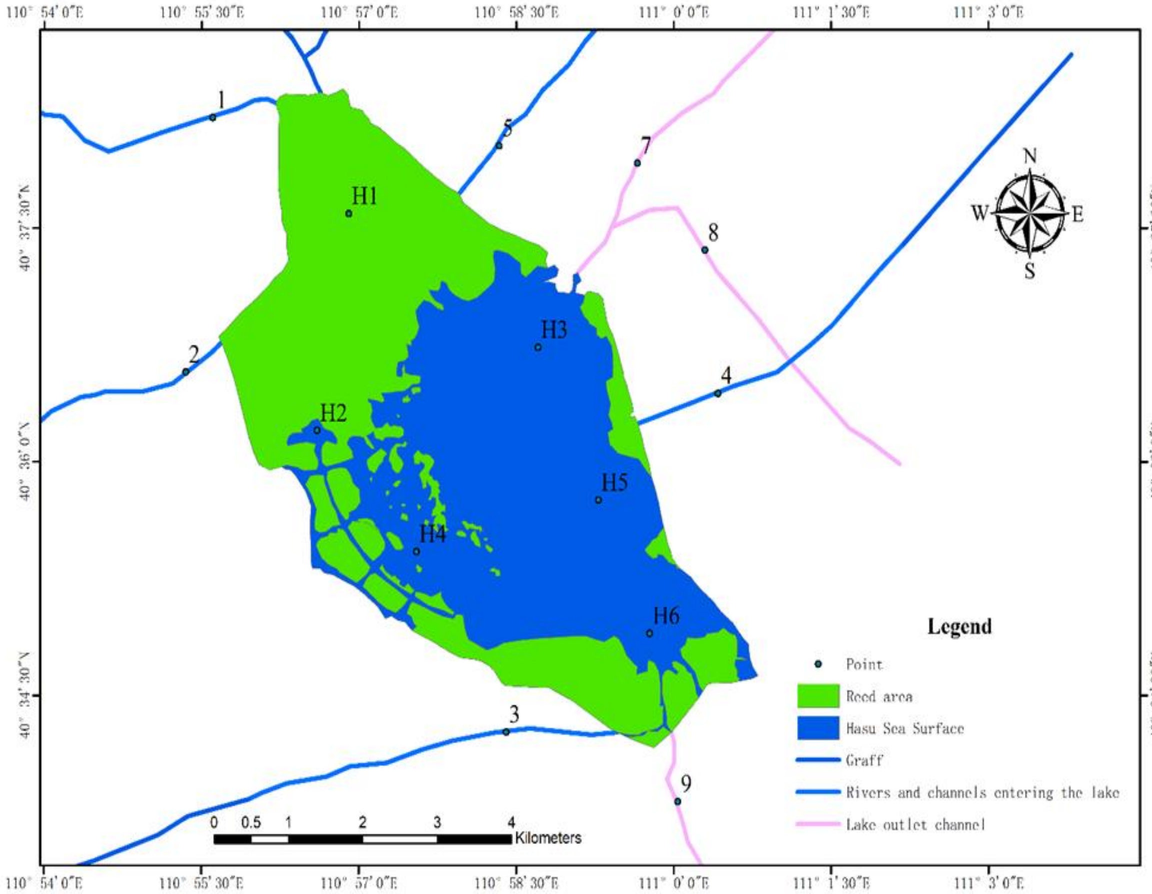

Figure 1. Hasuhai Monitoring Point in the Study Area

Table 1. Classification of Comprehensive Nutritional Status Index

grade	Poor nutrition	In nutrition	eutrophy	Mild eutrophication	Moderate eutrophication	Heavy nutrition
T LI()∑	<30	30~50	>50	50~60	60~70	>70

Table 2. The Selected Parameter is the Same as Chl.a Correlation between

parameter	Chl.a	TP	TN	SD	CODMn
rij	1	0.84	0.82	-0.83	0.83
rij2	1	0.7056	0.6724	0.6889	0.6889

exceeded the prescribed standard value of water class V. Chl. in July and May. The concentration of the other points is below the water standard value. The concentration of chlorophyll an in the monitoring point, with the exception of point H4, exceeds the surface water environmental quality standard, while the concentration of chlorophyll an in point H4 is below the water standard value. These average concentrations are 40 ug/L and 9 ug/L, respectively. At the same time, it can be seen that the chlorophyll a content of Harbin in July was much higher than that in May, about 4.44 times that of May, indicating that the seawater environmental eutrophication of Harbin in July is more serious.

3.2 Results of Eutrophication Assessment

Comparison table 5, table 6 although the comprehensive nutrition status index value is different, but still can reflect the element seawater environment eutrophication is more serious, may monitoring comprehensive nutrition status index average is 58.18, the average nutrition status for mild eutrophication, July monitoring comprehensive nutrition status index average is 67.12, the average nutrition status for moderate nutrition, July numerical overall higher than may, that the sea years eutrophication situation present summer> spring. Meanwhile, as can be seen in Figure Figure 13, the Chl. A, SD and TP have a greater proportion to eutrophication than other parameters and have more influence on the integrated nutritional state index values. Therefore, the management of environmental eutrophication of hasin seawater should start with the content of chlorophyll a and phosphorus and the transparency of the lake.

4. Discussion

The salt content in July was much higher than that in May. The reason for this may be that the amount of pollutants in July was greater than that in May, or because the content of organic and inorganic pollutants in the water bodies in July was greater than that in May. Based on the distribution of the monitoring points, the reason for the obvious increase in the nitrogen content of H2 and H3 in May may be that points H2 and H3 approach the rear river and Wanjiagou drainage channel respectively, and the sewage discharged from the upper reaches of the two inlet channels contains more nitrogen elements, which makes the nitrogen content of the two monitoring points near the entrance of the canal high. The increase in nitrogen content at H3 points in July may also be caused by sewage discharge, while the increase in H4 points may be due to the densely growing area of the reed, which increases the nitrogen content in this area[6]. In May, the average total nitrogen content of each monitoring site was 1.324 mg/L, and the average total nitrogen content of each monitoring point was 1.082 mg/L, which exceeded the water standard value stipulated in the surface water environmental quality standard. The average value in May is about 1.22 times that of the average in July, and the total nitrogen content in May is higher than the total nitrogen content in July, probably because the spring is the season for crop fertilization, and some fertilizers enter the water to increase the total phosphorus content. It may also be that the nitrogen content in the sewage discharged in May is higher than that in July, and the large evaporation in May leads to more nitrogen deposition, making the total nitrogen content in the lake in May higher than that in July. It follows that the elevation of nitrogen content in lakes may be mainly affected by human activities[7]In order to control the nitrogen content, we should start with the control of human activities to reduce the sewage[8], fertilizer[9]Into the lake, so as to control the content of nitrogen elements in the lake.

Site H1 is located near the entrance of the north ditch, probably due to the channel[10]There are more pollutants containing phosphorus in the sewage discharged upstream. At the same time, it is easy to cause sediment deposition at the entrance of the river channel, which makes the accumulation of phosphorus element, leading to the high content of phosphorus at H1 point.

Table 3. Test Results of Hasuhai Surface Water Test on May 20, 2021

	H1	H2	H3	H4	H5	H6
Permanganate Index (mg/L)	7.0	6.7	6.7	5.6	5.7	5.5
Total phosphorus (mg/L)	0.430	0.249	0.135	0.130	0.099	0.104
Total nitrogen (mg/L)	0.581	2.452	2.849	0.872	0.940	0.251
Chlorophyll a (ug / L)	12.811	9.460	9.072	14.157	4.694	5.473
pellucidity (cm)	20	18	20	30.5	44	24

Table 4. Test Results of Hasuhai Surface Water Test on July 29, 2021

	H1	H2	H3	H4	H5	H6
Permanganate Index (mg/L)	14.1	13.2	13.1	13.6	13.1	13.6
Total phosphorus (mg/L)	0.430	0.217	0.178	0.148	0.183	0.212
Total nitrogen (mg/L)	0.630	0.914	1.610	2.090	0.669	0.581
Chlorophyll a (ug / L)	39.495	34.979	48.701	22.037	49.796	48.244
pellucidity (cm)	20	18	20	30.5	44	24

Table 5. Analysis of Calculation Results of Monitoring data on May 20, 2021

PT	Nutritional status index for each parameter					∑TLI	Nutritional status
	Chl.a	TP	TN	SD	CODMn		
H1	52.697	80.650	45.327	82.403	52.851	62.106	Moderate eutrophication
H2	49.403	71.779	69.722	84.447	51.686	64.091	Moderate eutrophication
H3	48.948	61.868	72.267	82.403	51.686	62.189	Moderate eutrophication
H4	53.782	61.235	52.203	74.216	46.916	57.388	Mild eutrophication
H5	41.793	56.811	53.473	67.107	47.386	52.375	Mild eutrophication
H6	43.461	57.637	31.131	78.866	46.436	50.957	Mild eutrophication

Table 6. Analysis of Calculation Results of Monitoring Data on July 29, 2021

PT	Nutritional status index for each parameter					∑TLI	Nutritional status
	Chl.a	TP	TN	SD	CODMn		
H1	64.923	80.635	46.703	82.403	71.478	69.022	Moderate eutrophication
H2	63.605	69.548	52.997	84.447	69.724	67.767	Moderate eutrophication
H3	67.199	66.330	62.597	82.403	69.521	69.427	Moderate eutrophication
H4	58.587	63.333	67.018	74.216	70.518	66.043	Moderate eutrophication
H5	67.440	66.780	47.721	67.107	69.521	64.106	Moderate eutrophication
H6	67.096	69.169	45.317	78.866	70.518	66.373	Moderate eutrophication

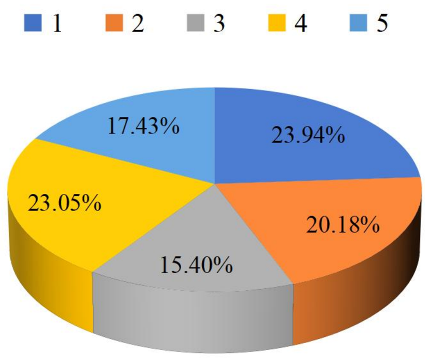

Figure 2. Average Proportion of each Parameter

The phosphorus concentration at each point in May was less than that at the previous test point, but it increased at points H5 and H6 in July.

On the whole, the phosphorus concentration of each point in May was 0.191 mg/L, and that of each point in July was 0.228 mg/L. The phosphorus concentration of each point in July was higher than that of each point in May. The reason for the higher phosphorus concentration in July is likely to be caused by the increase in temperature, and some studies found that with the temperature[11]. Phosphorus in the rising sediment is constantly released, and the release is maximum in the summer[3]. We analyzed the phosphorus concentration of each point together with the nitrogen concentration, and calculated the N / P, nitrogen-phosphorus ratio of each monitoring point[12]For the normal growth of phytoplankton in lakes, the normal metabolism of algae requires N / P is about 7, when N / P is greater than 7, P may be a limiting nutrient; when N / P is less than 7[13, 14], N may be limiting nutrient limitation. By calculation we obtain Tables 3 and 4. The nitrogen to phosphorus ratio of Hasohai was between 1.35 and 21.07. The limiting nutrients in H2, H3 and H5 were phosphorus, and the other points were nitrogen. The nitrogen to phosphorus ratio in July was between 1.47 and 14.12. The limiting nutrients of points H3 and H4 were phosphorus, and the rest of them were nitrogen. As shown in Table 7 and Table 8.

Comprehensive may and July element in the sea in the spatial distribution of elements in July

Table 7. Nitrogen phosphorus ratio and restricted nutrient types at each point in May

	H1	H2	H3	H4	H5	H6
N/P	1.35	9.85	21.07	6.70	9.49	2.41
Restrictive nutrient salt species	N	P	P	N	P	N

Table 8. Nitrogen phosphorus ratio and restricted nutrient types at each point in July

	H1	H2	H3	H4	H5	H6
N/P	1.47	4.21	9.04	14.12	3.66	2.74
Restrictive nutrient salt species	N	N	P	P	N	N

element Marine environment eutrophication situation is more serious, may be due to July canals sewage discharge more, the pollutant content is higher, at the same time, accelerate the growth of the phytoplankton in the lake, make July chlorophyll a content in the lake is higher.

5.Conclusion

(1) According to the ratio of nitrogen to phosphorus, H 2, H3 and H 5 are phosphorus limiting, and H 1, H 4 and H 6 are nitrogen limiting lakes. The contributions of chlorophyll a, SD, TP, C OD mn, and TN were 23.94%, 23.05%, 20.18%, 17.43%, and 15.40% to eutrophication. Hasu sea has severe eutrophication and moderate eutrophication on the whole, and the eutrophication in summer is greater than that in winter.

(2) The main reason for the eutrophication of the Hasu Sea may be caused by the discharge from the upstream of the inlet rivers and the human activities such as farmland fertilization around the Hasu Sea, which cause the pollutants into the lake. Therefore, to improve the lake ecosystem of Chagan Nur Lake, countermeasures and measures need to be taken in the aspects of external river input and internal pollution control.

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