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Biological Evaluation of Water Quality for Benthos in Typical Rivers of Eastern Jilin Province

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Abstract Benthos are aquatic organisms living at the bottom of water bodies for all or most of their life history. Apart from the settled and moving living, their forms of habitat are mostly attached to the hard substrate like rocks or soft bases such as mud and sand. In addition, there are benthic species that attach to the plant surfaces or other benthic animals, and inhabit the intertidal zone. In terms of feeding methods, most benthic animals feed on suspended matter and sediment. Most of them are invertebrates and are a complex ecological group. According to the size, they can be divided into macrobenthos and meio-benthos[1]. Benthos are an important part of the water ecosystem. Using a typical river (Gaya River) in eastern Jilin Province, this paper analyzed the water quality, the components of benthic organisms and their biological density through sampling surveys of three typical locations in the upper, middle and lower reaches of the Gaya River. In addition, it made a biological evaluation of the water quality of the Gaya River.

Key words Eastern Jilin Province, Typical River, Benthos, Evaluation scheme

1 Introduction

Benthos are aquatic organisms living at the bottom of water bodies for all or most of their life history. Apart from the settled and moving living, their forms of habitat are mostly attached to the hard substrate like rocks or soft bases such as mud and sand. In addition, there are benthic species that attach to the plant surfaces or other benthic animals, and inhabit the intertidal zone. In terms of feeding methods, most benthic animals feed on suspended matter and sediment. Most of them are invertebrates and are a complex ecological group. According to the size, they can be divided into macrobenthos and meio-benthos[1]. Benthos are an important part of the water ecosystem. The *National Hydrological Infrastructure Construction Plan* (2013 -2020) issued jointly by National Development and Reform Commission (NDRC) and the Ministry of Water Resources pointed out that it is necessary to further strengthen the construction of hydrological infrastructure around water ecological monitoring. After monitoring and comparing the water environment quality, hydrological quality, biological quality and other ecosystem elements of the major nine rivers in the Yanbian Korean Autonomous Prefecture in eastern Jilin Province, we selected the Gaya River, a typical river to evaluate the effects of Benthos on water quality, plankton and aquatic ecological safety, so as to provide a practical technical reference for carrying out biological monitoring of river water ecological monitoring in an economical and efficient manner.

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2 General physical and geographical conditions of the Gaya River

The Gaya River originates from the southeast of the Sanchang Peak in the Laosongling Mountains in Wangqing County. Its large tributaries include Chunyang River with drainage area of 940 km^2 and river length of 60 km, Qianhe with drainage area of 729 km^2 and river length of 56.4 km and Wangqing River with drainage area of 1 250 km^2 and river length of 85.9 km. After the Burhatong River, a major tributary on the northwest right bank of Qushui Village in Tumen City merges, the Gaya River flows into the Tumen River in the northeast of Tumen City. It is 205 km long with the average river slope of 1.6‰. Above Tianqiaoling, it runs through deep mountains and valleys. Between Tianqiaoling and Xiweizi, the river valley is 0.5 -1.0 km wide, the river course is curved, the river channel is narrow and deep, the bottom of the river is sand, pebbles, and willows, elms and weeds grow on both banks. The river valley below Xiweizi is 1.5 -2.0 km wide, with a lot of arable land, curved river channels, and sand and pebbles at the bottom of the river[2].

As the largest tributary of the Tumen River, the Gaya River originates from the western foothills of Sanchang Mountain in Laoye Ridge in the northern part of the county. Its total length is 216 km and drainage area is 13 614 km^2. Tumen River runs through 9 villages and towns, including Dongxin, Tianqiaoling, Daxinggou, Dongzhen, Wangqing, Xiweizi, Zhong'an, Baicaogou, and Xinxing in Wangqing County. It accepts 74 large and small tributaries along the way, with a flow length of 180.7 km, the annual runoff of 12.5 billion m^3 and drainage area of 6 242 km^2. The Gaya River is divided into two sections, the upper section and the lower section, with Xiweizi as the boundary. The upstream flow is small and the river channel is narrow, especially above Tianqiaoling, the forest is dense, and there are many mountains and valleys, the water is turbulent, and the drop is large. Below Tianqiaoling, the flow increases gradually, and the river becomes wider, and willows, elms and weeds grow along the riverside. The lower reaches of the river meandering, the water is gentle, there are willows, elm trees, weeds, *etc.* along the bank, and the two banks are mostly flat land[3].

3 Experiment point selection and sampling methods

3.1 Experiment point selection In the upper, middle and lower reaches of the Gaya River, we selected Chunyang Town, Tianqiaoling Town, and Daxinggou Town as the monitoring points. The geographical distribution is shown in Fig. 1.

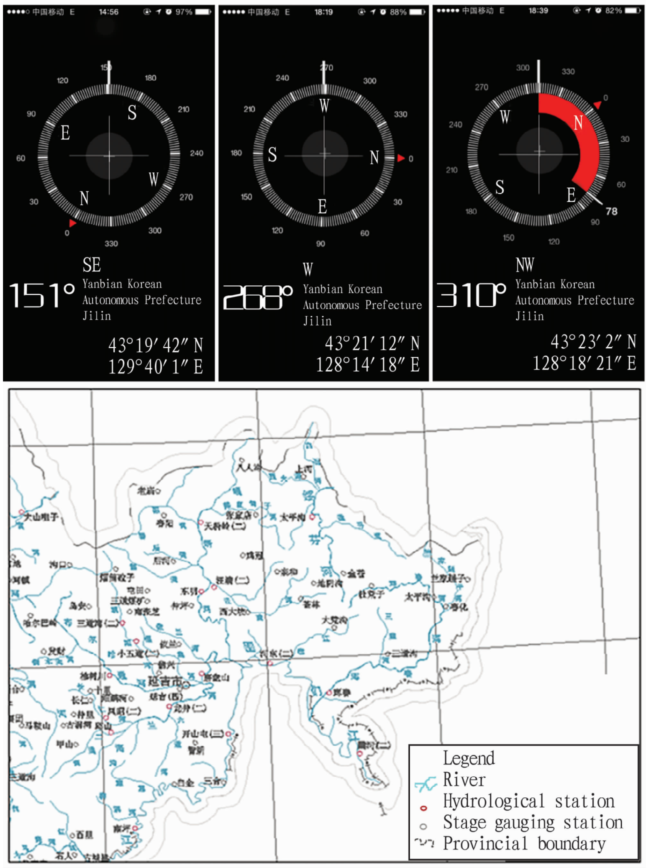

Fig. 1 Geographical distribution of monitoring points

3.2 Sampling methods Considering the special topography of the riverside and the surrounding geographical environment, we used a combination of triangular trawl sampling and mud picker sampling in the bottom biological sampling.

When the water body is too deep to use other qualitative medicine collection equipment, we put the triangular trawl into the water at the sampling point, pull a distance on the boat to get the bottom material, after lifting it, rinse part of the bottom mud in the trawl in the water and pour it into the bucket to wash, pass through a 40-mesh sample sieve, put the sample into the sample box, attach the label, put it into the incubator and send it to the laboratory[4].

When the water body is deep and the bottom of the mud is sandy, the Peterson mud picker is usually used. When using it, open the mud picker, hang the lifting ditch, hold the end of the rope with left hand, and slowly put the mud picker into the bottom of the water with right hand, shake off the lifting ditch and gently lift it up 20 cm. It is estimated that after the two blades are closed, pull it out of the water. Pour the mud into the bucket to wash, pass through a 40-mesh sample sieve, pick out the benthic organisms remaining on the sieve surface, add an appropriate amount of water, seal, attach the label, place in an incubator and take it back to the laboratory.

For the water quality sampling, we adopted the conventional sampling method. Double samples were collected in parallel at the biological sampling point. After sampling, the fixative was added according to the requirements of the sampling items and sent to the laboratory for monitoring within 24 h.

4 Laboratory classification and water quality experiment

4.1 Biological assay Samples that are not sorted on site need to be sorted and fixed in the laboratory. Samples are vulnerable to spoil and deteriorate, so they should be sorted as soon as possible after they are taken to the laboratory. Because the sampling route is longer this time, we adopted the method of sampling on the same day and sorting on the same day.

After sorting and investigation, most of the benthic animals in the Gaya River belong to the Platyhelminthes, Nematomorpha, Annelida, Mollusca, and Arthropoda.

The following types have larger biomass:

Branchiura sowerbyi of Plesiopora, Oligochaeta in Annelida: This kind of organism is very large, and it is common in polluted water bodies.

Limnodrilus helveticus Piguet of Plesiopora, Oligochaeta in Annelida: This kind of organism is common in mild-medium polluted water bodies.

Whitmania pigra of Gnathobdellida in Hirudinea in Annelida: This kind of organism does not suck blood, but suck plankton in the water, small insects, *etc.*, and it is common in medium-polluted water bodies.

Erpobdella octoculata of Rhynchobdellae, Hirudinea in Annelida: Like *Whitmania pigra*, this kind of organism is common in medium-polluted water bodies.

Bellamya and *Cipangopaludina cahayensis* of Mesogastropoda, Gastropoda in Mollusca live in fresh water and are common in medium-polluted water bodies.

Anodonta fluminea and *Anodonta woodiana* (*or Sinanodonta woodiana*) of Unionida in Mollusca are common, and *Corbicula fluminea* of Unionida in Mollusca also has a wide distribution.

Palaemon in Malacostraca of Arthropoda is generally distributed in the upper reaches of the river, in areas with better water quality.

Ephemeroptera and Plecoptera of Insecta in Arthropoda are more common in the middle and lower reaches of rivers, and *Caddisfly announcement* and the like are common in the lower reaches of rivers.

4.2 Water quality test After collecting samples in the 3 sections, we tested the the monitoring samples in accordance with the surface water detection method specified in the *Environmental Quality Standards for Surface Water* (GB2828-2002), and evaluated the water quality according to the five types of surface water evaluation standards stipulated in the *Environmental Quality Standards for Surface Water* (GB2828-2002).

5 Biological evaluation of water quality

5.1 Biological evaluation In China, the most comprehensive evaluation method for benthic organisms is the Biotic Index (*BI*), which is a benthic water quality evaluation method based on the pollution tolerance value of benthic organisms.

The *BI* is currently one of the major water quality biological evaluation indexes recommended by the Environmental Protection Agency of the United State of America[5]. Its calculation formula is as follows:

$$BI = \sum (TVi)(Ni)/N$$

where *TVi* is the pollution tolerance value of the i^{th} classification unit, *Ni* denotes the number of the i^{th} classification unit, and *N* is the total number of organisms. The *BI* of benthos is characterized by the addition of the pollution tolerance values of different classification units (mainly genera and species) in the formula. Tolerance value (TV) refers to the pollution tolerance of organisms to pollution factors. It is generally expressed as 10. The higher the pollution tolerance value, the stronger the ability of organisms to tolerate pollution; the lower the tolerance value, the more sensitive. The level of pollution tolerance reflects the sensitivity of organisms to water pollution. Compared with the traditional diversity index, the *BI* contains the pollution tolerance parameter and is much better than the general diversity index for extremely clean water bodies and mild or medium-polluted water bodies.

We compared the organism samples collected from the upper, middle, and lower reaches of Gaya River, analyzed the distribution and pollution resistance value and substituted it into the calculation formula. In compliance with the evaluation criteria (*BI* evaluation criteria: 0 – 4.2 is the cleanest, 4.2 – 5.7 is clean, 5.7 – 7.0 is mold pollution, 7.0 – 8.5 is medium pollution, and 8.5 – 10.0 is severe pollution), we reached the conclusion: the *BI* of sampling points in upper reaches is 4.3, the *BI* of sampling points in middle reaches is 5.87, and the *BI* of sampling points in lower reaches is 5.53. Therefore, the water quality of the upper reaches is clean, the water quality of the middle reaches is mild pollution, and the water quality of the lower reaches is also clean.

5.2 Water quality evaluation According to the experimental results, the water quality classification of upper, middle and lower reaches of the Gaya River is Type II, Type III, and Type II, which are consistent with the biological evaluation results.

6 Discussion

The samples of traditional water quality monitoring can only reflect the water quality status during the sampling period, and the flexibility in evaluation is poor. In contrast, from the perspective of the implementation of water environment monitoring, although benthos monitoring can fully reflect the conditions of the river basin, the sample collection is more difficult and the calculation process is more complicated. In addition, the quality requirements for water quality monitoring personnel are relatively high, and both analysis and identification need rich practice and profound biological knowledge[6]. In the future water environmental monitoring, it is recommended to promote the combination of traditional monitoring and biological monitoring, and break the barriers, to realize more accurate and sustainable.

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(From page 37)

use of biological pesticides or high-efficiency, low-toxicity and low-residue pesticides.

(vi) Strengthening the centralized of the livestock industry. It is recommended to implement the separation of humans and animals, separation of farms from villages to reduce pollutant emissions. In addition, qualified livestock farms must incorporate sewage into the sewage pipe network. Livestock breeding should be prohibited in Class A protected area and new livestock farms should be prohibited in Class B protected area.

(vii) Reinforcing the management of aquaculture. In the case of local water quality exceeding the standard, some fish ponds should be ecologically closed and returned to the lake to ensure that the water bodies in the reservoir area meet the water quality standards.

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