Acta Ecologica Sinica 36 (2016) 16–22

Contents lists available at ScienceDirect

Acta Ecologica Sinica

journal homepage: www.elsevier.com/locate/chnaes

# Temporal and spatial distribution of macrobenthos communities and their responses to environmental factors in Lake Taihu

Zhao Xie [a], Jie Zhang [a], Kun Cai [b], Zhao'an Xu [c], Donghao Wu [c], Beixin Wang [a,*]

[a] *Laboratory of Aquatic Insects and Stream Ecology, Department of Entomology, Nanjing Agricultural University, Nanjing 210095, China*
[b] *Jiangsu Environmental Monitoring Center, Nanjing 210036, China*
[c] *Monitoring Center of Hydrology and Water Resource, Lake Taihu Basin, Wuxi 214024, China*

ARTICLE INFO

*Article history:*
Received 27 March 2014
Received in revised form 13 January 2015
Accepted 6 April 2015

*Keywords:*
Macrobenthos
Spatiotemporal variation
Environmental variables
Lake Taihu

ABSTRACT

Study of the responses of macrobenthos communities structure to environmental gradients is a hot topic in community ecology and environmental assessment. Macrobenthos communities are not only influenced by environmental gradients, but also caused by life-cycle, hydrologic, water temperature, feeding resources or habit heterogeneity especially for the seasonal changes of structure and composition. The seasonal change may mask the effect introduced by environmental gradients. At the same time, macrobenthos has fixed habits because the long life history and low athletic abilities, and the distribution of macrobenthos community demonstrate habit difference caused by human activities and natural difference. Research about macrobenthos community spatial and temporal variability has an important means for biological assessment. To explore the distribution and seasonal change of macrobenthos communities and their responses to environmental factors in Lake Taihu, 12 metrics based on abundance, diversity, functional feeding group, dominance and tolerance value were chosen to represent macrobenthos community. We seasonally investigated macroinvertebrate assemblages and local environment at 18 sites in Lake Taihu from the winter of 2010 to the autumn of 2012. A total of 42 macrobenthos species were collected, including 15 species of molluscs, 10 species of annelids, and 17 species of arthropods. Indicator Value Analysis indicated (ISA) that *Corbicula fluminea*, *Limnodrilus hoffmeisteri* and *Tubificidae* sp. were the indicator species of the whole lake each with a indicator value of 84.21. In the North Bays, *L. hoffmeisteri*, *C. fluminea* and *Polychaeta* sp. with the indicator values of 57.54, 51.23 and 48.92 respectively were the indicator species. In the East Bays, *Nephthys* sp., *Branchiura* sowerbyi and *Bellamya aeruginosa* were the indicator species with indicator values of 48.01, 37.53 and 37.26 respectively. In the Open Lake Area, *C. fluminea*, *Nephthys* sp. and *Cythura* sp. were the indicator species with indicator value of 30.79, 25.61 and 23.28 respectively According to Generalized Linear Mixed Models, variations of macrobenthos community metrics within regions and seasons were of significant difference, the seasonal changes of macrobenthos community metrics exist throughout the sampling years. Distance-based linear models (DistLM) were used to examine the relationships between macrobenthos community metrics and environmental factors. The key environmental variables related to macrobenthos community were total nitrogen (TN), total phosphorus (TP) and ammonia nitrogen ($NH_4^+$) in North Bays, pH, total nitrogen (TN) and water temperature (T) in East Bays, and dissolved oxygen (DO) and water temperature (T) in Open Lake Area. In addition, abundance-based macrobenthos metrics best responded to the environmental factors. The result of distance-based linear models indicated that North Bays and East Bays were better explained by environmental factors relative to Open Lake. For macrobenthic community metrics, metrics based on abundance were better explained by environmental factors. The forward selection suggested that TN, TP and $NH_4^+$ were the main environmental factors affecting macrobenthic community in North Bays. PH, TN and water temperature were the main environmental factors affecting macrobenthic community in East Bays. DO and water temperature were the main environmental factors affecting macrobenthic community in Open Lake.

© 2015 Elsevier B.V. All rights reserved.

The increasing influence of human or anthropogenic activities on lake ecosystems also changed the ecology of these water bodies to a great extent. These changes on the other hand also facilitated the rapid development of relevant monitoring and bio-assessment methods for lake water quality [1]. Lake macrobenthos have poor mobility, long life-cycles and ability to respond to apparent changes. They are also an important part of the energy flow and food chain of lake ecosystems [2]. Changes in the community structure of the benthic macro-invertebrate also correlate very well with

* Corresponding author.
*E-mail address:* wangbeixin@njau.edu.cn (B. Wang).

http://dx.doi.org/10.1016/j.chnaes.2015.12.005
1872-2032/© 2015 Elsevier B.V. All rights reserved.

changes in some environmental factors [3–5]. Thus, they are often used as biological indicators for monitoring and managing aquatic environments.

The study of the changes in the community structure in response to the environmental gradient is a hot topic in community ecology, species protection and environmental assessment [6–8]. However, certain limitations and considerations exist in using these benthos community in assessing the influences and responses to anthropogenic interference, especially when comparing data at different temporal and spatial scales. It is because the structure of the benthic community is not only affected by anthropogenic interference but also by the inherent spatiotemporal differences in the community structure [9–15]. For example, seasonal variation significantly affects the structure of the benthic community, which in turn is affected by seasonal changes in hydrology and life history of organisms [9–11]. Furthermore, as a result of weak dispersal ability and habitat heterogeneity, obvious differences in the species composition and structure of benthic communities in different climatic zones, ecological areas and even between different habitats are also observed [12–15]. There might be risks to amplify the effect of human disturbance on the structure of benthic communities if the potential spatiotemporal differences are ignored when conducting biological monitoring or evaluation, thus affecting the accuracy of the results. Prior information on the temporal variability of the community of benthic species and community structure would therefore help improve the reliability and comparability of biological evaluations from different time scales. Furthermore, it would avoid over reliance on the hypothesis that on large time scales (e.g. annual), the composition and structure of the benthic community are relatively stable [13]. In addition, the relatively stable characteristics of the spatial distribution of benthic animals may be closely related to the natural variations in the ecosystems in different areas or could be the long-term impact of human activities. Therefore, knowledge of spatiotemporal variations and the underlying mechanisms of macrobenthic community structuring will contribute to the further scientific understanding of the reasons behind these ecological differences, and will eventually help in improving methods for biological assessment of water quality [14,15].

This study aims to analyze the temporal and spatial variations in the community structures of the benthic macrofauna in the different districts of Lake Taihu, namely the North Bay, East Bay and Open Lake from winter 2009 to autumn of 2012. In addition, we would also like to understand the different environmental factors affecting the structuring of benthic faunal community (e.g. 12 parameters reflecting the community structures such as the population density, diversity index, the parameters of feeding functional groups etc.) in the different areas or regions of the lake. Finally, we aim to identify the suitable biological species and community parameters which could be potential indicators of environmental changes specifically of human made disturbances, and later be used as references for the biological assessment of water quality in Lake Taihu.

## 1. Materials and methods

### 1.1. Study area and sampling sites

Lake Taihu is found in the Yangtze River Delta with a total area of 2338 $km^2$ and considered to be one of China's five largest lakes [16]. The annual average depth was 3.19 m (2010 to 2012) and receives an average rainfall of 1499 mm per year, with a mean temperature 17.0 °C [17].

The different districts of the lake, referred to here as the North and East Bays, and Open Lake, were classified according to sediment type, variety of aquatic plants, wind disturbances and other parameters present as described by Cai Yongjiu *et al.* [18,19]. The North Bay is mostly covered by thick, soft sediments (>20 cm) [19,20] and has sustained severe interference from anthropogenic activities. The water is eutrophic which triggered algal bloom outbreaks in the area in the past [21]. East Bay on the other hand is a typical shallow grass bay, rich in aquatic vegetation. Before 2009, the eutrophication and swampiness were severe, and were heavily impacted by purse seine agriculture and habitat quality was seriously degraded [22]. The Open Lake area receives the most disturbances from wind all year-round, and therefore the water nutrient level is low and had less sediment [19,20].

In this study, six (6) sampling sites were uniformly chosen in each of the North Bay, East Bay and the Open Lake areas as shown in Fig. 1, totaling to 18 sampling sites. Biological and water samples were collected from January 2010 to October 2012 every 3 months in each of the 18 sampling sites. A total of 12 samples were collected from different seasons belonging to different years at each sampling location.

### 1.2. Benthic fauna and environment variables

#### 1.2.1. Physical and chemical data

During sampling, some physico-chemical parameters were measured and determined on sites like water temperature, transparency, dissolved oxygen (DO) and pH. In the laboratory, total nitrogen (TN), total phosphorus (TP), ammonia ($NH_4^+$) and the chemical oxygen demand (COD) were determined following the methods described in the manual "The analytic methods for the monitoring of water and wastewater (4th edition)" [23].

#### 1.2.2. Macrobenthos

The benthic fauna samples (biological) were collected by a 1/16 $m^2$ Peterson sediment sampler. Samples were collected in replicate quadrats at each sampling point. The sediment samples were sieved through 60 unit mesh sieve at the site and fixed by adding 8% formaldehyde solution (final concentration), while the other biological samples were brought back to the laboratory for sorting, identification and enumeration. Individual specimens belonging to phylum Mollusca were classified down to the species level following Cai Ruxing *et al.* [24], other species on the other hand were classified to genus level as described by Hou Zhonge *et al.* [25–28].

### 1.3. Data processing

Shannon–Wiener diversity index (SWDI) and Simpson diversity index (SDI) [29] were calculated using PRIMER6.0. Data were summarized and tabulated in Excel 2013. After which, we calculated for overall density, *chironomid* larval density, taxonomic diversity and relative abundance (%) of the crustaceans, molluscs, polychaeta, collectors, advantage taxa, top three advantage taxa, proportion of the pollution tolerant taxa and the BI index (Table 2) [30]. Index selection was carried out following Cai Kun's result of integrated screenings which is based on the discriminative ability of the biological indices in Lake Taihu area and their responsiveness to environment correlates and biological significance [16].

The indicator species for the whole Lake Taihu and each areas were identified using Indicator Species Analysis (ISA) implemented in PC-ORD. ISA is used to identify the values of the indicator species using the richness and the occurrence frequency of the species. The greater the indicated value, the stronger the potential of a particular species as an indicator [31].

Generalized linear mixed model (GLMMIX) was used to compare differences among the benthic community parameters in all temporal and spatial scales. The differences in the indices of the community structure of the benthic fauna between sampling sites and gradients in different sampling seasons were determined by the single-factor variance analysis test using SPSS 20.0. Before the analysis, each parameter was tested for normal distribution [32,33]. For the parameters that did not conform with normal distribution, data transformation was used for standardization. GLMMIX was constructed by using the package Mass implemented in R software.

Download English Version:

https://daneshyari.com/en/article/4379759

Download Persian Version:

https://daneshyari.com/article/4379759

Daneshyari.com