

Community structure of macrozoobenthos and the evaluation of water environment in Lake Baima, Jiangsu Province, China

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Abstract. To characterize the community structure of macrozoobenthos and evaluate the water environment in Lake Baima, macrozoobenthos were investigated at 11 sites of Lake Baima monthly in 2016. Water quality was evaluated based on the Environmental Quality Standards for Surface Water (GB3838-2002, in Chinese), comprehensive trophic level index and biological indices. A total of 16 species were recorded, belonging to 4 phyla, 16 orders, including 8 chironomids, 3 oligochaetes, 2 Mollusca, and 3 other species. The mean density and biomass of macrozoobenthos were 277.06 ind./m² and 31.3953 g/m², respectively. *Tanypus chinensis*, *Limnodrilus hoffmeisteri*, *Branchiura sowerbyi*, *Prosilocerus akamusi*, *Chironomus plumosus* and *Bellamyia* sp. were the dominant species in Lake Baima. Higher spatial heterogeneity was observed for the mean biomass than the mean density. The highest density was recorded in the central sites, and relatively lower values were observed in the offshore sites. The biomass presented the opposite distribution pattern compared with density. It showed that the lake was moderately polluted at a mesotrophic level, and the eutrophication strongly influenced the structure of macrozoobenthic assemblages in Lake Baima. As an important water source and aquaculture site, more attention should be paid on water environment protection in Lake Baima.

1. Introduction

Natural physical processes and human activities are two chief influencing factors which control the biodiversity in freshwater ecosystems, occurring at different spatial-temporal scales [1]. Macrozoobenthos is an important element in freshwater ecosystems, presenting a vital role in environmental quality assessment of aquatic ecosystems [2]. Shallow lakes are important freshwater resource to human, and have been affected in industrial use, aquaculture and agricultural irrigation by human with the same time. Nutrient inputs are very high in shallow lakes [3]. The major shallow lakes place along the Yangtze River, in China [3]. However, the study of regional processes and environmental conditions on the biodiversity of macrozoobenthos is deficient in this region [4]. In China, eutrophication is the most prominent problem to freshwater shallow lakes [5-7], and the algal blooms are becoming a normal state [8]. With the society increasing and economy developing, water quality deterioration should be gotten enough attention [9,10]. The pollution-tolerant taxa play an important role in evaluating the eutrophication of freshwater shallow lakes, chironomidae and tubificidae in particular [11].

In this study, we select Lake Baima as the study area, which located in the Huai River's lower reaches, in China. Because of the excessive agriculture development and aquaculture, the aquatic ecological environment of Lake Baima is becoming worse and worse. The present study, based on



twelve cruises surveys (monthly in 2016), the distribution of macrobenthic community was investigated with spatial pattern and temporal dynamics in Lake Baima. The structure of macrobenthos and nutrition's degree were presented in this paper, and the relationship with environmental conditions was also analyzed. Four taxonomic diversity indices were calculated to evaluate the levels of eutrophication and ecosystem health of Lake Baima.

2. Methods

2.1. General information of Lake Baima

Lake Baima (33°09'-33°19'N, 119°02'-119°12'E), located in the south-east of Huai'an city, Jiangsu Province. The impounded area of Lake Baima is 117.5 km², with the water retention capacity of 1.05×10^8 m³. The length is 17.8 km in north-south direction. The mean bottom elevation is about 5.33 m (1985 National Height Datum). Lake Baima is a shallow aquatic vegetation lake, with the major flowing-in river channel (Caoze River, Wei River, Hua River, Yongji River, Wenshan River) and the major flowing-out river channel (Xin River, Yunxi River, Ruanqiao River, Baimahuyin River). The water quality of Baima Lake is mainly affected by urban industrial sewage discharge, agricultural non-point source pollution, and high-density fishery farming.

2.2. Water analysis and macrozoobenthos sampling [12]

There were 11 sampling sites in Baima Lake (figure 1), which were located at the offshore zone and the centre. The field investigation was divided into two parts, water analysis and macrozoobenthos collection. The sampling frequency is monthly, from January to December 2016. DO, pH, turbidity, conductivity were collected and analyzed by multi-parameter water quality detector (YSI-EXO₂), and transparency was collected by Plug's plate. The *Chl-a*, TP and TN were pre-processed and analyzed in lab. The water collection and analysis refer to Environmental Quality Standards for Surface Water (GB3838-2002, in Chinese). The macrozoobenthos samples were collected with Peterson's grab (0.021 m²), and filtered by a 250µm aperture mesh size sieve. The macrozoobenthos samples were preserved in 7% buffered formalin. In the laboratory, samples were classified, counted, and weighted [13,14].

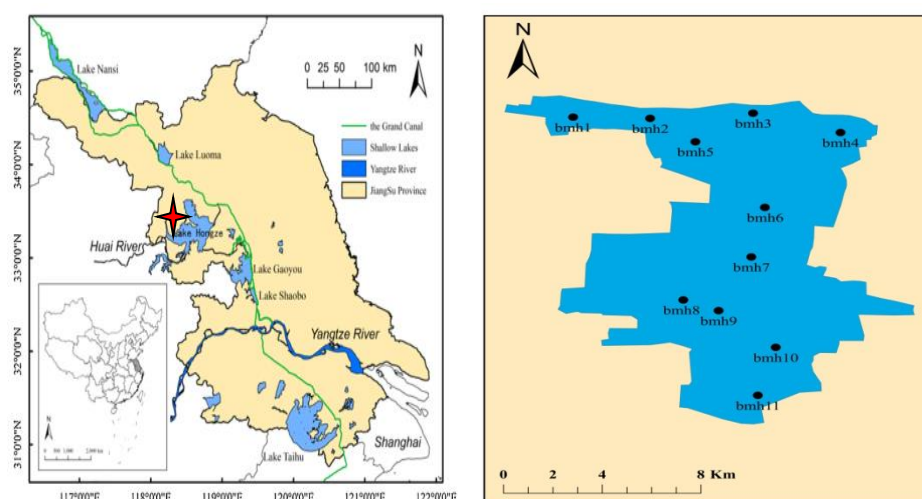


Figure 1. 11 sampling sites in Baima Lake, China.

3. Results and analysis

3.1. Water quality

The results of water quality were presented in table 1. Turbidity, transparency, *Chl-a*, TN and TP

varied greatly among the sampling sites. The high concentration of *Chl-a*, TN, TP and the turbidity were mainly distributed in the north of Baima Lake. The low concentration was distributed in the south and centre. On the contrary, the transparency of northern sampling sites was low. There was a lot of purse seines in the north of Baima Lake. The nutrient emission from fishery breeding was the major cause. The nutrient state calculated from transparency, *Chl-a*, TP and TN also presented more eutrophic in the north (TSI > 60). The TSI of the southern sampling sites was lower than 60. The south of Baima Lake was consisted by a lot of wetlands, with few anthropogenic activities.

Table 1. The water quality of 11 sampling sites collected in Lake Baima.

Parameter		bmh1	bmh2	bmh3	bmh4	bmh5	bmh6	bmh7	bmh8	bmh9	bmh10	bmh11
DO	mg/L	11.6±1.6	12.6±2.3	12.4±2.3	12.0±3.6	11.7±3.0	7.9±3.6	10.5±1.5	7.7±4.0	9.1±3.3	7.9±3.2	8.5±2.5
pH		8.60±0.39	8.79±0.51	8.86±0.42	8.76±0.63	8.69±0.58	8.16±0.32	8.63±0.32	8.11±0.40	8.37±0.42	8.20±0.34	8.34±0.28
Turbidity	NTU	45.7±49.3	31.3±21.5	24.6±8.4	23.7±10.2	25.2±12.1	16.8±5.8	10.6±5.5	8.9±5.3	4.4±4.0	2.4±0.8	54.9±124.9
Conductivity	µS/cm	552±94	510±73	480±80	470±85	491±77	463±95	458±108	437±111	429±121	420±115	427±132
Transparency	cm	29±20	35±5	39±6	39±10	40±6	53±7	71±4	71±4	111±6	133±34	117±4
<i>Chl-a</i>	µg/L	23.6±14.4	30.6±20.46	26.0±12.3	24.8±11.8	39.1±32.2	17.3±5.9	14.9±8.3	9.7±6.2	13.1±15.5	4.8±4.6	7.1±7.9
TP	mg/L	0.18±0.20	0.11±0.04	0.1±0.05	0.08±0.02	0.1±0.02	0.14±0.15	0.11±0.11	0.12±0.13	0.04±0.03	0.04±0.02	0.04±0.03
TN	mg/L	2.07±0.44	1.68±0.92	2.24±0.77	1.7±0.28	2.74±0.94	1.44±0.59	1.83±1.33	1.4±0.16	0.86±0.34	0.72±0.11	0.64±0.28
TSI		66.19	63.68	63.34	61.31	65.42	60.18	58.35	56.17	49.38	44.37	45.88

3.2. Classification and spatial pattern fo macrozoobenthos

A total of 16 species were recorded, belonging to 4 phyla, 16 orders, including 8 *chironomids*, 3 *oligochaetes*, 2 *Mollusca*, and 3 other species. The *Limnodrilus hoffmeisteri* and *Branchiura sowerbyi*, the *Rhyacodrilus sinicus* and *Tanytus chinensis*, the *Prosilocerus akamusi* and *Chironomus plumosus* contributed the highest frequency of occurrence among the twelve months' sampling. In terms of density, the *Limnodrilus hoffmeisteri* and *Tanytus chinensis* represented 30.99% and 15.49% of the total density, respectively. In terms of biomass, it was mainly dominated by *Bellamyia sp.* (87.63%) and *Alocinma longicornis* (4.33%). The mean density and biomass of macrozoobenthos in Baima Lake were 277.06 ind./m² and 31.3953 g/m², respectively (table 2). The dominant species in Lake Baima were *Limnodrilus hoffmeisteri* and *Tanytus chinensis*, *Prosilocerus akamusi* and *Chironomus plumosus*, *Bellamyia sp.* and *Branchiura sowerbyi*.

Table 2. The density and biomass of macrozoobenthos collected in Lake Baima.

Taxa	Density		Biomass		Occurrence	Dominance index
	ind./m ²	%	g/m ²	%		
<i>Oligochaeta</i>						
<i>Limnodrilus hoffmeisteri</i>	42.93	15.49	0.1238	0.39	11	174.78
<i>Branchiura sowerbyi</i>	32.47	11.72	0.6120	1.95	9	123.01
<i>Rhyacodrilus sinicus</i>	11.18	4.04	0.0056	0.02	10	40.54
<i>Chironomidae</i>						

<i>Tanytus chinensis</i>	85.86	30.99	0.1704	0.54	8	252.26
<i>Prosilocerus akamusi</i>	27.42	9.90	0.1580	0.50	7	72.79
<i>Chironomus plumosus</i>	25.97	9.37	0.6980	2.22	7	81.19
<i>Chironomus plumosus-reductus</i>	3.25	1.17	0.1039	0.33	4	6.01
<i>Chironomus semireductus</i>	3.61	1.30	0.0260	0.08	1	1.38
<i>Glyptotendipes tokunagai</i> Sasa	3.97	1.43	0.0020	0.01	4	5.75
<i>Endochironomus</i> sp.	2.53	0.91	0.0177	0.06	7	6.77
<i>Polypedilum</i> sp.	1.44	0.52	0.0014	0.00	2	1.05
Mollusca						
<i>Bellamya</i> sp.	22.37	8.07	27.5108	87.63	6	574.20
<i>Alocinma longicornis</i>	10.46	3.78	1.3600	4.33	3	24.32
Other Species						
<i>Glossiphonia complanata</i>	1.80	0.65	0.1263	0.40	2	2.11
<i>Erpobdella octoculata</i>	0.72	0.26	0.4545	1.45	1	1.71
<i>Nereis succinea</i>	1.08	0.39	0.0249	0.08	2	0.94

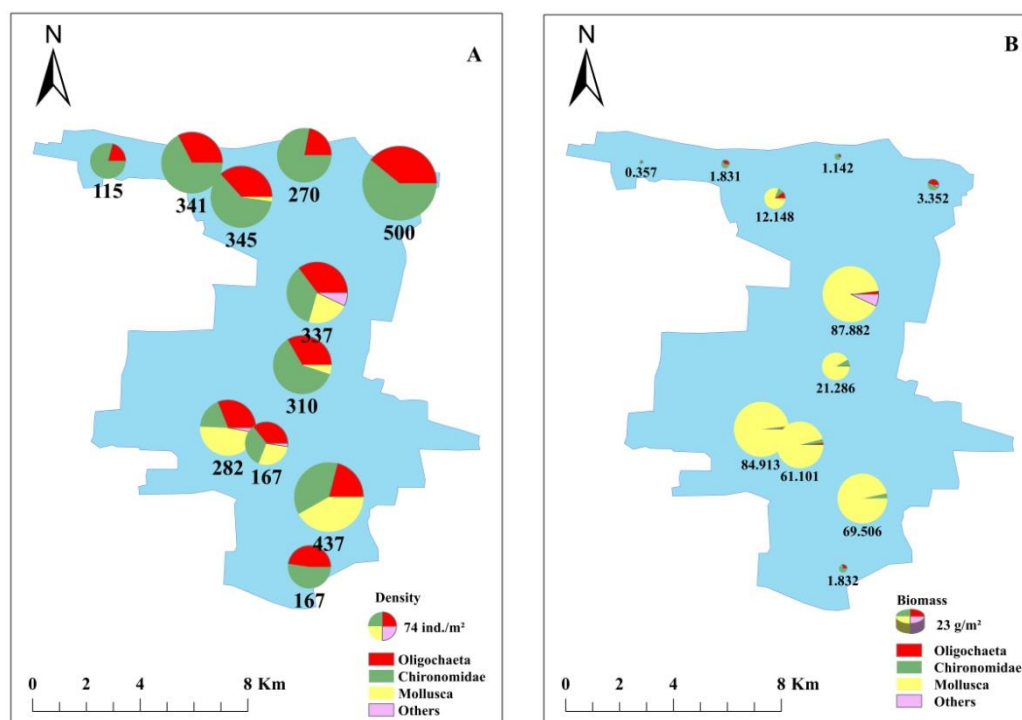


Figure 2. Spatial patterns of macrozoobenthos collected in Lake Baima.

Higher spatial heterogeneity was observed for the mean biomass than the mean density (figure 2A). The highest value of density was obtained at bmh3, and the offshore sites (bmh1, bmh9, bmh11) presented relatively lower values. These sites were dominated by *Oligochaeta* (of total density), and *Chironomidae*. Total biomass also varied considerably (0.00–87.63 g/m², figure 2B). Compared with

density, the biomass presented an opposite distribution pattern. The lowest values of biomass was recorded in some offshore sites (bmh1-5, bmh11) dominated by *Mollusca*. Relatively high biomass was found in the centre (bmh6, bmh8) and mainly characterized by *Bellamyia sp.*, and *Alocinma longicornis*.

3.3. The biodiversity indices of macrozoobenthos

The Wright, Goodnight, BPI and Shannon-Wiener indices indicated relatively low evenness and diversity of benthic community in Lake Baima (figure 3). Physiochemical parameters and macrozoobenthic community structure were compared among the regions of Lake Baima. Water quality was evaluated based on the surface water environmental quality standard, comprehensive trophic level index and biological indices. It showed that the lake was moderately polluted at a mesotrophic level. As an important water source and aquaculture site, more attention should be paid on water environment protection in Lake Baima.

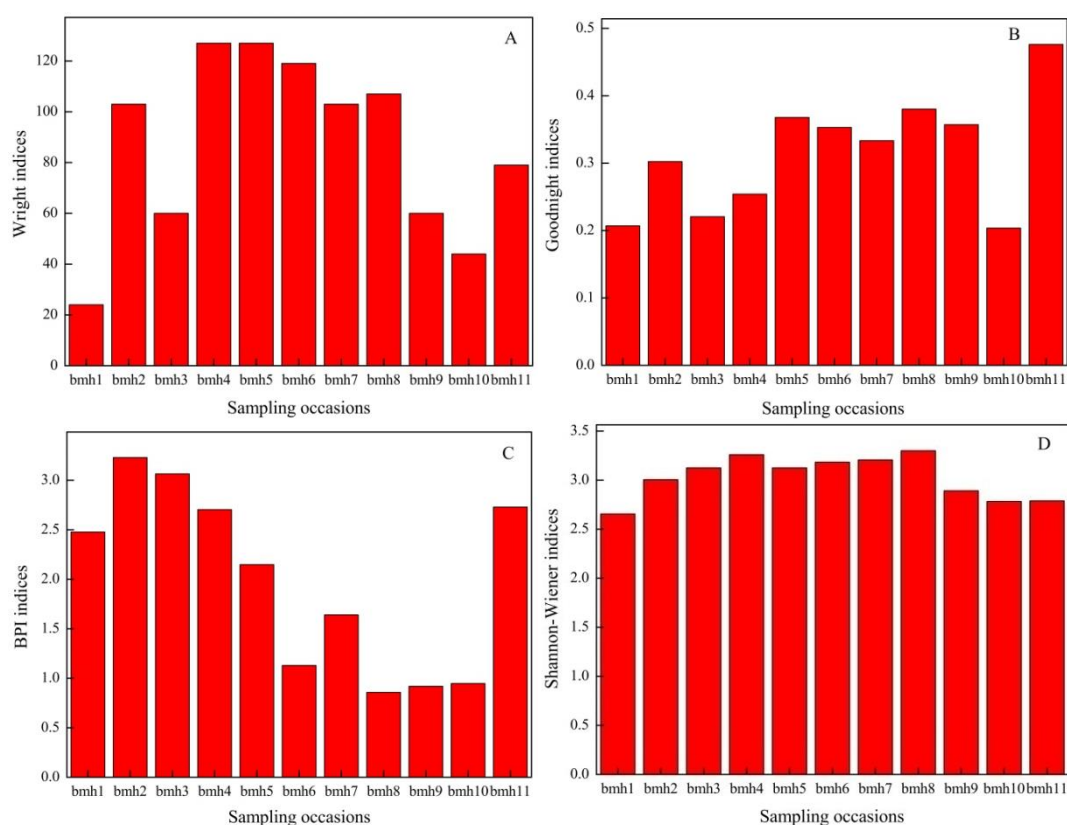


Figure 3. The Wright (A), Goodnight (B), BPI (C) and Shannon-Wiener (D) indices of macrozoobenthos collected in Lake Baima.

It has to be noted that *Nereis succinea (polychaete)* was recorded in Lake Baima. The *Nereis succinea* was commonly considered to be estuarine and marine species. The lower reaches of the Yangtze River was also a major habitat [15]. Because of the tide and the flow from the upstream of Yangtze River, the estuarine and marine species moved against the stream. With the South-to-North Water Diversion Project, *Nereis succinea*'s appearance in Lake Baima made sense.

4. Conclusions

In summary, this paper demonstrated distinct spatial pattern of macrozoobenthos between the offshore and central zones. In this paper, 16 species were identified from 132 samples. Comparing with the

water quality, the results indicated that eutrophication was highly correlated with macrozoobenthos' spatial pattern. It showed that the lake was moderately polluted at a mesotrophic level. As an important water source and aquaculture site, more attention should be paid on water environment protection in Lake Baima.

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