Water quality evaluation of typical Lake Wetland Parks around Dianchi Lake

Ziyuan Wang, Xingyue Liu, Weichao Wang, Wei Li*

School of Geography and Ecotourism, Southwest Forestry University, Kunming 650224, China

Abstract. Dianchi Lake is one of the key management points of China's "three rivers and three lakes basins", and the construction of wetland park plays an important role in purifying Dianchi lake water body and maintaining the health of lake ecosystem. Based on single factor evaluation method and three improved Nemerow pollution index methods, this study evaluates water quality of South Dianchi Wetland Park, Xihua Wetland Park and Laoyu River Wetland Park, with concentrations of total nitrogen (TN), total phosphorous (TP), chemical oxygen demand (COD), zinc (Zn), nickel (Ni), cadmium (Cd), chromium (Cr), lead (Pb) specifically measured and monitored. The results showed that: (1) the pollution levels of COD, TN, TP and Cr in the three wetland parks are relatively high. (2) based on single factor evaluation method and the improved Nemerow pollution index method, the evaluation grade of the water quality of the three wetland parks is inferior to Grade V. On the whole, the water pollution of Laoyu River Wetland Park is the most worrisome, and the water pollution of South Dianchi and Xihua Wetland Park is slightly better. (3) COD and TP are the main types of pollutants entering the lake in the basins where the three wetland parks are located. Therefore, immediate attention should be paid to the management of water quality state of Dianchi Lake, and the treatment of urban, agricultural non-point source and some uncollected point source pollution should be further strengthened.

Key words: Wetland park; Dianchi Lake; water quality evaluation; single factor evaluation method; Nemerow pollution index method; pollution source.

1. Introduction

Water resource is indispensable material resources for the survival and development of all life on earth. Since the 21st century. Wetland protection has become a global environmental problem and one of the themes of international wetland research[1]. At the same time, wetland park is an organic combination of protecting and restoring wetlands, and plays an important role in purifying water bodies and maintaining a virtuous cycle of wetland ecosystem.

Dianchi Lake, located in the southwest of Kunming, is the largest lake in Yunnan Province, known as the "Pearl of the plateau". However, with the rapid development of urban construction, the water pollution problem of Dianchi Lake is becoming serious. In recent years, the rise of the construction of wetland parks around Dianchi Lake not only provides ecological sightseeing and leisure places for the city, but also focuses on improving the water quality of the lake and restoring and giving full play to the key ecosystem functions of wetland around it.

On the basis of relevant research, we use single factor evaluation method and the improved Nemerow pollution index method to evaluate the water quality of Laoyu River Wetland Park, South Dianchi Wetland Park and Xihua Wetland Park, and analyze the pollution sources, in order to provide suggestions and references for the water quality treatment and optimization of wetland parks around Dianchi Lake.

2. Methods

2.1 Sampling

Starting from the three directions of East, West and south, this study selects three typical wetland parks in Dianchi Lake Basin as water quality sampling points (South Dianchi Wetland Park, Xihua Wetland park and Laoyu River Wetland Park). The position information of our sampling points is provided in Table 1. Water sampling was completed on December 6, 2020. The sampling points were selected along the wetland park, and two water samples were collected at each sampling point. In the process of sampling, when the water level was stable, pressed the sampling bottle to sink into the water for sampling at the depth of 10 cm-20 cm, and avoided shaking the water body. After sampling, closed the bottle

* Corresponding author: ww0592@gmail.com

cap immediately to prevent oxidation reaction, then sealed it and kept it away from light[3].

The alkaline persulfate digestion technique was applied to determine total nitrogen (TN) and total phosphorous (TP) of water samples, and Potassium dichromate method was used to determine chemical oxygen demand (COD). Heavy metals in water samples were determined using ultrasound-assisted dispersive liquid-liquid microextraction method[4-5]. The water quality evaluation indexes refer to According to China' s Environmental Quality Standards for Surface Water (GB3838-2002), and the standard concentration value is compared with the class III water quality standard.

Table 1. The position information of sampling points

Sampling points	Longitude	Latitude	Altitude
South Dianchi Wetland Park	102°37′52.64"E	24°41′6.45"N	1892m
Xihua Wetland Park	102°39′33.87"E	24°52′40.55"N	1867m
Laoyu River Wetland Park	102°46′12"E	24°49′33.6"N	1894m

2.2 Single factor evaluation method

Single factor evaluation method compares the measured value of the pollution factors of the evaluated water body with the environmental quality standard value of surface water, and selects the category with the worst water quality among all pollution factors as the category of the measured water quality. The method is the simplest and widely used, but it has the defect that it can not comprehensively evaluate the water body. The calculation formula is shown below.

$$F_i = \frac{C_i}{S_i} \tag{1}$$

F_i: Single factor pollution index of pollution factor *i* at the sampling point, its value reflects the degree of exceeding the standard of pollutants. C_i: the measured value of pollution factor *i* at the sampling point (mg/L). S_i: the standard value of pollution factor *i* at the sampling point(mg/L) [6].

2.3 Nemerow pollution index method

Nemerow pollution index method considers the pollution degree of other index factors in the evaluation system. It is a comprehensive evaluation method. However, the traditional method still does not consider the weight of each pollution factor. Therefore, we use the improved Nemerow pollution index method to evaluate the water quality.

First, determine the weight of each pollution factor, and then calculate the improved Nemerow pollution index. The calculation formula is as follows.

$$r_i = S_{\max} / S_i \tag{2}$$

$$\omega_i = r_i / \sum_{i=1}^{n} r_i \tag{3}$$

$$F'_{i,\max} = \frac{F_{i,\max} + F_\omega}{2} \tag{4}$$

$$\overline{F'} = \sum_{i=1}^{n} \omega_i F_i \tag{5}$$

$$P' = \sqrt{\frac{F'^{2}_{i,\max} + \overline{F'}^{2}}{2}} \tag{6}$$

S_{max}: the maximum value of standard concentration among all pollution factors. n: the number of pollution factors participating in the evaluation. ω_i: the weight value of the ith pollution factor. $F_{i,max}$ is the maximum value of F_i. $F'_{i,}$max: the weighted maximum value of F_i. F_ω: Single factor pollution index of the pollution factor with the largest weight value. $\overline{F'}$: the average value of corrected F_i. P': the improved Nemerow pollution index.

3. 3. Results

In general, the water quality of the three wetland parks was highly polluted in terms of COD, TN, TP and Cr, among which the concentration of COD, TP and Cr exceeded the standard concentration by the highest multiple, and the other four indicators were not polluted, among which the concentration of Zn and Pb was the lowest, followed by Ni and Cd. The metal elements detected in Laoyu River Wetland Park were significantly lower than the other two wetland parks, but the concentration of TP was the highest, the concentration of TN and Cr in South Dianchi Wetland Park was the highest, and the COD of Xihua Wetland Park was significantly higher than that of other wetland parks(Table 2).

Table 2. The concentrations of all index in water samples

Sampling points		COD (mg/L)	TN (mg/L)	TP (mg/L)	Metal element				
					Zn (mg/L)	Ni (mg/L)	Pb (ug/L)	Cd (ug/L)	Cr (mg/L)
South Dianchi Wetland Park	Sampling 1	104	2.99	0.256	0.019	0.002	1.49	4.650	0.415
	Sampling 2	95	2.32	0.33	0.012	0.001	48	2.400	0.660
Xihua Wetland Park	Sampling 1	257	1.59	0.222	0.013	0.001	30	0.400	0.200
	Sampling 2	124	1.77	0.236	<0.001	<0.001	1.12	0.500	0.500
Laoyu River Wetland Park	Sampling 1	76	2.52	1.14	<0.001	<0.001	<0.01	<0.01	0.060
	Sampling 2	99	1.79	1.47	0.02	<0.001	<0.01	<0.01	0.150

Single factor evaluation method was used to evaluate the water pollution level according to the worst pollution index of each water sample. The results showed that the

water pollution level of the three wetland parks is inferior to Grade V. The serious exceeding of the detection concentrations of TP, COD and Cr was the reason why the water quality of the three wetland parks was inferior to Grade V under this method. However, the concentration of other pollution indicators was far lower than the standard concentration. This meant that Single factor evaluation method pays too much attention to the worst indicators without comprehensive consideration, and the results may be too conservative(Table 3).

Table 3. Evaluation results of single factor pollution index method

Sampling points	F_i								Grade of pollution
	COD	TN	TP	Zn	Ni	Pb	Cd	Cr	
South Dianchi Wetland Park	4.975	2.655	5.86	0.015	0.075	0.495	0.705	**10.75**	Inferior Grade V
Xihua Wetland Park	**9.525**	1.68	4.58	<0.007	<0.05	0.311	0.09	7	Inferior Grade V
Laoyu River Wetland Park	4.375	2.155	**26.1**	<0.01	<0.05	<0.00002	<0.002	2.1	Inferior Grade V

By calculating the weight of each index, the weight value of Cd was the largest, indicating that this index has the greatest impact on the evaluation system. The second was Ni, and COD had the least impact(Table 4). Next, according to the standard, the pollution grade classification standard of the improved Nemerow pollution index method was obtained, and the Nemerow index was calculated. The calculation results can be seen from Table 5. The improved Nemerow pollution index of the water samples from Laoyu River Wetland Park was much higher than that of the other two wetland parks. Therefore, overall, the water pollution of Laoyu River Wetland Park was the most serious, and that of South Dianchi lake and Xihua Wetland Park was slightly better. The pollution assessment results of this method were consistent with single factor evaluation method, that is, The water quality of the three wetland parks was inferior to Grade V.

Table 4. Evaluation results of Nemerow pollution index method

Sampling points		$F'_{i,max}$	$\overline{F'}$	P'	P'_{mean}	Grade of pollution
South Dianchi Wetland Park	Sampling 1	4.615	1.485	3.428	4.202	Inferior Grade V
	Sampling 2	6.840	1.655	4.976		
Xihua Wetland Park	Sampling 1	6.465	0.646	4.594	4.119	Inferior Grade V
	Sampling 2	5.050	1.024	3.644		
Laoyu River Wetland Park	Sampling 1	11.401	1.556	8.136	9.318	Inferior Grade V
	Sampling 2	14.701	2.093	10.500		

Note: P'_{mean}: average of P'.

4. Discussion

The serious exceeding of individual index concentrations in the water quality evaluation system is the main reason for the poor overall water quality of the three wetland parks. We should focus on controlling the emissions of COD, TP and Cr, and attach great importance to the pollution treatment of urban non-point sources and agricultural non-point sources. According to the characteristics of aboveground and underground runoff in Dianchi Lake Basin, build a more scientific urban drainage system, reduce urban non-point sources, stabilize urban flood peaks, regulate the scouring of pollutants by urban rainstorm runoff, and control the entry of non-point source pollutants into the lake in the whole process[7-8]. For agricultural non-point sources, we should actively apply and promote agricultural non-point source pollution prevention and control technologies integrating drip irrigation and sprinkler irrigation technology, slow-release fertilizer technology, precision fertilization technology and solid waste treatment technology, so as to intercept and eliminate agricultural pollutants from the source, process and end point[9].

Compared with the previous data, the concentration of most indicators of the three wetland parks detected in this study decreased. In addition, Studies have found that the concentrations of TN, TP and NH_3-N at the outlet of Dianchi wetland park were significantly lower than those at the inlet[10], indicating that the wetland has a certain purification effect on the water quality of Dianchi Lake. According to the statistics[11], the daily tourist volume of South Dianchi, Xihua and Laoyu River Wetland Park is, 91 ~ 236, 67 ~ 173 and 357 ~ 1537 respectively. Among them, the daily tourist volume of Laoyu River Wetland Park is the largest and that of Xihua Wetland Park is the least. Generally, the number of tourists is inversely correlated with the degree of pollution, which is consistent with the evaluation results of our study. Therefore, we should strengthen the management of

Wetland Park tourism, strictly maintain the daily number of tourists above the environmental carrying capacity, and implement the management of diversion of tourists. In addition, in the future research, we should try to avoid the problem that the detected water samples are affected by the lake shore environment, and carry out the dynamic monitoring of water quality in Dianchi Lake wetland parks for a long time series.

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