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Research on the Water Quality Evaluation in Balihe Lake Based on Water Quality Index Method

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ABSTRACT
Based on the water quality data observed at 15 sampling sections in Balihe Lake in Oct. 2017, the water quality status in the lake was evaluated and analyzed with single factor water quality index and a comprehensive water quality index of TP (total phosphorus), TN (total nitrogen), NH_3-N (ammonia nitrogen) and DO (dissolved oxygen). The results of single factor water quality index showed that the water quality in Balihe Lake was polluted by TN and TP, and belonged to V or even poor V class of "Environmental Quality Standards for Surface Water (GB 3838-2002)". Similar conclusion can be drawn with the calculated comprehensive water quality index which indicated that the water quality in the lake was still a long way from the target level. Water quality evaluation results based on water quality index method can objectively and directly reflect the water environmental status of Balihe Lake, which may provide some guidance to the delimitation of priority governance area for water quality control.
Keywords - Balihe Lake, single factor water quality index, comprehensive water quality index, water quality evaluation

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I. INTRODUCTION

With the rapid development of economy and society, the water pollution situation in China was becoming very serious, especially the sewage discharge far exceeds the water environment capacity [1]. In the process of water environment comprehensive treatment, water quality evaluation is a basic and forward-looking work, and the objective evaluation results depend on the scientific evaluation system [2]. In order to realize the popularization and application, the water quality assessment methods should have the characteristics of rationality, accuracy and feasibility [3]. Since 1960s, many evaluation methods related to water environment have been established at home and abroad, such as single factor evaluation method, comprehensive pollution index method, fuzzy mathematics evaluation method, grey system evaluation method, analytic hierarchy process, artificial neural network method, water quality identification index method, etc. [4-6]. Among them, each method has its own rationality and limitation, but there is no unified and definite multi-regional urban evaluation model so far because the water environment system is a constantly changing, extremely complex and uncertain large system [7, 8].

Balihe Lake, which is located at the junction area of Huaihe River and Shaying River, has a drainage area of 500km^2 and is the largest tributary of the Anhui section of Shaying River. It accounts about 1/8 of the drainage area, 1/6 annual flow discharge and 1/5 water pollution loads of Shaying River Basin. With the development of industry, agriculture and various production activities within the basin, water pollution in Balihe Lake gradually became serious due to the increasing pollution discharge. Meanwhile, the level of pollution control was not improved correspondingly. In recent years, the pollution of sweet potato starch wastewater and agricultural non-point source pollution in the basin has resulted in the damage of the aquatic ecosystem structure and function, which has restricted the social and economic development and brought tremendous pressure to the water quality improvement of Huaihe River.

Above all, the water quality evaluation based on scientific and rational method was important to the water environmental control and treatment in Balihe Lake. In this study, water quality index method was selected to evaluate the water quality in Balihe Lake [9, 10], which may provide some guidance to the priority governance area delimitation of water quality control and treatment.

II. EXPERIMENTAL METHOD

2.1 Sampling sites and time

15 sampling cross-sections was approximately uniformly distributed in Balihe Lake

along the flow direction. On each cross-section, there were 3 sampling sites set from north to south (see Fig. 1). In Oct. 2017, water quality at these sampling sites was measured to study the water quality in Balihe Lake.

2.2 Detection of water quality indicators

The water sampling and detection in this study refer to the "Monitoring and Analysis Methods of Water and Wastewater (4th Edition)" [11]. TN, TP and NH_3-N were measured in laboratory with the water sampling collected. DO was measured in situ by YSI ProPlus Portable Multi-parameter Water Quality Analyser.

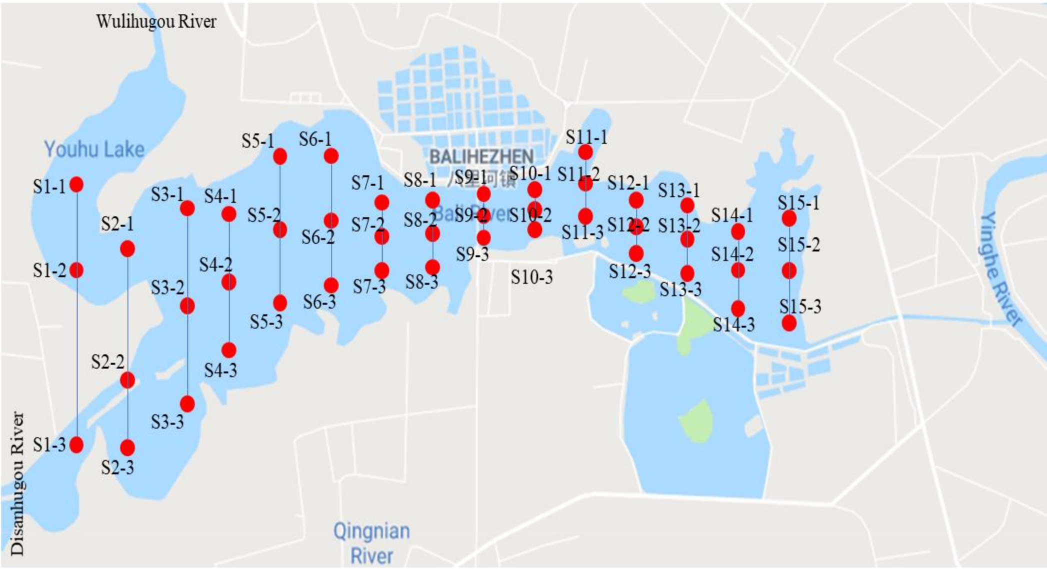

Fig. 1 The distribution of sampling sections and sites in Balihe Lake

III. WATER QUALITY INDEX METHOD

3.1 Single factor water quality index

Single factor water quality index consists of one integer, two or three digits after decimal point. Its structure is

$$P_1 = X_1.X_2X_3,$$

where X_1 is the water quality class of a specific water quality indicator, X_2 is the position of measured value in the range of X_1 water quality class, X_3 represents the relative difference between the actual and target water quality category. In this study, the distinction of X_2 was negligible in the water quality evaluation based on single factor water quality index. As such, X_1 and X_2 were selected to represent the water quality class and the relative difference between the actual and target water quality category.

Based on the measured results of the water quality in Balihe Lake, TP, TN, NH_3-N and DO were selected to calculated the single factor water quality index and evaluate the water quality status in the lake. In such index, X_1 can be found in "Environmental Quality Standards for Surface Water (GB 3838-2002)" [12]. And X2 has a consistent formula since that these four water quality indicators are all incremental indicators. If the water quality is between I and V class of surface water (including I and V), the formula of X_2 is

$$X_2 = \frac{c_i - c_{i-lower}}{c_{i-upper} - c_{i-lower}},$$

where c_i is the measured value of the ith water quality indicator, and $c_{i\text{-}upper}$ and $c_{i\text{-}lower}$ are upper and lower limits of X_1 class for the ith water quality indicator, respectively. X_2 takes only one significant digit according to the principle of rounding.

When water quality is poor V class, the calculating method of X_1 and X_2 is

$$X_1.X_2 = 6 + \frac{c_i - c_{is\text{-}upper}}{c_{is\text{-}upper}},$$

where $c_{is\text{-}upper}$ is the upper limits of V class for the ith water quality indicator. $X_1.X_2$ represent the water quality class and therefore degree of single water quality indicator. Based on the value of $X_1.X_2$, the water quality class can be determined by the following principles.

$1.0 \le X_1.X_2 \le 2.0$ --water quality class Ⅰ

$2.0 \le X_1.X_2 \le 3.0$ --water quality class Ⅱ

$3.0 \le X_1.X_2 \le 4.0$ --water quality class Ⅲ

$4.0 \le X_1.X_2 \le 5.0$ --water quality class Ⅳ

$5.0 \le X_1.X_2 \le 6.0$ --water quality class Ⅴ

$X_1.X_2 \ge 6.0$ --water quality class poor V

3.2 Comprehensive water quality index

The comprehensive water quality index utilized in this study is composed of an integer digit and three of four decimal digits [13]. And its formula is

$$I_{wq} = X_1.X_2X_3X_4,$$

where $X_1.X_2$ is the average value of these four single factor water quality indexes, X_3 and X_4, which can be obtained according to the comparison results. X_3 is the number of water quality indicators worse than the water environment functional objectives. X_4 is the difference between the actual and target categories of the comprehensive water quality. Particularly, X_4=0 if the water quality is better than the target, and X_4=X_1-f (f is the target water quality class) if the water quality is worse than the target and $X_2 \neq 0$. In addition, if the water quality is worse than the target and X_2=0, X_4=X_1-f-1.

Based on the first two significant digits of the comprehensive water quality index, the comprehensive water quality class can be determined with the same principles to the single factor water quality index.

IV. RESULTS AND DISCUSSION

4.1 Water quality analyses and evaluation based on single factor water quality index

Based on the data of water quality in Balihe Lake and the calculating method clarified in section 3.1, the single factor water quality indexes corresponding to TN, TP, NH_3-N and DO were calculated, respectively. The calculated results were shown in Table 1 and the spatial variations of these indexes were plotted in Fig. 2.

Table 1 Calculated single factor water quality indexes

Section	TP	TN	NH_3-N	DO
1	6.3	5.2	3.7	5.6
2	6.5	5.3	3.0	5.5
3	6.6	5.5	4.3	5.5
4	6.8	6.1	4.9	5.4
5	6.75	6.2	5.1	4.5
6	6.5	6.6	5.6	4.3
7	6.3	6.6	5.6	4.6
8	6.25	6.4	5.0	4.6
9	6.25	6.3	5.1	4.5
10	6.2	6.2	5.3	4.5
11	6.1	6.0	5.1	4.9
12	6.1	6.1	5.6	5.0
13	6.2	6.0	5.7	4.7
14	6.2	6.1	5.8	4.7
15	6.3	6.0	5.9	4.4

As can be seen in the table and figure, the effects of TP on water quality in Balihe Lake were the largest, the indexes of all these 15 sampling sections corresponding to TP presented the quality of poor V class. For TN, the water quality also belonged to poor V class for the sampling sections 4-15 (80% of the sampling sections) while section 1-3 presented class V. Relatively speaking, DO was much better than the other indicators since most sampling sites presented IV class of water quality. Totally, the evaluation results corresponding to four different water quality indicators were different. Only TP and TN seemed to show similar spatial variations between the sampling section 8 and 15.

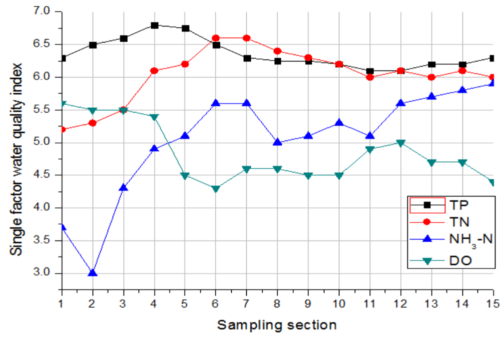

Fig. 2 Variations of the single factor water quality indexes

4.2 Water quality analyses and evaluation based on comprehensive water quality index

By averaging the single factor indexes of TP, TN, NH_3-N and DO corresponding to different sampling sections, the comprehensive water quality indexes can be obtained correspondingly. The calculated results were shown in Table 2. According to the first two significant digitals of the calculated comprehensive water quality indexes $X_1.X_2$, the water quality status of these sampling sections can be comprehensively evaluated. In addition, the spatial variation of the comprehensive water quality index and therefore the water quality status of Balihe Lake was plotted and shown in Fig. 3.

Table 2 The calculation of comprehensive water quality indexes

Section	TP	TN	NH_3-N	DO	Mean	Class
1	6.3	5.2	3.7	5.6	5.2	V
2	6.5	5.3	3.0	5.5	5.1	V
3	6.6	5.5	4.3	5.5	5.5	V
4	6.8	6.1	4.9	5.4	5.8	V
5	6.75	6.2	5.1	4.5	5.6	V
6	6.5	6.6	5.6	4.3	5.8	V
7	6.3	6.6	5.6	4.6	5.8	V
8	6.25	6.4	5.0	4.6	5.6	V
9	6.25	6.3	5.1	4.5	5.5	V
10	6.2	6.2	5.3	4.5	5.6	V
11	6.1	6.0	5.1	4.9	5.5	V
12	6.1	6.1	5.6	5.0	5.7	V
13	6.2	6.0	5.7	4.7	5.7	V
14	6.2	6.1	5.8	4.7	5.7	V
15	6.3	6.0	5.9	4.4	5.7	V

As can be seen in the table and figure, the comprehensive water quality status at all these 15 sampling sections belonged to the surface water quality class of V. The water pollution was severe, but according to the filed survey, there was no black and odorous phenomenon. Comprehensive water quality index method can evaluate the comprehensive water quality status more objectively, and can be used to compare the water quality status between different sampling sites of different water body. Therefore, it has a wide range of applications in the field of water quality assessment.

V. CONCLUSIONS

Based on the monitored water quality indicators including TP, TN, NH_3-N and DO at 15 sampling sections, single factor and comprehensive water quality index methods were performed to evaluate the water quality status in Balihe Lake. The following conclusions can be got from the results.

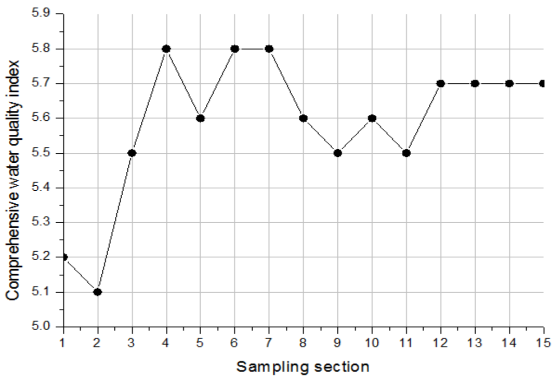

Fig. 3 The variation of comprehensive water quality index

(1) From the perspective of single factor water quality indexes, DO presented better in comparison with the other indicators. For TP and TN, more than 80% of the sampling sites showed water quality belonging to poor V class, and there was a long way to match the water quality target.
(2) The evaluation results of the comprehensive water quality index presented V class water quality at all the sampling sections, which also indicated the serious water pollution status of Balihe Lake comprehensively.
(3) Comprehensive water quality index method may be widely used in water quality assessment due to it can comprehensively evaluate the water quality status more objectively and can be used to compare the status of different sites or water body.
Although some of the results in this study may make sense to the water environment protection or treatment in Balihe Lake, more research on the water quality evaluation is still necessary, especially for using other assessment methods.

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REFERENCES

[1]. F. Yan, L. Liu, Y.F. Li, et al., A dynamic water quality index model based on functional data analysis, Ecological Indicators, 57, 2015, 249-258.
[2]. Z. Sina, Modification of expected conflicts between drinking water quality index and irrigation water quality index in water quality ranking of shared extraction wells using multi criteria decision making techniques, Ecological Indicators, 83, 2017, 368-379.
[3]. R. Noori, R. Berndtsson, M. Hosseinzadeh, et al., A critical review on the application of the national sanitation foundation water quality index. Environmental Pollution, 244, 2019 575-587.
[4]. W.H. Lan, H.Y. An, Discussion on methods of water quality assessment. Arid Environmental Monitoring, 3, 2002, 167-169.
[5]. X.G. Huang, X.H. Liu, Comparison on several methods of quality evaluation on water environment. Ground Water, 27, 2005, 125-126.
[6]. J. Shen, Y. Pan, Y. Huang, A review on evaluation methods of urban surface water. Environmental Protection and Technology, 17, 2011, 41-45.
[7]. S. Şener, E. Şener, A. Davraz, Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey). Science of the Total Environment, 584-585, 2017, 131-144.
[8]. J.Y. Ho, H.A. Afan, A.H. El-Shafie, et al. Towards a time and cost effective approach to water quality index class prediction. Journal of Hydrology, 575, 2019, 148-165.
[9]. Y.L. Tian, Y. Jiang, Q. Liu, et al. Using a water quality index to assess the water quality of the upper and middle streams of the Luanhe River, northern China. Science of the Total Environment, 667, 2019, 142-151.
[10]. H.L. Yin, Z.X. Xu, Discussion on China's single-factor water quality assessment method. Water Purification Technology, 27(2), 2008, 1-3. (In Chinese)
[11]. Environmental Protection Administration of Peoples Republic of China, Monitoring and Analysis Methods of Water and Wastewater (4th Edition) (Beijing, CN: China

Environmental Science Press, 2009). (in Chinese)
[12]. Environmental Protection Administration of Peoples Republic of China, Surface Water Environmental Quality Standards (GB 3838-2002) (Beijing, CN, 2002). (in Chinese)
[13]. C. Hu, D. Su, Application of comprehensive water quality identification index in water quality assessment of Hun River. Ecology and Environment, 20(1), 2011, 186-192.

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