Study on the influence of small hydropower stations on the macroinvertebrates community—Take Nanhe River as a case, China

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Abstract. This study take Nahan River as a case to research the impacts of small hydropower stations on macroinvertebrates community. Results showed that a total of 13 macroinvertebrate samples was collected and contained 56 taxa belonging to 18 families and 35 genera. The influence of runoff regulation was more seriously than hydrological period. There were obvious zoning phenomenon of macroinvertebrates between reservoir, downdam reaches and natural reaches. From reservoir, downdam reaches to natural reaches, species abundance increased in turn. There are the least species in reservoir, the most in natural rivers. The reservoirs had the highest biomass and were quite different from those in downdam and natural reaches. However, there was no significant difference between different periods of hydropower station.

1. Introduction
Macroinvertebrates is one of the most widely distributed taxa of river habitats, and is also an important part of river ecological system (Hall et al., 2003), plays an important role in the process of material circulation and energy flow in the river ecosystem. As of the end of 2015, China has built small hydropower station (installed below 50 thousand KW) more than 4.7 seats. These small hydropower stations had seriously influence on river ecological environment (Sundermann, 2011). If these hydropower stations had a significant influence on macroinvertebrates community structure? And if the influence had differences between runoff regulation and hydrological period? Based on the above questions, this study take Nan River as a case to study the influence of small hydropower stations on macroinvertebrates.

2. Research area and methods
2.1. Research area
Nanhe River, which located in Hubei Province, China. The total length of 255km, the basin area of 6497km², the river drop of about 470m, is a subtropical monsoon climate, the average annual rainfall of 917.8mm. There are 4 small hydropower stations located at this rive. In this study, a total of 12 sample sites were set up. The sample sites were showed in figure 1. The investigation were carry out in December, 2013 and July, 2014.
2.2. Methods

1) Macroinvertebrates investigation

The macroinvertebrates were collected by D-frame net (width 0.30 m, 450 m diameter nylon yarn) in river and Peterson grap (1/16 m²) in reservoirs. Samples were sieved in situ and the 420μm fraction was live-picked in field and preserved in 10% formalin. Macroinvertebrates were identified in the laboratory with the aid of a dissecting microscope to the lowest possible taxon using identification keys (Brinkhurst and Jamieson, 1971; Morse et al., 1994).

2) Data analysis

Density (individual’s m-2) and biomass (g m-2) of macroinvertebrates within each site were calculated using arithmetic average from all samples and or sites. Nonparametric multivariate analysis of variance (perMANOVA) and gradient ranking (GA) (Canoco 4.5) were used to analysis distribution characteristics of community sites, among them, GA was selected by detrended correspondence analysis (DCA). Excel 2013 and SPSS 17 software were used to data analysis and chart making. One-way ANOVA was used to analyze the significance of different habitat characteristics (p=0.05).

3. Results and analysis

3.1. Species composition and standing crop

A total of 13 macroinvertebrate samples were collected in Nanhe Rivers during the study contained 56 taxa belonging to 18 families and 35 genera. Insects represented the most diverse group and comprised 40 taxa. Oligochaeta comprised 11 taxa, molluscs comprised 3 taxa while other groups (Nematoda, Hirudinea and Crustacea) were represented by 2 taxa. Diptera was the dominant group in aquatic insects. The average densities and biomass were 966±112 ind/m² and 17.31±1.54 g/m² respectively.

3.2. Effect of small hydropower station on macroinvertebrate

Runoff regulation and hydrological period (wet season and dry season) are two main flow regulation modes to influence macroinvertebrates. Runoff regulation make out three different habitat type, such as reservoir, downdam reaches and natural reaches. Species abundance difference between different habitat type were analysis using single factor analysis of variance (ANOVA) under two flow regulation modes (Table 1).

Table 1. Analysis results of One-way ANOVA of Nanhe river macroinvertebrates abundance between different groups

|                      | Sum of squares | df   | M mean square | F     | significance |
|----------------------|----------------|------|---------------|-------|--------------|
| Runoff regulation    |                |      |               |       |              |
| Between groups       | 81.04          | 2    | 40.52         | 9.46  | 0.001**      |
| In groups            | 89.92          | 21   | 4.28          |       |              |
| Total                | 170.96         | 23   |               |       |              |
| Hydrological period  |                |      |               |       |              |
| Between groups       | 12.04          | 1    | 12.04         | 1.667 | 0.21         |
| In groups            | 158.92         | 22   | 7.22          |       |              |
| Total                | 170.96         | 23   |               |       |              |

Note: ** Significant at 0.01 level

The results showed that for species parameters, more significant effect of runoff regulation mode, and the influence of hydrologic period is relatively weak, therefore, can be in 2011(dry season) and 2012(wet season), a comprehensive analysis of the data, without considering the influence of different period for hydrological data. For multivariate analysis of nonparametric variance data of the Nanhe River Basin (perMANOVA) also showed that based on the grouping of runoff regulation under the
different macroinvertebrates community structure significantly (p=0.0036**, 99999 times based on permutation test results), figure1 shows, different sections of macroinvertebrates DCA sequencing results.

![DCA ordination diagram of macroinvertebrates in Nanhe River](image)

**Figure 1.** DCA ordination diagram of macroinvertebrates in Nanhe River

The explanation rate of species difference of axis 1 was about 15.5%, and the cumulative interpretation rate of axis 1 and axis 2 was 24.0%, and the maximum gradient length was about 5.033, which indicated that the response of species to the environment was a single peak pattern. Three kinds of samples formed an obvious partition trend in the coordinate system composed of axis 1 and axis 2, and grouping was basically consistent with the runoff regulation model, which mean the distributive characteristics of species community along the environmental gradient in the Nanhe river area, underdam reahces and Natural River have significant difference. The difference between the organisms in the reservoir and the down dam is mainly in the axis 2, and the difference between the natural and non-natural river reaches is mainly in the axis 1.

The structure parameters of macroinvertebrates in the reservoir, downdam reaches and natural reaches were classified and counted (Table2). The results showed that the small deviation fluctuation between species abundance and diversity index (Shannon-Wiener index and Margalef richness index), indicating that the three parameters in the group within each sampling section is relatively stable, on the contrary, the deviation volatility of the biological density and biomass was larger, which showed that the differences of these parameters between the two groups were significant. From the reservoir, downdam to natural river, the species richness increased gradually, the species in the reservoir was the least, and the natural river was the most; macroinvertebrates density in downdam was the highest, followed by natural rivers and reservoir; the reservoirs had the highest biomass and were quite different from those in downdam and natural river; According to the above parameters, we can summarize the structure characteristics of bioroenosis in 3 typical areas: The species of macroinvertebrates in the reservoir was less, the diversity was low, showing a more concentrated single species advantage, and the individual weight of the biological individual was heavier. Under the dam, the species of macroinvertebrates increase slightly, the diversity was improved, the number of species was large, but because of the small weight, the biomass was not large. The species of macroinvertebrates in the natural river was the largest, the diversity was high, and the weight of the individual was smaller.
Table 2. Statistical results of macroinvertebrates structure parameters in Nanhe River

|                  | Reservoir       | downdam         | natural river  |
|------------------|-----------------|-----------------|----------------|
| Species richness | 4.4±0.7         | 6.5±0.3         | 9.5±1.3        |
| Biological density (ind/m²) | 412.0±132.3     | 1396.0±733.6    | 825.4±160.3    |
| Biomass (g/m²)   | 56.3±20.9       | 25.24±11.4      | 5.99±2.6       |
| Shannon-Wiener index | 1.06±0.16       | 1.48±0.07       | 1.58±0.21      |
| Margalef richness index | 6.22±1.05       | 9.66±0.63       | 10.46±1.16     |

4. Conclusion
The influence of runoff regulation was more seriously than hydrological period. There were obvious zoning phenomenon of macroinvertebrates between reservoir, down dam reaches and natural reaches. From reservoir, down dam reaches to natural reaches, species abundance increased in turn. There are the least species in reservoir, the most in natural reaches. The reservoirs had the highest biomass and were quite different from those in down dam and natural reaches. However, there was no significant difference between different periods of hydropower station.

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