Sustainable Development Research; Vol. 7, No. 2; 2025
ISSN 2690-9898 E-ISSN 2690-9901
https://doi.org/10.30560/sdr.v7n2p119

Water Quality Assessment and Analysis of Causes at Dajin Lake, a World Natural Heritage Site in Danxia, China

Yanling Wang[1], Huicheng Fu[1] & Yini Tian[1]

[1] School of Karst Science, Guizhou Normal University, Guiyang, China; State Engineering Technology Institute for Karst Desertification Control, Guizhou Normal University, Guiyang, China

Correspondence: Yanling Wang, School of Karst Science, Guizhou Normal University, Guiyang, China; State Engineering Technology Institute for Karst Desertification Control, Guizhou Normal University, Guiyang, China.

Received: May 6, 2025 Accepted: June 7, 2025 Online Published: June 10, 2025

Abstract

The World Heritage Convention requires that heritage sites submit periodic reports every six years. During the preparation of the third periodic report for the Danxia Series of World Natural Heritage Sites in China, it was found that previous reports were relatively brief, particularly lacking supplementary materials regarding pollution factors. Therefore, this study takes Dajin Lake within the Danxia Taining World Natural Heritage Site in China as its research object. Based on water quality monitoring data from 2019, seven water quality indicators were selected, including permanganate index (CODMn), chemical oxygen demand (COD), dissolved oxygen (DO), biochemical oxygen demand (BOD5), ammonia nitrogen (NH3-N), total nitrogen (TN), and total phosphorus (TP), to evaluate the water quality of Dajin Lake and analyze the causes, with the aim of understanding the current state of Dajin Lake's water quality.

Keywords: Chinese Danxia, natural heritage, water quality assessment, Taining

1. Preface

The protection of the outstanding universal value of World Heritage sites has attracted considerable attention both domestically and internationally. Since its inclusion in the World Heritage List, the Danxia Series of World Natural Heritage Sites in China has undergone two rounds of regular reporting. During the process of preparing the third round of reports, it was found that the previous two reports were rather brief, particularly regarding the pollution aspects affecting the heritage sites. There was no supplementary material on the current state of pollution, making it necessary to evaluate the water quality conditions of the heritage sites.

2. Introduction

2.1 Research Background and Significance

The Danxia Series of China's World Natural Heritage Sites was officially inscribed on the World Heritage List on August 2, 2010, becoming China's eighth World Natural Heritage Site and its 40th World Heritage Site. The China Danxia World Natural Heritage Site is composed of six sites: the Early Youth Stage Representative—Guizhou Chishui, the Late Youth Stage Representative—Fujian Taining, the Early Mature Stage Representative—Hunan Langshan, the Late Mature Stage Representative—Guangdong Danxia Mountain, the Early Old Age Stage Representative—Jiangxi Longhushan-Guifeng, and the Late Old Age Stage Representative—Zhejiang Jianglangshan [1].

The World Heritage Convention (Convention Concerning the Protection of the World Cultural and Natural Heritage) requires that heritage sites submit self-reports every six years, based on both the national government level and the heritage site level, known as periodic reports. The first round of global periodic reports began in 1998 and has now progressed to the third round [2]. China's third round of periodic reports on the Danxia Series of World Natural Heritage Sites was submitted in 2021. During the process of completing the third round of periodic reports, it was found that previous reports were relatively brief, particularly regarding pollution factors affecting the heritage sites, with no specific supplementary materials on the current state of pollution. The pollution status of these heritage sites has attracted significant attention both domestically and internationally.

Therefore, this study focuses on the water pollution section of the third round of periodic report questionnaires, using the Dajin Lake in the Danxia Taining World Natural Heritage Site (hereinafter referred to as Dajin Lake) as an example. Based on the 2019 water quality monitoring data of Dajin Lake, this study employs the single-factor evaluation method and the comprehensive pollution index method to evaluate the water quality of Dajin Lake and analyze the causes, aiming to provide reference and supplementary information for understanding the current water quality status of Dajin Lake and this round of periodic reporting.

2.2 Current Status of Domestic and International Research

2.2.1 Current Status of Water Quality Evaluation Research

By reviewing existing literature on water quality assessment, it was found that most studies on water pollution conditions, both domestically and internationally, focus on the current status and prediction of water quality. These studies are mostly conducted from the perspective of water resource protection and management, with few studies based on the regular reports of world heritage sites.

2.2.2 Current Status of Water Quality Evaluation Methods

Water quality evaluation is one of the key measures in water quality management. Among the current research on water quality evaluation, commonly used methods include single-factor evaluation methods [3-4], comprehensive pollution index methods [5-6], principal component analysis methods [7-8], fuzzy comprehensive evaluation methods [9-10], and grey correlation coefficient methods [11], among others. These methods have different focuses and each has its own advantages and disadvantages. Among the current water quality evaluation methods, the single-factor evaluation method and the comprehensive pollution index method are the most widely applied.

3. Materials and Methods

3.1 Overview of the Study Area

Taining Jinhu Lake (Figure 1) is located in Taining County at the southern end of Wuyi Mountain, situated in the upper reaches of the Min River. It was formed by the construction of the Chitan Hydropower Station and is a national scenic area and the largest artificial lake in Fujian Province. The Jinhu Lake basin houses several important ecological functional zones, including the Taiping Danxia, a representative example of the Late Youth Period of China's Danxia World Natural Heritage Site; the Taiping World Geopark; the Emei Peak Provincial Nature Reserve; and the Fujian Minjiang Nature Reserve. It is Fujian Province's second world-class tourist destination after Wuyishan's "Double World Heritage" sites. Jinhu Scenic Area is renowned worldwide for its unique water-based Danxia landforms, with the shores featuring a variety of peaks, rocks, caves, and waterfalls, earning it the title of "Danxia Landform Cave Museum" [13].

Geographically, Jinhu Lake in Taining belongs to the Southeast Asian tropical region. Its climate is influenced by the mountainous microclimate, combined with the regulatory effect of the lake's water surface, creating a unique microclimate for the Jinhu Lake area, characterized by cool summers, warm winters, spring rains, and autumn breezes [14].

Jinhu Lake is 51 km long, with a water area of 36 km^2, a watershed area of 4,766 km^2, a reservoir capacity of 870 million m^3, and a regulating reservoir capacity of 626 million m^3. It integrates functions such as power generation, tourism, navigation, and flood control [15-16].

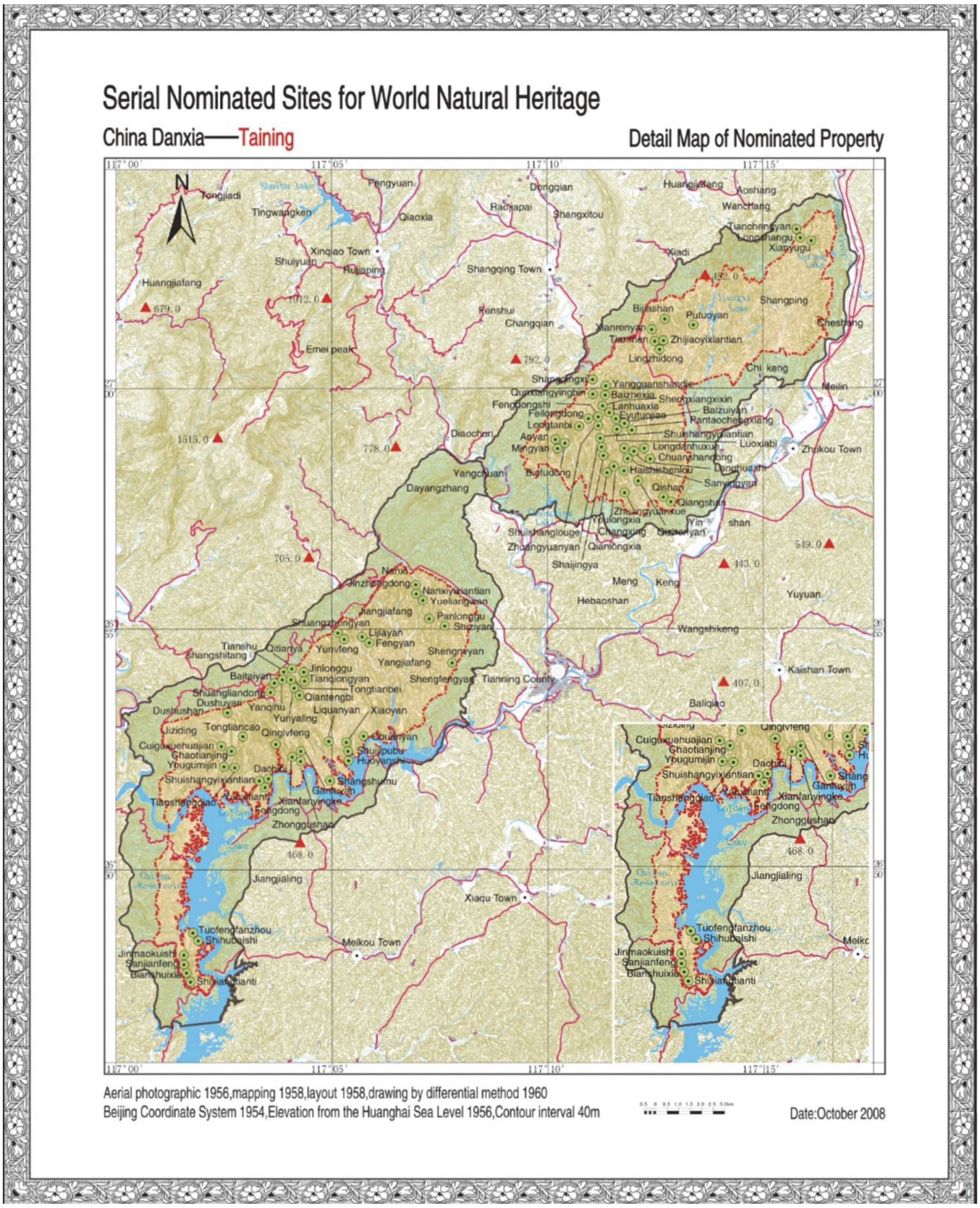

Figure 1. Location of Jinhu Lake in the Taining Danxia Heritage Site [12]

3.2 Water Quality Indicators

Six monitoring sections (S1-S6) were established in the Jinhu River Basin. Each monitoring section conducted sampling during three periods (low water period, normal water period, and high water period) throughout the year, with sampling conducted once in March, July, and November.

The water quality data for the six monitoring sections in 2019 used in this paper were selected from the water quality monitoring results of the three water periods at the six sections. Seven water quality parameters were selected for evaluation: permanganate index (CODMn), chemical oxygen demand (COD), dissolved oxygen (DO), biochemical oxygen demand (BOD_5), ammonia nitrogen (NH_3-N), total nitrogen (TN), and total phosphorus (TP).

3.3 Water Quality Evaluation Methods

This study employs the single-factor evaluation method and the comprehensive pollution index method to assess the water quality of Jinhu Lake. The water quality evaluation standards adhere to the Class III standards specified in the "Surface Water Environmental Quality Standards" (GB3838-2002).

3.3.1 Single-Factor Evaluation Method

The single-factor evaluation method classifies water quality levels based on the evaluation standard limits specified in the "Surface Water Environmental Quality Standards" (GB3838-2002) [17] (Table 1), derives evaluation results for individual indicators, and determines the water quality category based on the category of the worst-performing indicator. This method employs the "one-vote veto" principle, is relatively simple to calculate, and can quickly determine water quality categories [18], with results that are relatively intuitive. However, it cannot comprehensively reflect the overall water quality status [19].

Table 1. Surface Water Quality Standards (Unit: mg/L)

project	Class I	Class II	ClassIII
CODMn	≤2	≤4	≤6
COD	≤15	≤15	≤20
DO	≥7.5	≥6	≥5
BOD5	≤3	≤3	≤4
NH_3-N	≤0.15	≤0.5	≤1.0
TN	≤0.2	≤0.5	≤1.0
TP	≤0.02(Lakes and reservoirs 0.01)	≤0.1(Lakes and reservoirs 0.025)	≤0.2(Lakes and reservoirs 0.05)

3.3.2 Comprehensive Pollution Index Method

The comprehensive pollution index method is a method based on the single-factor index method, which calculates the average value by assigning equal weights to each section [20]. The comprehensive pollution index method can comprehensively reflect the pollution status of water bodies, but it cannot determine water quality categories. The calculation formula [21] is as follows:

$$P_i = C_i/S_i$$

$$P = \sum_{i=1}^{n} P_i \ /\mathbf{n}$$

$$k_i = P_i/\mathrm{n}P \times \mathbf{100\%}$$

In the formula: P_i represents the pollution index of water quality indicator i, C_i is the annual average monitoring value of pollutant i, S_i is the Class III standard value of pollutant i in the Surface Water Environmental Quality Standards (GB3838-2002), mg/L. P is the comprehensive pollution index of a monitoring section participating in the evaluation, n is the number of pollutants participating in the evaluation, k_i is the pollution contribution rate of the single water quality indicator i at that section. The water quality grading corresponding to the comprehensive pollution index is shown in Table 2, with higher values indicating more severe pollution.

Table 2. Water Quality Classification

P	P≤0.20	0.21≤P≤0.40	0.41≤P≤0.70	0.71≤P≤1.00	P≥1
level	cleaning	Still clean	light pollution	moderate pollution	heavy pollution

4. Results and Analysis

4.1 Physical and Chemical Properties and Nutrient Salt Indicators

As shown in Table 3, the annual average values of ρ(NH_3-N) at various sampling sections of Jinhu Lake in Taining range from 0.03 to 0.08 mg/L, all below 0.15 mg/L, meeting Class I water quality standards. Among these, the annual average NH_3-N concentration at the upstream sections of Jinhu Lake is higher than that at the downstream sections. The annual average values of ρ(TN) are all below 1.0 mg/L, with annual variation ranging from 0.80 to 0.90 mg/L, meeting the target Class III water quality standards. This indicates that the overall TN levels at all sections of Jinhu Lake follow the pattern of high water period > normal water period > low water period. The annual average range of the ρ(TP) monitoring project is 0.02–0.04 mg/L. The annual average values of all six monitoring sections of Jinhu Lake are below the Class III lake and reservoir water quality standard limit of 0.05 mg/L. Among them, the average values of the ρ(TP) monitoring project at the S1 and S2 sections of Jinhu Lake are the highest, at 0.04 mg/L. and during the dry season monitoring at the S1 and S2 sections, the TP concentration reached 0.07 mg/L, exceeding the Class III water quality standard of 0.05 mg/L. In summary, the overall trend of TP across all sections of Jinhu Lake is dry season > wet season > normal season.

Table 3. Statistics on Water Quality Monitoring Results in Jinhu (Unit: mg/L)

Name	project	DO	COD_{Mn}	COD	BOD_5	NH_3-N	TP	TN	result
S1	Range	7.4-8.4	1.6-2	7.0-9.0	0.8-1.6	0.012-0.197	0.02-0.07	0.63-0.98	III
	Mean	7.90	1.77	8.00	1.20	0.08	0.04	0.84	
	Category	I	I	I	I	I	III	III	
S2	Range	7.4-8.1	1.8-2.1	8.0-13.0	0.8-2.2	0.012-0.2	0.02-0.07	0.74-0.97	III
	Mean	7.80	1.93	9.67	1.40	0.08	0.04	0.85	
	Category	I	I	I	I	I	III	III	
S3	Range	7.1-8.2	1.3-1.9	6.0-10.0	0.5-1.3	0.012-0.04	0.01-0.04	0.86-0.96	III
	Mean	7.77	1.63	7.67	0.90	0.03	0.03	0.90	
	Category	I	I	I	I	I	III	III	
S4	Range	7.1-7.6	1.3-1.9	7.0-8.0.	0.6-1.4	0.013-0.05	0.01-0.04	0.73-0.98	III
	Mean	7.43	1.63	7.67	1.00	0.03	0.03	0.88	
	Category	II	I	I	I	I	III	III	
S5	Range	6.8-7.9	1.4-1.8	7.00	0.6-1.5	0.012-0.062	0.01-0.04	0.74-0.87	III
	Mean	7.20	1.57	7.00	1.00	0.03	0.03	0.80	
	Category	II	I	I	I	I	III	III	
S6	Range	7.2-8.3	1.3-1.9	8.00	0.2-1.5	0.012-0.132	0.01-0.03	0.81-0.92	III
	Mean	7.83	1.60	8.00	0.90	0.05	0.02	0.86	
	Category	I	I	I	I	I	II	III	

4.2 Organic Pollution Indicators

The annual average range of ρ(DO) at the six monitoring sections in Jinhu Lake across the three water periods throughout the year was between 7.20 and 7.90 mg/L, all exceeding the Class II water quality standard limit of 6.0 mg/L, and thus meeting the Class II water quality standard. The annual average values of ρ(COD_{Mn}) were all below the Class II water quality standard limit of 4.0 mg/L. Except for the dry season water quality monitoring data at the S1 and S2 sections, which were 2.0 mg/L and 2.1 mg/L, respectively, the monitoring values at all other sections during different water periods met the Class I water quality standard. The annual average values of ρ(COD) ranged from 7.0 to 9.67 mg/L, and all monitoring values for all water periods in Jinhu Lake were below the Class I water quality standard limit of 15 mg/L. The annual average values of ρ(BOD_5) were all below the Class I water quality standard limit of 3.0 mg/L, with only the BOD_5 monitoring value at the S2 section during the normal water period exceeding 2.

Overall, the water quality of Jinhu Lake meets Class III water quality standards. Among these, the annual average values of water quality indicators such as ρ(COD_{Mn}), ρ(COD), ρ(BOD_5), and ρ(NH_3-N) all meet Class I water quality standards, the average value of ρ(DO) meets Class II water quality standards, and ρ(TN) and ρ(TP) meet Class III water quality standards, serving as the determining factors for water quality classification. ρ(TN) is consistently close to the Class III water quality standard limit, while ρ(TP) reached 0.07 during the dry season at the S1 and S2 sections, exceeding the Class III water quality standard limit. This is consistent with Cai Jinbang's [22] prediction that total nitrogen and total phosphorus in Jinhu Lake will continue to decline. Research indicates that the nitrogen and phosphorus pollution in Jinhu Lake primarily originates from agricultural runoff within the watershed, domestic wastewater from surrounding towns and villages, and livestock and poultry farming wastewater within the watershed. It is predicted that the total nitrogen and total phosphorus levels in the reservoir area will fail to meet the Class III water quality standards in 2019.

4.3 Single-Factor Evaluation Results

This paper selects seven water quality monitoring parameters: permanganate index (CODMn), chemical oxygen demand (COD), dissolved oxygen (DO), biochemical oxygen demand (BOD_5), ammonia nitrogen (NH_3-N), total nitrogen (TN), and total phosphorus (TP) as the primary evaluation indicators for the water quality of Jinhu Lake. A single-factor evaluation method is used to assess water quality at six monitoring sections in the Jinhu River basin in Taining.

Calculations (Table 3) indicate that total phosphorus and total nitrogen are the classification criteria for Jinhu water quality. When total nitrogen and total phosphorus are not included in the evaluation, all monitoring sections across the entire Jinhu basin meet Class II water quality standards, with the annual average values of three parameters—ρ(COD_{Mn}), ρ(COD), and ρ(BOD_5)—already meeting Class I water quality standards. When total nitrogen and TP and TN in the evaluation, the water quality at all six monitoring sections meets Class III standards, indicating that TP and TN are the classification criteria. Additionally, the ρ(TP) monitoring results at the S1 and S2 sections during the dry season exceeded the standards on two occasions (Figure 1), failing to meet the Class III water quality standard requirements. The ρ(TN) monitoring values are consistently close to the Class III water quality standard limits (Figure 2), posing a risk of exceeding the standards. It can be seen that TN and TP are the limiting factors for water quality in Jinhu Lake among all evaluation parameters, exerting significant influence on water quality at all six monitoring sections across the three water periods.

Single-factor evaluation results indicate that the annual average water quality values at the six monitoring cross-sections in the Jinhu Lake basin meet the Class III standard values specified in the "Surface Water Environmental Quality Standards" (GB3838-2002), with multiple monitoring parameters meeting Class I and II water quality standards. The water quality classification parameters are total phosphorus and total nitrogen. Among these, ρ(TN) consistently approaches the Class III water quality standard limit, posing a risk of exceeding the standard, while ρ(TP) monitoring values have exceeded the standard twice. This may be due to pollution sources such as agricultural runoff, urban domestic wastewater, rural domestic wastewater, and livestock and poultry farming wastewater in the upstream water supply, causing some ρ(TP) monitoring data in the upper reaches of Jinhu Lake to exceed the Class III water quality standard. This indicates that environmental protection in the Jinhu Lake basin still poses potential risks.

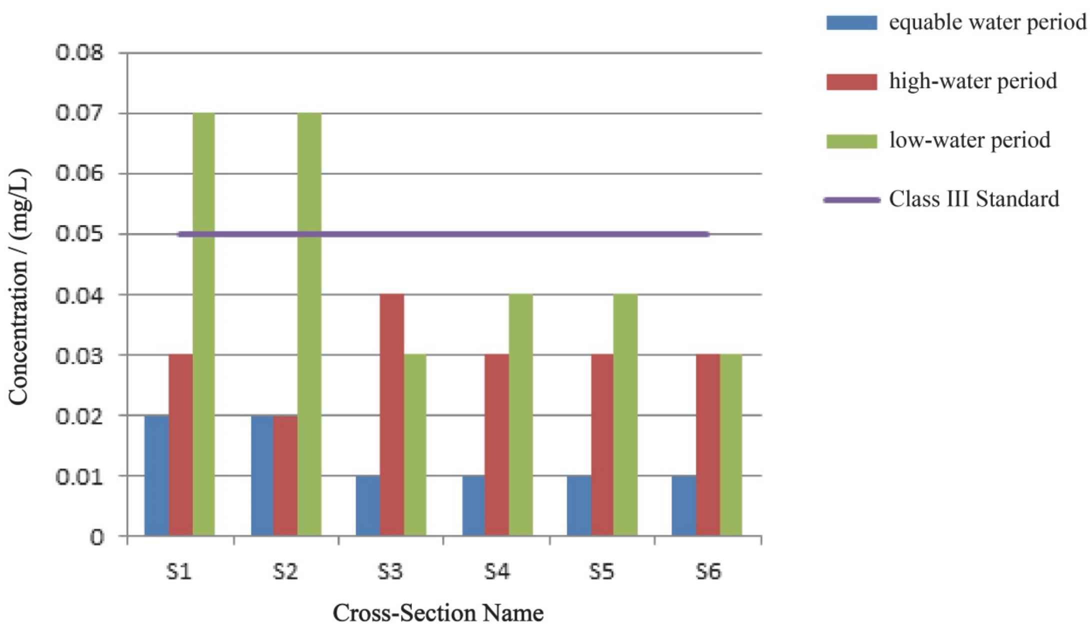

Figure 2. Changes in TP concentration at the Jinhu water quality monitoring section

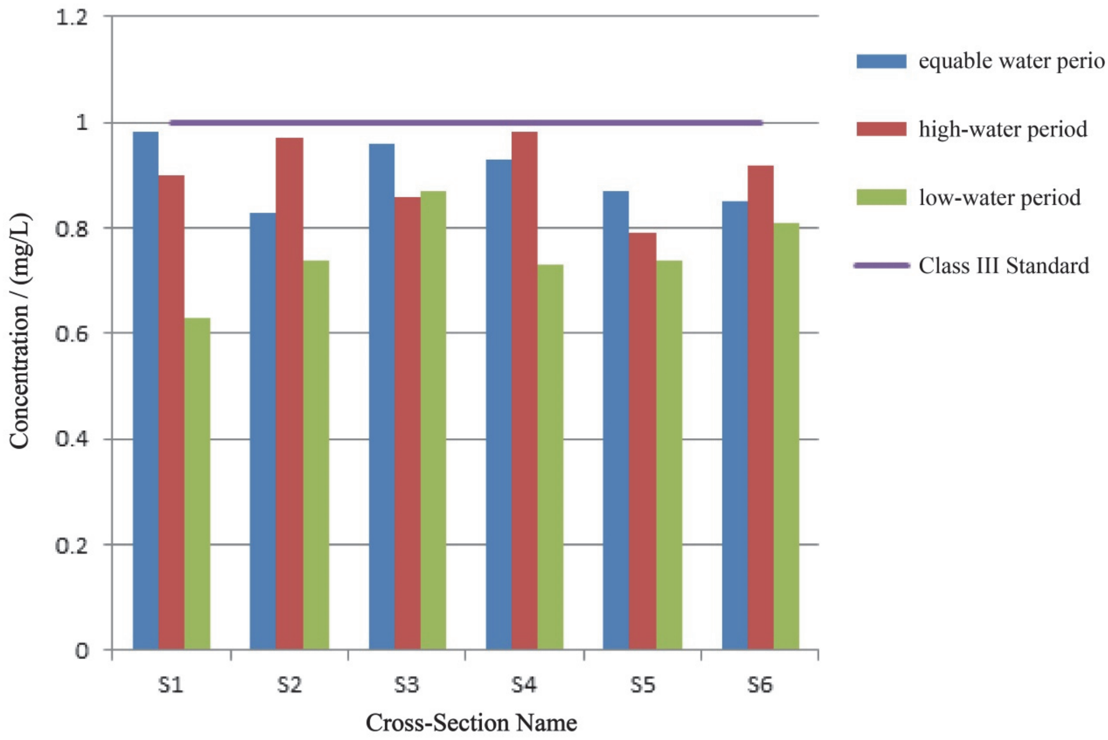

Figure 3. Changes in TN concentration at the Jinhu water quality monitoring section

4.4 Comprehensive Pollution Index Evaluation Results

Due to the influence of rainfall, the flow rates of Jinhu Lake vary significantly across different months, divided into three periods: the normal water period, the high water period, and the low water period. Sampling is conducted in three phases during March, July, and November, respectively. Based on the statistical results of data from various monitoring sections in Jinhu Lake, seven water quality monitoring parameters were selected: permanganate index (COD_{Mn}), chemical oxygen demand (COD), dissolved oxygen (DO), biochemical oxygen demand (BOD_5), ammonia nitrogen (NH_3-N), total nitrogen (TN), and total phosphorus (TP) as the primary evaluation factors for the comprehensive pollution index method in the Jinhu Lake basin. Using the formula of the comprehensive pollution index method, the pollution contribution rates of the pollution factors and the comprehensive pollution indices for different water periods were calculated for the six monitoring sections (Table 4).

Table 4. Comprehensive Pollution Index and Pollution Contribution Rate for Each Section of Jinhu Lake (Unit: mg/L)

Name	project	DO	COD_{Mn}	COD	BOD_5	NH_3-N	TP	TN	Pollution Index
S1	P	10.0%9.7%	16.1%	14.3%	0.4%	14.3%	35.1%	0.40	
	F	3.2%	11.2%	16.1%	8.0%	1.2%	24.1%	36.1%	0.36
	K	10.8%	9.2%	9.7%	8.3%	5.6%	38.9%	17.5%	0.51
S2	P	9.8%	10.5%	21.2%	18.0%	0.3%	13.1%	27.1%	0.44
	F	3.8%	12.6%	16.7%	8.4%	1.3%	16.7%	40.6%	0.34
	K	11.5%	9.1%	10.4%	7.8%	5.2%	36.6%	19.3%	0.55
S3	P	19.7%	9.4%	15.0%	5.6%	0.4%	8.6%	41.2%	0.33
	F	5.9%	11.8%	11.1%	8.5%	1.5%	29.5%	31.7%	0.39
	K	13.9%	9.2%	16.5%	10.9%	1.0%	19.8%	28.7%	0.43
S4	P	19.1%	9.4%	14.9%	6.4%	2.1%	8.5%	39.6%	0.34

	F	0.0%	12.4%	15.4%	9.7%	1.5%	23.2%	37.8%	0.37
	K	18.2%	8.9%	12.7%	11.1%	0.3%	25.5%	23.2%	0.45
S5	P	21.2%	9.7%	14.8%	6.4%	2.5%	8.5%	36.9%	0.34
	F	4.6%	12.4%	14.5%	10.4%	0.4%	24.9%	32.8%	0.34
	K	21.9%	7.7%	10.8%	11.7%	0.3%	24.7%	22.8%	0.46
S6	P	19.2%	9.6%	17.5%	2.2%	5.7%	8.7%	37.1%	0.33
	F	4.9%	12.2%	15.2%	9.5%	0.4%	22.8%	35.0%	0.38
	K	14.2%	9.4%	13.9%	13.2%	0.3%	20.8%	28.1%	0.41

As shown in Table 4, the top three pollutants in Jinhu Lake are total nitrogen, total phosphorus, chemical oxygen demand, and dissolved oxygen, with average contribution rates of 31.7%, 20.5%, 14.6%, and 11.8%, respectively. However, the impact of these pollutants varies across different sections and water periods. By comparing the pollution factors across different sections, it can be analyzed that the primary pollution factors at the S5 section of Jinhu Lake are total nitrogen, total phosphorus, and dissolved oxygen, with contribution rates of 30.8%, 19.4%, and 15.9%, respectively. Meanwhile, the primary pollution factors at the remaining five sections are also total nitrogen, total phosphorus, and chemical oxygen demand.

The annual average comprehensive pollution index for Jinhu Lake is 0.40, indicating that the water quality of Jinhu Lake is classified as moderately clean. Based on the average comprehensive pollution index of the different sections monitored in Jinhu Lake, among the six selected monitoring sections, the water quality evaluation level of the upstream S1 and S2 sections is slightly polluted, with comprehensive pollution indices of 0.42 and 0.44, respectively. Among these, the S2 section has the highest comprehensive pollution index of 0.44, indicating relatively severe pollution. The remaining four sections are classified as moderately clean, with the composite pollution index ranging from 0.37 to 0.39. Among these, the S6 section has the lowest composite pollution index (0.37), indicating relatively the least pollution. It can be seen that the water quality of the downstream sections of Jinhu Lake is generally better than that of the upstream sections, possibly because the river water entering Jinhu Lake undergoes self-purification by the lake and reservoir, diluting and decomposing pollutants in the water, ultimately achieving water purification. When examining the different water periods at the six monitoring sections, the comprehensive pollution index ranges for the six monitoring sections during the normal, abundant, and dry water periods were 0.33–0.44, 0.34–0.39, and 0.41–0.55, respectively. During the normal water period, 83.33% of the comprehensive pollution indices at the various sections of Jinhu Lake were below 0.41. while all six sections during the high water period had comprehensive pollution indices below 0.41, with water quality classified as moderately clean. During the low water period, all six sections had comprehensive pollution indices above 0.41, with all sections classified as slightly polluted. As shown in Figure 3, the water quality in the Jinhu Lake basin is poorest during the low water period, and the water quality during the high water period is generally better than during the normal and low water periods. This may be due to the fact that Jinhu Lake has a smaller water volume during the dry season due to rainfall, resulting in relatively weaker self-purification capacity of the water body. This leads to slower water turnover in Jinhu Lake, causing pollutants entering the reservoir to not be diluted in time, resulting in poorer water quality.

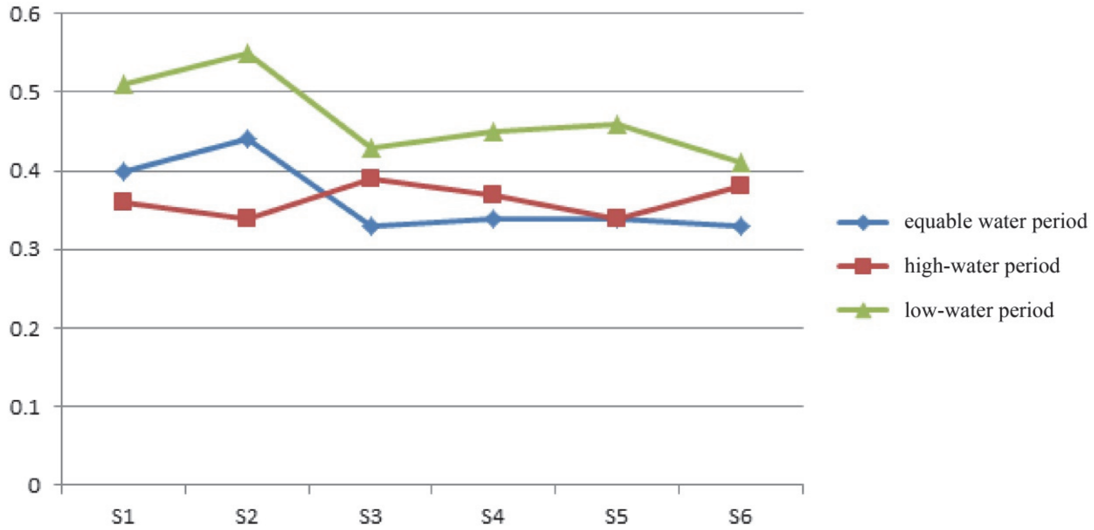

Figure 4. Comprehensive pollution index of monitoring sections at different water periods in Jinhu Lake

The results of the comprehensive pollution index evaluation indicate that the annual average comprehensive pollution index for the six monitoring sections of Jinhu Lake across three water periods is 0.40, indicating that water quality is in a relatively clean state. The pollution levels of the monitoring sections are roughly ranked as follows: S2 > S1 > S4 > S3 = S5 > S6. Total nitrogen and total phosphorus are the primary pollutants in the water body of Jinhu Lake.

By analyzing and comparing the results obtained from the two methods, it was concluded that for the water quality of Jinhu Lake, the results of the comprehensive pollution index evaluation are generally consistent with those of the single-factor evaluation.

5. Conclusion

(1) The overall water quality of Jinhu Lake is relatively good. Among the seven selected water quality indicators, compared to the four organic pollution indicators, the physical and chemical indicators and nutrient salt indicators ρ(TP) and ρ(TN) show relatively severe pollution and are the limiting factors for water quality at each section.

(2) The results of the single-factor evaluation indicate that the annual average water quality values at all six monitoring sections in the Jinhu Lake basin meet the Class III water quality standards. Among the seven evaluated indicators, total phosphorus and total nitrogen are the key indicators for classifying the water quality of Jinhu Lake. When TP and TN are not included in the evaluation, the average water quality monitoring values at the six monitoring sections in the Jinhu River basin are primarily Class I and II; when total phosphorus and total nitrogen are included in the evaluation, the comprehensive water quality at all six sections is classified as Class III, indicating that total phosphorus and total nitrogen are the key indicators for classifying Jinhu water quality.

(3) The results of the comprehensive pollution index evaluation show that the comprehensive pollution index of the six monitoring sections of Jinhu Lake ranges from 0.33 to 0.55, with an annual average comprehensive pollution index of 0.40. This indicates that the overall water quality level of Jinhu Lake is in a relatively clean state, with water quality generally better downstream than upstream, and worse during the dry season than during the normal and wet seasons.

Based on the average comprehensive pollution index of different sections in the Jinhu Lake basin, among the six selected monitoring sections, the water quality levels of the upstream S1 and S2 sections are slightly polluted, while the remaining four sections are in a relatively clean state. By calculating the pollution factor contribution rates, the top three pollution factors in the Jinhu Lake basin are total nitrogen, total phosphorus, and chemical oxygen demand, with average contribution rates of 31.7%, 20.5%, and 14.6%, respectively. The combined contribution rates of TP and TN reach 52.2%, making them the primary pollution factors at all six monitoring sections of Jinhu Lake.

References

[1] Peng, H. (2012). Zhongguo Danxia dizhi de shijie yichan jiazhi jiqi baohu yu guanli [The world heritage

value of China's Danxia landforms and their protection and management]. *Landscape Architecture*, *(1)*, 63-67.

[2] Wei, Q. (2019). Shijie yichan gongyue de fazhan yu shishi jizhi: Cong dingqi baogao bianqian kan [The development and implementation mechanism of the World Heritage Convention as reflected in changes to periodic reports]. *Research on Natural and Cultural Heritage*, *4*(6), 5-20.

[3] Liu, C., He, H., Tan, X., et al. (2012). Jiaozhouwan liuyu shui zhi pingjia moxing de jianli yu yingyong [Establishment and application of water quality assessment model for Jiaozhou Bay Basin]. *Advanced Materials Research*, *518-523*, 1793-1798. https://doi.org/10.4028/www.scientific.net/AMR.518-523.1793

[4] Wang, Z., Zhang, K., & Liu, L. (2016). Danyinzi zhishu fa zai dishui wuran pingjia zhong de youhua [Optimization of the single-factor index method in groundwater pollution assessment]. *Environmental Engineering*, *34*(S1), 810-812+816.

[5] Zhou, M., Li, W., & Yi, L. (2016). Si zhong shui zhi pingjia fangfa tezheng de fenxi yu bijiao [Analysis and comparison of the characteristics of four water quality assessment methods]. *Environmental Science and Management*, *41*(12), 173-177.

[6] Bi, Y., Wang, H., Xia, B., et al. (2022). Shenzhen Longganghe yu ji xing chengshi heliu shui wuran tezheng ji shui zhi lianhe pingjia [Characteristics of water pollution in rain-fed urban rivers and joint evaluation of water quality: The case of Longgang River in Shenzhen]. *Environmental Science*, *43*(2), 782-794. https://doi.org/10.13227/j.hjkx.202104285

[7] Wu, Y. (2020). Shui zhi zonghe pingjia yu yuce yanjiu jinzhan [Advances in comprehensive evaluation and prediction of water quality]. *Anhui Agricultural Sciences*, *48*(2), 23-26.

[8] Liu, C., Xu, L., & Gao, H. (2010). Hechuan shui zhi pingjia fangfa ji yanjiu jinzhan [Methods for evaluating river water quality and research progress]. In *Chinese Society of Hydraulic Engineering: Special Issue on Raw Water Forum in China* (pp. 299-302). Chinese Society of Hydraulic Engineering.

[9] Cao, L., Li, P., Li, S., et al. (2018). Mohu zonghe pingjia yu hui ju fenxi zai heliu jiankang pingjia zhong de yingyong [Application of fuzzy comprehensive evaluation and grey cluster analysis in river health assessment]. *Environmental Engineering*, *36*(8), 189-192.

[10] Zhou, Z. (2009). Jiyu mohu zonghe pingjia fa de shui huanjing pingjia jiqi kekaoxing fenxi [Water environment assessment based on fuzzy comprehensive evaluation method and its reliability analysis]. *China Rural Water and Hydropower*, *(5)*, 15-17.

[11] Zheng, Z., Zhang, S., & Zhang, X. (2016). Huise guanlian fenxi fa zai Dongpinghu shui zhi pingjia zhong de yingyong [Application of grey relational analysis method in water quality evaluation of Dongping Lake]. *Shandong Water Conservancy*, *(9)*, 55-56.

[12] Ministry of Housing and Urban-Rural Development. (2009). *Zhongguo Danxia shijie ziran yichan shenbao wenben [Text of China's Danxia World Natural Heritage Application]*.

[13] Huang, J., & Lin, M. (2005). Dajinhu shijie dizhi gongyuan lüyou chanpin de sheji yu kaifa [Design and development of tourism products for the Dajin Lake World Geopark]. *Fujian Geography*, *(3)*, 44-47.

[14] Pan, G., & Fan, J. (2008). Dajinhu lüyou ziyuan kaifa yu liyong xianzhuang de sikao [Reflections on the current status of the development and utilization of Da Jin Lake's tourism resources]. In *Proceedings of the Strait West Coast Rural Leisure Industry Development Symposium* (pp. 359-365).

[15] Lin, M. (2014). *Shui huanjing yueshu xia huxing lüyou mudi de xietiao yu fazhan yanjiu [Research on the coordination and development of lake-type tourist destinations under water environment constraints]* [Doctoral dissertation, Fujian Normal University].

[16] Liu, M. (1996). Taining Jinhu shui zhi fenxi [Water quality analysis of Jinhu Lake, Taining]. *Fujian Environment*, *(3)*, 16-17.

[17] State Environmental Protection Administration, & State Administration of Quality Supervision, Inspection and Quarantine. (2002). *Dibiao shui huanjing zhiliang biaozhun: GB3838-2002 [Surface water environmental quality standards]*. China Environmental Science Press.

[18] Cong, M., Yang, H., Zhang, X., et al. (2021). Danyinzi fa yu bian mohu fa zai shui zhi pingjia zhong de yingyong [Application of single factor method and variable fuzzy method in water quality evaluation]. *South-to-North Water Diversion and Water Resources Science and Technology (Chinese and English)*, *19*(4), 720-728.

[19] Cheng, K., Meng, X., & Yu, M. (2020). Chengshi heliu shui zhi wuran pingjia fangfa yanjiu jinzhan [Research progress on methods for evaluating water quality pollution in urban rivers]. *Metallurgical Management*, *(7)*, 212-213.

[20] Zhang, J., Jiao, S., Zhao, M., et al. (2021). Guizhou sheng Baohuahu liuyu zhuyao dibiao heliu shui zhi pingjia yu fenxi [Evaluation and analysis of water quality in major surface rivers in the Baohua Lake Basin, Guizhou Province]. *People's Yangtze River*, *52*(6), 13-19.

[21] Xia, F., Hu, S., Gong, Z., et al. (2017). Butong shui zhi pingjia fangfa yingyong de bijiao yanjiu: Yi Danjiangkou shuiku ruhe wei li [Comparative study on the application of different water quality evaluation methods: Taking the rivers flowing into the Danjiangkou Reservoir as an example]. *People's Yangtze River*, *48*(17), 11-15+24.

[22] Cai, J., Wang, B., Liu, C., et al. (2018). Taining Jinhu wuran yuan diaocha ji shui zhi yingxiang yuce fenxi [Investigation of pollution sources and prediction analysis of water quality impact in Jinhu Lake, Taining]. In *Proceedings of the Fourth National Symposium on River Basin Ecological Protection and Water Pollution Control* (pp. 46-53).