Plankton community structure analysis and water quality bioassessment in Jiulong Lake

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Abstract. Based on the investigations of species composition, community structure and biodiversity of plankton in Jiulong Lake, we evaluated the water quality and the type of nourishment in this area in May 2016. Results revealed that phytoplankton community was dominated by Bacillariophyta and Chlorophyta with an average cell density of 4.567×10^4 ind/L. Ten species of zooplankton mainly composed of Cladocera, Copepoda and Rotifer were identified and the average abundance was 16.25ind/L. Diversity analysis showed that Shannon-Wiener indices of phytoplankton and zooplankton were at 2.94 to 4.57 and 3.54 to 4.24, Pielou uniformity indices were at 0.59 to 0.92 and 0.66 to 0.78, respectively. The water body of Jiulong Lake could be classified as oligotrophication by cell density while as clean to slight pollution by diversity index. The study has important practical significance for monitoring and evaluating aquatic bio-indicators reflecting the water quality of Jiulong Lake.

1. Introduction

Jiulong Lake is one of the main scenic spots in the Zhaohu Mountain Nature Reserve in Haiyang, Shandong. It provides an important ecosystem service and an important ecological security guarantee for the economic development of the Jiaodong Peninsula. However, eutrophication seriously affects the healthy development of aquatic ecosystems and has become a global water environment problem. Plankton is an important biological component of aquatic ecosystems and its population changes and community structure affect the function of the ecosystem directly[1]. Plankton plays a key role in the production and transmission of nutrients in water and can be used as important biological indicator to monitor and evaluate the contamination degree of the water environment. This study monitored the biological characteristics of plankton population structure of Jiulong Lake in May 2016. The water quality and the nutrition type in this area were evaluated based on a combined method using existing quantity evaluation，biological indicator assessment and diversity index analysis, which provided reference for environmental protection and pollution control of Jiulong Lake.

2. Materials and Methods

According to the main water system component of the Jiulong Lake, the sampling of plankton was carried out in May 2016 at 6 monitoring stations (Figure 1).

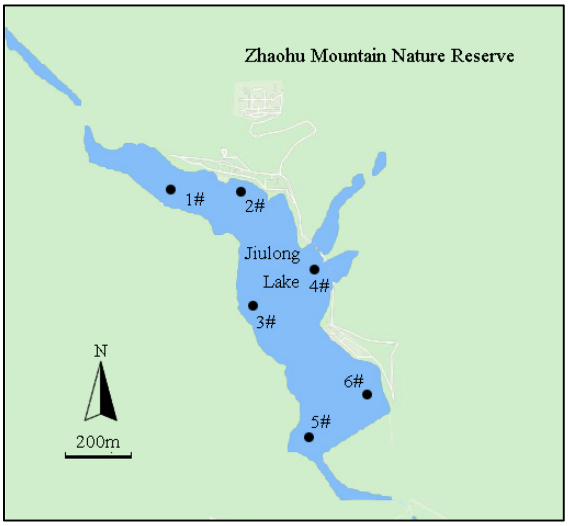

Figure 1. Distribution of sampling sites (1# 121°02'53.16" 36°00'58.27", 2# 121°13'04.42" 36°50'56.63", 3# 121°13'04.96" 36°50'47.00", 4# 121°13'12.65" 36°50'47.26", 5# 121°13'12.86" 36°50'35.71", 6# 121°13'20.02" 36°50'36.31").

2.1. Sample collection, identification and analysis
The phytoplankton and zooplankton were collected by vertically trawling with type III and type I plankton net from bottom to surface at each station respectively, and 5% Lugol's solution was added in samples for preservation. The collection, treatment, species identification and biomass analysis of samples were conducted in laboratories in line with methods specified in “Specifications for freshwater plankton surveys” (SC/T9402-2010).

2.2. Data analysis and water quality assessment
Dominance *Y* was used to evaluate dominant species in this lake. Shannon-Wiener diversity index (*H’*) and Pielou evenness index (*J*) were integrated to analyze the diversity of plankton in the target area[2]. Biological indices can reflect the comprehensive effects of pollutants on the plankton and long-term accumulation of pollutants objectively. This study used the ecology methods to evaluate the water quality and the type of nourishment of Jiulong Lake, including the existing quantity method, the dominant species indication method, and the diversity index method[3]. The division of contaminate grade and nourishing degree based on international standards and classifications are showed in Table 1 and Table 2 respectively[4].

Table 1. Pollution level division based on biodiversity indices.

Pollution level	Cleanness	Slight pollution	Moderate pollution	Heaviest pollution	High pollution
H’	>4.5	4.5-3	3-2	2-1	<1
J	>0.8	0.8-0.5	0.5-0.3	0.3-0.1	<0.1

Table 2. Nutritional level division based on abundance (ind/L).

Trophic type	Oligotrophication	Mesotrophication	Eutrophication
Phytoplankton	$<3\times10^5$	$3\text{-}10\times10^5$	$>10\times10^5$
Zooplankton	<1000	1000-3000	>3000

3. Results and Discussion

3.1. Composition, abundance and dominant species of phytoplankton

In May 2016, 11 species of phytoplankton were found in the survey area, among which 6 species, accounting for 54.5% of the total, belonged to chlorophyta and 5 species, accounting for 45.5% of the total, belonged to bacillariophyta. The phytoplankton cell abundance was between 3.71×10^4ind/L~5.31×10^4ind/L, with an average of 4.57×10^4ind/L. The distribution trends showed the high similarity of phytoplankton species and small spatial difference of abundance at each monitoring point (Figure 2). Chlorophyta accounted for most species of phytoplankton in the investigating waters, both in variety and quantity. *Closterium*, *Ulothrix* and *Achnanthes* were identified as dominant species based on the dominance (*Y*) greater than 0.02, which contributed 86.5% of the total number of phytoplankton. The dominance index, occurrence rate and cell abundance of the dominant species were listed in Table 3.

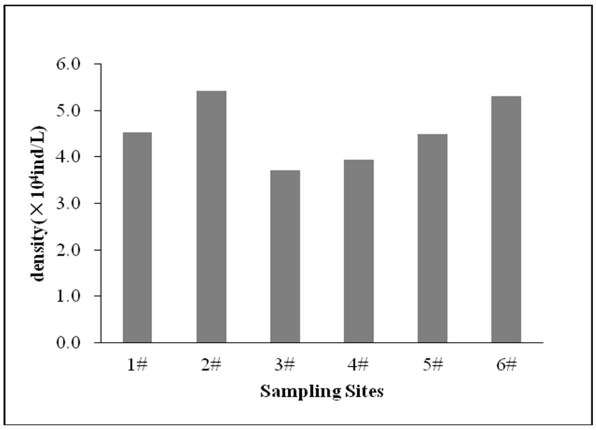

Figure 2. Density of phytoplankton.

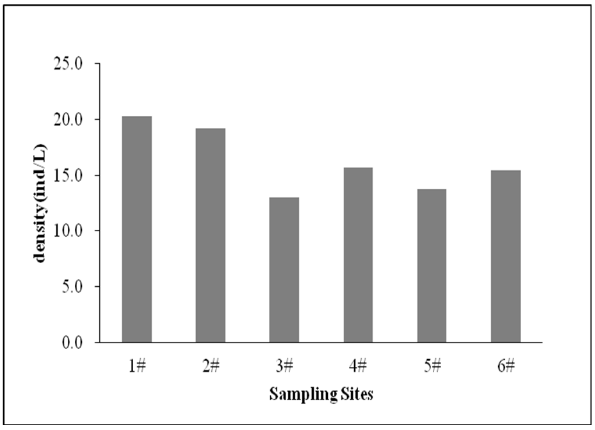

Figure 3. Density of zooplankton.

Table 3. Parameters for dominant species of phytoplankton.

Dominant species	Density($\times10^4$ind/L)	occurrence rate(%)	*Y*
Closterium,	3.02	66.7	0.073
Ulothrix	1.02	66.7	0.249
Achnanthes	8.11	83.3	0.247

3.2. Composition, abundance and dominant species of zooplankton

A total of 10 species of zooplankton were identified, including 70% of Cladocera, 20% of Rotifer and 10% of Copepod. The density of zooplankton was at 13.03ind/L~20.33ind/L, with an average value of 16.25ind/L. Zooplankton density varied little among the six monitoring stations (Figure 3). Six species of zooplankton were selected to be the dominant species including *Trichocerca longiseta*, *Bosmina fatalis*, *Diaphanosoma leuchtenbergianum*, *Daphnia (D.) cucullata*, *Bosmina longirostris* and

Sinocalanus, which accounted for 91.9% of the total number of zooplankton. The dominance index and cell abundance of the dominant species were listed in Table 4.

Table 4. Parameters for dominant species of zooplankton.

Dominant species	Density(ind/L)	*Y*
Trichocerca longiseta	45.84	0.47
Bosmina fatalis	16.18	0.138
Diaphanosoma leuchtenbergianum	4.95	0.042
Daphnia(D.)cucullata	5.51	0.047
Bosmina longirostris	9.90	0.068
Sinocalanus	7.26	0.062

3.3. Assessment based on richness and bio-indicators

The abundance of plankton both in the whole and each sampling point was below the minimum value by reference to the evaluation standard listed in Table2, from which a conclusion can be made that the Jiulong Lake was mainly in oligotrophication nutrition type. The composition of plankton community is a dynamic reflection of the comprehensive effects of various ecological factors such as physics, chemistry and biology in lakes. The pollution indicator species are important parameters for biological evaluation of water quality. In the analysis work, the dominant species of plankton are generally used to determine the nutritional status of the lake. The identification of plankton bio-indicators was carried out referring to the relevant literature [5]. The analysis results showed that the dominant species in every sampling point of Jiulong Lake were mostly clean type indicators and northern broad-spectrum species. Three dominant species of phytoplankton and six dominant species of zooplankton were identified in this survey with high density. Seven of them belonged to oligo group, including *Closterium*, *Ulothrix*, *Bosmina fatalis*, *Trichocerca longiseta*, *Daphnia(D.)cucullata*, *Bosmina longirostris* and *Sinocalanus.* The rest two species were o-β mesosaprobity. Therefore, based on the evaluation results of the phytoplankton and zooplankton pollution indicators, the water quality of Jiulong Lake was generally good, ranging from clean to slight pollution.

3.4. Assessment based on biodiversity indices

The biodiversity indices can reflect the characteristics of plankton community and water nutrient status under different environmental conditions, which are widely used as the basis for determining the pollution levels of water bodies. The diversity indices of phytoplankton and zooplankton of each sampling station are shown in Figure 4 and Figure 5 respectively. Shannon-Wiener diversity index of phytoplankton and zooplankton were at 2.94 to 4.57 and 3.54 to 4.24, with the average value of 3.71 and 4.05 respectively. Pielou evenness index of phytoplankton and zooplankton ranged from 0.59 to 0.92 and 0.66 to 0.78, with the average value of 0.713 and 0.725 respectively. According to Table 1, Jiulong Lake can be sorted as clean to slight pollution type, which was consistent with the results based the richness and bio-indicators evaluation.

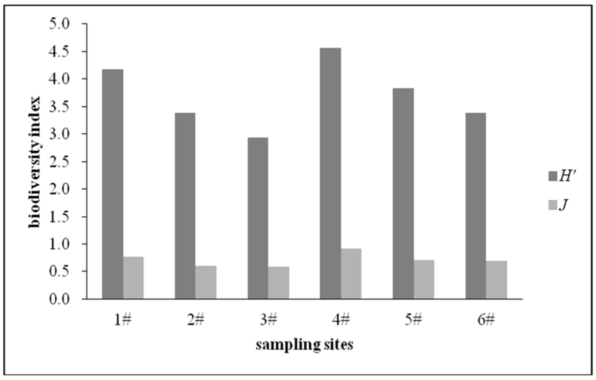

Figure 4. Biodiversity indices of phytoplankton.

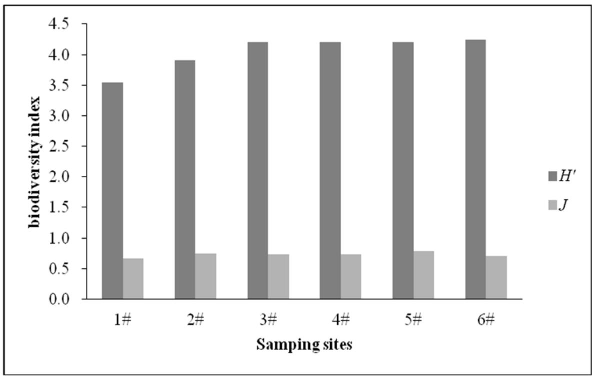

Figure 5. Biodiversity indices of zooplankton.

4. Conclusions

Biodiversity indices, uniformity, dominance and abundance are important parameters reflecting the characteristics of the bio-community structure and ecological environment in the surveyed waters. Based on the analysis of plankton community composition, the water quality and nutrient grade of Jiulong Lake were comprehensively evaluated by means of cell density, bio-indicators and biodiversity indices. The results showed that the species and abundance of plankton in Jiulong Lake were relatively low with small spatial differences both in plankton community structure and cell density. From an ecological point of view, the organic carbon and phosphate in the water area were relatively low, which directly affected the cell division and growth of phytoplankton and reduced the number of phytoplankton in the unit water, leading to a decrease in the primary productivity level and biomass of zooplankton in the area. According to the evaluation of plankton cell density, Jiulong Lake water body was at a level of oligotrophic nutrition, and could be sorted as clean to slight pollution type based on the analysis of biodiversity indices.

References

[1] Yuan, M.L., Zhang, C.X., Jiang, Z.J. (2014) Seasonal variations in phytoplankton community structure in the Sanggou, Ailian, and Lidao Bays. Journal of Ocean University of China, 13: 1012-1024.

[2] Sun, J., Liu, D.Y. (2004) The application of diversity indices in marine phytoplankton studies. Actaoceanologica sinica, 26: 62-75.

[3] Belaoussoff, S., Kevan, P.G., Murphy, S. (2003) Assessing tillage disturbance on assemblages of ground beetles (Coleoptera:Carabidae) by using a range of ecological indices. Biodiversity and Conservation, 12: 851-882.

[4] Zheng, B.H., Tian, Z.Q., Zhang, L. and Zheng, F.D. (2007) The characteristics of the hydrobios' distribution and the analysis of water quality along the west shore of Taihu Lake. Acta Ecologica Sinica, 27: 4214-4223.

[5] Zhang, H.L., Sun, L.N., Luo, Q. (2011) Seasonal variations and sources of pollutants in surface water of Hunhe River. Chinese Journal of Ecology, 30: 119-125.