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# Response Relationship Between River Benthic Fauna Community Structure and Environmental Factors in Qinyuan County

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## Abstract

**Benthic animals are an important part of aquatic ecosystem, and their distribution and population structure are deeply affected by environmental factors. As an important aquatic ecosystem, the diversity and abundance of benthic animals in rivers are regulated by a variety of environmental factors. Qinyuan County is a typical inland river area, and the changes of river ecological environment may have important effects on the distribution pattern of benthic animals. In order to reveal the effect of environmental factors on the population distribution of benthic fauna in Qinyuan County, the relationship between environmental factors and the characteristics of benthic fauna community was discussed by canonical correlation analysis. The results showed that river width (P=0.008) and flow velocity (P=0.042) were significant environmental factors, which had important effects on the distribution of benthic fauna. This study reveals the key role of water environmental factors, especially river width and velocity, in the distribution of river benthic communities in Qinyuan County, and provides scientific basis for further understanding of the structure and function of aquatic ecosystems in this area. At the same time, the research results also provide a reference for regional ecological protection and water resources management, especially in waters ecological restoration and biodiversity conservation.**

## Keywords

**Macrobenthic invertebrates; Canonical correlation analysis; Qinyuan county.**

## 1. INTRODUCTION

Macrobenthic invertebrates (referred to as benthic animals) are a group of animals that live at the bottom of water for all or most of their life history and can be trapped by screens with a pore size of 500um. They have functions such as accelerating the decomposition of organic debris, regulating the food chain and maintaining biological integrity, and play a connecting role in the material exchange and energy flow of river water ecology [1]. Macrobenthic invertebrate communities are often used as indicators of aquatic ecosystem health because many species are sensitive to pollution and sudden changes in the environment, and community characteristics (such as abundance, richness, diversity, evenness, and community composition) can be monitored to determine whether the community has changed over time due to natural or anthropogenic influences[2-3].

The comprehensive health score of the current situation of water resources utilization in Qinyuan County is good, that is, at present, Qinyuan County as a whole is in a relatively healthy state and basically belongs to the scope of sustainable development. The specific performance is that the local ecological environment is good, not only the per capita water resources and

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biodiversity are in a dominant position, the green area and forest coverage rate are high, but also the sewage discharge index meets the national requirements. The social and economic development trend of Qinyuan County is generally stable, the population density is relatively low, and the per capita GDP meets the living needs of residents [4]. However, there are few investigations on the status quo of inland river ecology in Qinyuan County, so we investigated the diversity of macrobenthic invertebrates in four rivers in Qinyuan County.

## 2. MATERIALS AND METHODS

### 2.1. Sampling time and point position

The survey was carried out in July 2024. The survey area covers a total of 20 stations of rivers in Qinyuan County, including Zihong River, Qin River, Chishiqiao River and Baizi River. The specific station information is shown in Fig 1.

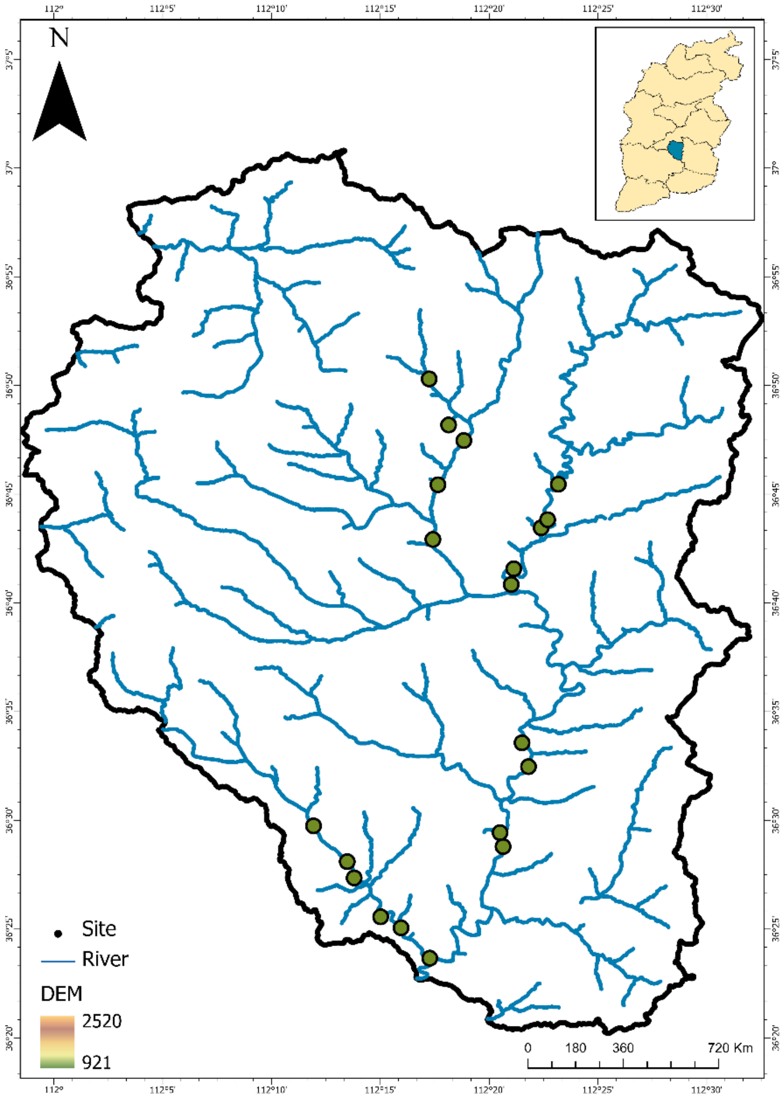


**Figure 1.** River point distribution in Qinyuan County

### 2.2. Sample collection and identification

The collection of benthic animals was carried out using Surber nets and D-shaped nets (30×30cm, 1 mm aperture). The benthic animals were screened with a 40-mesh screen. After

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screening, the samples were stored in a 100ml sampling bottle with 75% ethanol. Microscopes are used in the laboratory to classify, identify and count individual samples.

## 2.3. Character division

With regard to functional shape, the main reference [5-6], a total of 8 feature groups and 30 traits were defined, including morphing, individual size, flow state preference, temperature preference, breathing mode, etc., representing life history, activity ability, form, physiology and other aspects respectively. The specific shape selection, grade description and character code are shown in Table 1.

**Table 1.** Functional traits, character grades and codes of macroinvertebrates

| Traits | Trait states | Code |
|---|---|---|
| **Voltinism** | Semivoltine (<1 ,generation/y) | Volt1 |
| | Univoltine (1 =generation/y) | Volt2 |
| | Bi- or multivoltine (>1, generation/y) | Volt3 |
| **Body size** | Small (< 9 mm) | Size1 |
| | Medium (9-16 mm) | Size2 |
| | Large(> 16 mm) | Size3 |
| **Habit** | Climbers | Habi1 |
| | Burrowers | Habi2 |
| | Sprawlers | Habi3 |
| | Clingers | Habi4 |
| | Swimmers | Habi5 |
| | Skate | Habi6 |
| **Functional Feeding Groups** | Collector-gatherers | Trop1 |
| | Collector-filterers | Trop2 |
| | Scrapers | Trop3 |
| | Predators | Trop4 |
| | Shredders | Trop5 |
| **Temperature preference** | Cool | Ther1 |
| | Cool/warm eurythermal | Ther2 |
| | Warm | Ther3 |
| **Occurrence in drift** | Rare | Drft1 |
| | Common | Drft2 |
| | Abundant | Drft3 |
| **Respiration type** | Tegumentary | Resp1 |
| | Branchial | Resp2 |
| | Air(spiracles, tracheae, plastrons) | Resp3 |
| **Rheophile** | Depositional only | Rheo1 |
| | Depositional and erosional | Rheo2 |
| | Erosional | Rheo3 |

## 2.4. Statistical Analysis

The dominant species of macrobenthic invertebrates were calculated using Excel tables. The dominance index (Y) was calculated by formula (2). When the Y value exceeds 0.02, the species is considered to be dominant [7].

$$(2)\quad Y = (ni/N) \times fi$$

Where ni is the number of individuals of the i species, N is the total number of individuals of all species, and fi is the occurrence frequency of the i species.

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The biodiversity was calculated using R4.3.3. Classification alpha diversity is carried out using the R package "vegan" and function alpha diversity is carried out using the dbFD function in the "FD" package. Canonical correlation analysis (CCA) was performed using Canoco5 to map the corresponding relationship between macrobenthic invertebrate communities and environmental factors [8].

# 3. RESULT

## 3.1. Characteristics of benthic animal community

A total of 94 species of macrobenthic invertebrates were detected in Qinyuan County, which were divided into 3 phyla, 6 classes, 16 orders, 39 families and 74 genera. The dominant phyla was Arthropoda (81 species), followed by Mollusca (8 species) and Annelida (5 species). The arthropods include oligochaeta (2%), Bdelloid (3%), Gastropoda (6%), lamellibranchiata (2%), Crustacea (3%) and Insecta (83%), of which insecta accounts for the largest proportion. The species with a frequency of more than 4% of all species included Limnodrilus sp 4.76%, Radix sp 4.76%, Hydropsyche sp 4.44%, and Caenis sp) 5.08% and Baetis sp 4.13%.

In terms of diversity index, The distribution range of macrobenthic invertebrate community biodiversity index at each sampling site was species richness (7 ~ 39), Shannon Weiner index (0.79 ~ 3.03), evenness (0.33 ~ 0.89), function richness (2.64 ~ 16.19), function evenness (0.42 ~ 0.85) and function dispersion (0.4) ~ 0.89). The dominant species of the four rivers belong to Mayfly, but the species are different. The dominant species of the Bozi River is Ornithophorus (1.18), with an average density of 175.56ind/m2, the dominant species of the Qinhe River and the Chishiqiao River is Oriental Phorocera (0.82, 1.01), with an average density of 113.33ind/m2, 188.89ind/m2, respectively. The dominant species was Phorocera taiwanensis (1.1) with an average density of 91.11ind/m2. The specific biodiversity index values at each point are shown in Table 2.

**Table 2.** Species richness, Shannon Weiner index, evenness, functional richness, functional evenness and functional dispersion of macroinvertebrates at each sampling point

| Site | species richness | Shannon-Wiener | Pielou's evenness | functional richness | functional eveness | Functional dispersion |
|---|---|---|---|---|---|---|
| **BZH1** | 12 | 1.196857228 | 0.481650781 | 2.92667919 | 0.44458325 | 0.82816391 |
| **BZH2** | 39 | 3.027735715 | 0.826445958 | 16.1868517 | 0.51466606 | 0.63703010 |
| **BZH3** | 10 | 1.245988809 | 0.541126064 | 7.41957576 | 0.41858413 | 0.74966696 |
| **BZH4** | 23 | 2.473505288 | 0.788872541 | 12.1764652 | 0.46902101 | 0.67710971 |
| **BZH5** | 15 | 1.974855117 | 0.729253511 | 14.1059668 | 0.47266015 | 0.57100561 |
| **QH1** | 23 | 2.142763488 | 0.683389393 | 14.3036928 | 0.53382993 | 0.61123858 |
| **QH2** | 15 | 2.132512777 | 0.787471656 | 6.51339852 | 0.46345353 | 0.45226023 |
| **QH3** | 12 | 2.063244608 | 0.830310711 | 14.3757026 | 0.47048612 | 0.39470809 |
| **QH4** | 11 | 1.578328456 | 0.658214091 | 8.35702794 | 0.72518915 | 0.8198297 |
| **QH5** | 11 | 0.784164574 | 0.327022027 | 10.5502347 | 0.65533831 | 0.88765517 |
| **ZHH1** | 17 | 2.078933862 | 0.733772438 | 5.33363261 | 0.59632488 | 0.81280613 |
| **ZHH2** | 10 | 1.217935921 | 0.52894285 | 2.6344195 | 0.71671356 | 0.83334792 |
| **ZHH3** | 10 | 2.036155939 | 0.884291289 | 3.58428633 | 0.78147754 | 0.7763059 |
| **ZHH4** | 14 | 1.784705782 | 0.676266393 | 5.3437617 | 0.59160860 | 0.59137691 |
| **ZHH5** | 7 | 1.517151585 | 0.779661685 | 6.13708667 | 0.8483711 | 0.83934559 |
| **CSQH1** | 12 | 2.143008366 | 0.862410009 | 11.0797658 | 0.62818554 | 0.57629214 |
| **CSQH2** | 16 | 2.206485921 | 0.795821574 | 15.1205603 | 0.48967503 | 0.69484222 |
| **CSQH3** | 13 | 1.761514999 | 0.686764046 | 4.34194024 | 0.52124288 | 0.53869279 |
| **CSQH4** | 19 | 1.74207227 | 0.591648284 | 6.94664347 | 0.5260911 | 0.63554286 |
| **CSQH5** | 26 | 2.481360493 | 0.761598211 | 11.0183674 | 0.49808821 | 0.59308433 |

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## 3.2. Character composition of river benthic animals

We analyzed the composition of functional traits (Table 3), and the results showed that 2-generation or multi-generation types accounted for the largest proportion of chemical traits, and the relative abundance was 47.93%. The individual size was mainly medium size, and the relative abundance was 48.05%. In terms of life type, swimmers accounted for the largest proportion, and the relative abundance was 56.47%. In terms of functional feeding, direct collectors were dominant, and the relative abundance was 72.61%. The proportion of eurythermic individuals with the highest temperature preference was 85.63%. The individuals with higher drift frequency were the most abundant, and the relative abundance was 57.96%. The proportion of individuals with tracheobranchial respiratory mode was 87.31%. The proportion of sedimentary type was the largest, and the relative abundance was 56.59%.

**Table 3.** Functional trait composition and relative abundance of macroinvertebrates %

| Traits | Code | Relative abundance |
|---|---|---|
| **Voltinism** | Volt1 | 8.5 |
| | Volt2 | 43.53 |
| | Volt3 | 47.93 |
| **Body size** | Size1 | 16.87 |
| | Size2 | 48.05 |
| | Size3 | 35.08 |
| **Habit** | Habi1 | 10.52 |
| | Habi2 | 14.7 |
| | Habi3 | 10.56 |
| | Habi4 | 7.5 |
| | Habi5 | 56.47 |
| | Habi6 | 0.24 |
| **Functional Feeding Groups** | Trop1 | 72.61 |
| | Trop2 | 6.71 |
| | Trop3 | 11.47 |
| | Trop4 | 8.33 |
| | Trop5 | 0.88 |
| **Temperature preference** | Ther1 | 1.89 |
| | Ther2 | 85.63 |
| | Ther3 | 12.48 |
| **Occurrence in drift** | Drft1 | 37.95 |
| | Drft2 | 4.09 |
| | Drft3 | 57.96 |
| **Respiration type** | Resp1 | 9.37 |
| | Resp2 | 87.31 |
| | Resp3 | 3.33 |
| **Rheophile** | Rheo1 | 56.59 |
| | Rheo2 | 22.09 |
| | Rheo3 | 21.32 |

## 3.3. Relationship between benthic community outcomes and environmental factors

Analysis of environmental factors includes total phosphorus, total nitrogen, high Bate index, dissolved oxygen, PH, conductivity, TDS, salinity, river width, velocity, depth. We use canonical correlation analysis to explore the relationship between macrobenthic invertebrates and environmental factors. The results are shown in Figure 2. From the results, Axis1 explains 54.29% and Axis2 explains 48.74%, which together account for most of the variation between biological

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and environmental factors. River width (P=0.008) and flow velocity (P=0.042), as significant environmental factors, played an important role in the distribution of macrobenthic invertebrates, among which Urobranchia, Leptothrix, Acanthopus and Chironomus were most affected by river width. The velocity of the flow was most affected by Heteromorhynchus melanoides, Striatoceras, Vesicula, Oriental Phorocera and Microphorus.

**Table 4.** Significance test of environmental factors in CCA analysis

| Environmental factors | Contribution rate % | F | P |
|---|---|---|---|
| **Wid** | 17.7 | 2.2 | 0.008 |
| **TN** | 12.1 | 1.5 | 0.056 |
| **Dep** | 10.4 | 1.3 | 0.12 |
| **vel** | 11.6 | 1.5 | 0.042 |
| **TP** | 8.5 | 1.1 | 0.27 |
| **S** | 8.0 | 1.1 | 0.428 |
| **EC** | 8.2 | 1.1 | 0.308 |
| **TDS** | 6.7 | 0.9 | 0.628 |
| **DO** | 6.0 | 0.8 | 0.684 |
| **pH** | 6.7 | 0.9 | 0.6 |
| **CODMN** | 4.2 | 0.5 | 0.812 |

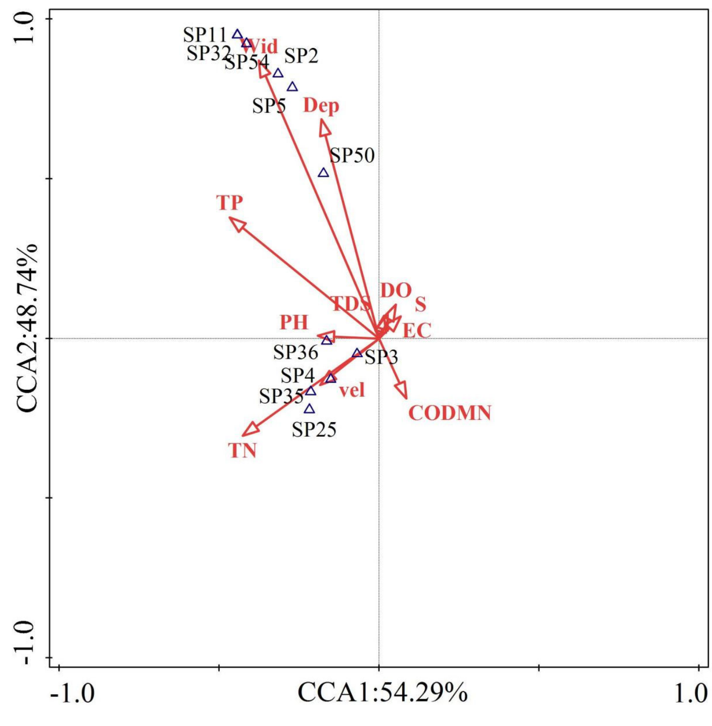


**Figure 2.** Redundancy analysis (RDA) between species and environmental factors

## 4. DISCUSSION

In this survey, the diversity of macrobenthic invertebrates was higher in Qinyuan River, 94 species were identified, more than 38 species in Qinyuan River (Jincheng section). In terms of the composition of macrobenthic invertebrates, the species richness of insect class was the highest (78), which was also consistent with the results of most studies [9]. A total of 19 clean EPT species (Ephemeroptera, Trichoptera and Plecoptera) were detected and distributed in all

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4 rivers (Plecoptera) From the distribution of macrobenthic invertebrates, the species richness of Baizi River was the highest (56), followed by Qin River (45), Chishi Bridge River (41) and Zihong River (31).

The results of canonical correlation analysis show that river width and velocity are the key factors affecting benthic animals, which is consistent with most papers [10-11]. For example, Bao Simin [12] investigated the large benthic animals in Buyuan River in April (dry season) and October (rainy season) in 2019, and the results show that River width, nitrate nitrogen and chemical oxygen demand are the main environmental factors affecting the community structure of macrobenthos in Buyuan River.

Therefore, according to the results of exemplary correlation analysis, we suggest that the natural width of the river should be maintained in river management and protection, excessive artificial channel transformation and bank hardening should be avoided, and local vegetation should be planted to enhance the stability of the river bank, prevent erosion, and provide a diversified habitat. The influence of flow velocity should be considered in the construction of water conservancy projects, and the measures of diversion or slow flow should be taken to ensure the natural change of the flow velocity of the downstream reaches, and to avoid excessive water flow regulation and pumping, and to maintain the natural hydrological process to maintain the dynamic balance of the ecosystem. At the same time, a long-term monitoring system should be established to continuously monitor changes in river width and velocity, assess their impact on benthic animals, and deeply study their specific impact mechanisms to develop targeted protection measures.

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