



## Influence of the island with grass and the island with trees to water quality in Yihe River, China

Xiang Li<sup>a,b</sup>, Yuan Gao<sup>a,c,\*</sup>

<sup>a</sup>Shandong Provincial Key Laboratory of Water and Soil Conservation and Environmental Protection, College of Resources and Environment, Linyi University, Linyi 276000, China

<sup>b</sup>Linyi Fourth High School, Linyi 276037, China, email: 250659681@qq.com (X. Li)

<sup>c</sup>Linyi Scientific Exploration Laboratory, Linyi 276037, China, emails: gaoy@lyu.edu.cn, gaoyuan1182@tom.com (Y. Gao)

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### ABSTRACT

This research aims to investigate the differences of water temperature, pH, total nitrogen (TN), total phosphorus (TP) and chlorophyll a (Chla) between the island with grass and the island with trees of Yihe River, China, and provide an important reference for the protection of water resources. Three plots were set up in Yihe River: waters of island with grass, waters of island with trees and waters of riverway. Eight replicated water samples were taken from each site in May, August and October, 2016. Results: water temperature of Yihe River: waters of riverway > waters of island with grass > waters of island with trees. The pH and TN contents are the highest in waters of island with trees. TP content: waters of riverway > waters of island with trees > waters of island with grass. The content of Chla is the highest in waters of island with grass. Indication: (1) the island with grass and the island with trees can reduce the water temperature nearby, and effect of the island with trees is smaller than the island with grass. (2) The island with trees can obviously increase water pH and TN content nearby. (3) The island with grass and the island with trees can reduce the water TP content nearby, and the effect of the island with grass is smaller than the island with trees. (4) The island with grass can significantly increase the content of Chla nearby. Suggestions: (1) protect the existing island with grass and the island with trees in the shallow waters of Yihe River, improve plant coverage, restore the ecology of native wetlands and enhance interception and purification of nitrogen and phosphorus. (2) Release purifying fish such as chub, bighead; control the growth of algae and improve the self-purification ability of water bodies. (3) Pay attention to the purification effect of the wetlands on the island with grass and the island with trees so as to achieve a win-win situation between economic development and environmental improvement.

*Keywords:* Yihe River; Island with grass; Island with trees; Water quality; Chlorophyll a

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### 1. Introduction

With the development of economy, the discharge of sewage and waste water increases and the eutrophication of water body has become a global environment problem [1,2]. The eutrophication of water body will lead to a series of ecological problems, such as the rapid increase in the number

of phytoplankton, the occurrence of algal bloom and the destruction of ecosystems [3]. Phytoplankton is an important part of aquatic ecosystems [4]. As a primary producer, it provides feed for zooplankton and filter-feeding fish in the water and forms the basis for material circulation. In addition, phytoplankton is very sensitive to pollutants in the water environment as an indicator species. As an important

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\* Corresponding author.

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indicator reflecting the characteristics and quality of water environment, it is widely used in water environment monitoring and evaluation studies [5]. Chlorophyll a (Chla) is an important component of phytoplankton. All algae contain Chla and its proportion in algae is relatively stable [6,7]. The content of Chla in water body is an important index to detect phytoplankton and can be used to characterize the biomass of phytoplankton. It is an important indicator for describing and classifying the nutritional status of the water body and studying the habitat of water [8–10], and plays a key role in eutrophication evaluation [11].

Central islands refer to the islands in rivers or lakes, mostly formed by flow cutting rocks or natural sediments in the slow-flowing area. It is particularly vulnerable and sensitive to human interferences. Yihe River is an important river in the Huaihe River Basin. It is located in the southern part of Shandong Province and the northern part of Jiangsu Province (34°23'N–36°20'N, 117°25'E–118°42'E), originating from Yiyuan County, flowing into Xinyi River at Wulou Village, flowing into the Yellow Sea at Yanwei harbor. With a total length of 574 km, it has a basin area of  $1.73 \times 10^4$  km<sup>2</sup> [12]. Previous studies are on phytoplankton diversity and water quality evaluation in the Yihe River [12–14], but there is no research on the influence of the island with grass and the island with trees to water quality. Hence, we surveyed the differences in water temperature, pH, total nitrogen (TN), total phosphorus (TP) and Chla contents between the island with grass and the island with trees of Yihe River. It is hoped that this investigation can provide an important reference for protecting the water resources of Yihe River.

## 2. Methodology

### 2.1. Study area

The island with grass and the island with trees are located in Yihe River. The geographic coordinates of the island with grass are 35°09'2"N, 118°34'2"E. The geographic coordinates of the island with trees are 35°08'5"N, 118°34'9"E. These islands are located in the middle of the river. They are formed by the sediment deposited by the river and have been formed for about 50 years. Both the island with grass and the island with trees are earthy, with no large stones or gravel. The main vegetation of the former are herbaceous aquatic plants such as *Phragmites australis* Trin, while the main vegetation of the latter are trees such as *Salix babylonica* L. These islands in the river certainly have an effect on the water body, but the questions of what impacts does it have? and how does it influence? are investigated in this study.

### 2.2. Survey sampling

Three research plots were set up in Yihe River, China: waters of island with grass, waters of island with trees and waters of riverway. Eight replicated water sampling sites were set up for each site, which were from eastward, southward, westward, northward, southeastern, southwestern, northeastern and northwestern. The sampling time was May 2016 (summer), August 2016 (summer) and October 2016 (autumn).

Four sampling points were set up for the waters around island of Yihe River, to investigate the influence of distance

on the water body, respectively, 1 m from island, 10 m from island, 20 m from island, and 1,000 m from island. Four replications were set for each sampling point, which were from east, south, west and north of island. The sampling time was June, August, October and December, 2015.

For the investigation, 500 mL clean pure water bottle was used and 50 cm subsurface water samples were collected for analysis and testing. The pH and water temperature were in-situ measured by dual range measuring instrument (pH56, MARTINI, Mauritius) using thermometer method (GB6920-91) and glass electrode method (GB6920-86). The water TN content was spectrophotometrically [15] measured by a concentration meter (HI96728, HANNA, Italia). The water TP content was spectrophotometrically [15] measured by a concentration meter (HI96706, HANNA). The water Chla content was determined by ethanol spectrophotometer method [15,16].

## 3. Results and analysis

### 3.1. Water quality evaluation of waters around island

The annual average water temperature of waters around island of Yihe River is 19.2°C, with a variation of 4.6°C–33.6°C. The annual average water pH value is 7.63, with a variation of 6.96–9.32. The annual average water TN value is 3.07 mg L<sup>-1</sup>, with a variation of 0.85–5.12 mg L<sup>-1</sup>. The annual average water TP value is 0.09 mg L<sup>-1</sup>, with a variation of 0.02–0.33 mg L<sup>-1</sup>. The annual average water Chla value is 53.57 µg L<sup>-1</sup>, with a variation of 5.58–150.65 mg L<sup>-1</sup>.

We compared water TN and water TP, the two major nutritional indicators of waters around island, with large lakes or reservoirs in the 400-km radius. Dongping Lake is a piedmont plain inland lake with a total area of 627 km<sup>2</sup>. It is located in the southwest of Shandong Province, China. Its perennial water surface is 124 km<sup>2</sup> with an average water depth of 2.5 m and a lake volume of  $40 \times 10^8$  m<sup>3</sup>. It is the second largest freshwater lake in Shandong Province [17]. Nansi Lake is a collective term for the four connected lakes of Weishan Lake, Zhaoyang Lake, Dushan Lake and Nanyang Lake. It is located in the junction of Jiangsu Province and Shandong Province, China. The whole lakes cover an area of 1,266 km<sup>2</sup> with an average depth of 1.46 m and a maximum water depth of 2.76 m. With a volume of  $16.06 \times 10^8$  m<sup>3</sup>, it is the largest freshwater lake in Shandong, the first in North China and the sixth in China [18]. Yunmeng Lake, which was built in 1959, is the second largest reservoir in Shandong Province, formerly known as Andi Reservoir. It is located in the intersection of Yihe River tributary, China. The whole lakes cover an area of 1,693 km<sup>2</sup> and a total storage capacity of  $7.49 \times 10^8$  m<sup>3</sup>. It was listed as the main urban source of drinking water for Linyi City from 1996 [15]. The Shilianghe Reservoir is the largest artificial reservoir in Jiangsu Province. It is located in the boundary of Donghai County and Ganyu County in the northeast of Jiangsu Province, China. It was built in 1962. It has a maximum reservoir area of 91 km<sup>2</sup>, with a maximum storage capacity of  $5.31 \times 10^8$  m<sup>3</sup> and a control basin area of 15,365 km<sup>2</sup> [19].

The results showed that: TN, Yihe River (3.07 mg L<sup>-1</sup>) > Dongping Lake (2.80 mg L<sup>-1</sup>) [17] > Nansi Lake (2.61 mg L<sup>-1</sup>) [18] > Yunmeng Lake (1.58 mg L<sup>-1</sup>) [15] > Shilianghe Reservoir (0.92 mg L<sup>-1</sup>) [19]. TP, Nansi Lake (0.17 mg L<sup>-1</sup>) [18] > Yihe River (0.09 mg L<sup>-1</sup>) > Shilianghe Reservoir (0.09 mg L<sup>-1</sup>)

[19] > Dongping Lake ( $0.08 \text{ mg L}^{-1}$ ) [17] > Yunmeng Lake ( $0.07 \text{ mg L}^{-1}$ ) [15]. Chla, Yihe River ( $53.57 \mu\text{g L}^{-1}$ ) > Nansi Lake ( $31.5 \mu\text{g L}^{-1}$ ) [18] > Yunmeng Lake ( $30.6 \mu\text{g L}^{-1}$ ) [15] > Dongping Lake ( $18.3 \mu\text{g L}^{-1}$ ). Yihe River had a high index of TN, TP and Chla. Many studies have shown that “TN/TP” also affects the growth of phytoplankton. It is N restrictive, when the “TN/TP” is less than 7. It is P restrictive, when the “TN/TP” is greater than 7 [20]. This study showed that Yihe River is P restrictive because “TN/TP” is equal to 35.45.

### 3.2. Distance effect on the impact of island on water body

The water temperature of waters around island of Yihe River:  $1 \text{ m} > 1,000 \text{ m} > 20 \text{ m} > 10 \text{ m}$  (Fig. 1(A)). pH:  $10 \text{ m} > 1 \text{ m} > 1,000 \text{ m} > 20 \text{ m}$  (Fig. 1(B)), TN:  $1 \text{ m} > 10 \text{ m} > 20 \text{ m} > 1,000 \text{ m}$  (Fig. 1(C)). TP:  $1,000 \text{ m} > 20 \text{ m} > 10 \text{ m} > 1 \text{ m}$  (Fig. 1(D)). Chla:  $1,000 \text{ m} > 10 \text{ m} > 20 \text{ m} > 1 \text{ m}$  (Fig. 1(E)). The island of Yihe River has two opposite effects on the water TN and water TP. It increases the water TN content while reducing the water TP content.

### 3.3. Impacts of the island with grass and the island with trees on water body

The water temperatures of Yihe River in spring and autumn: waters of riverway > waters of island with grass > waters of island with trees. The summer water temperature: waters of riverway > waters of island with grass = waters of island with trees (Fig. 2(A)). The spring and autumn pH values of Yihe River water body: waters of island with trees > waters of riverway > waters of island with grass. The summer pH: waters of island with trees > waters of island with grass > waters of riverway (Fig. 2(B)). The TN content in spring and summer of Yihe River water body: waters of island with trees > waters of riverway > waters of island with grass. The TN content in autumn: waters of island with trees > waters of island with grass > waters of riverway (Fig. 2(C)). The TP content in spring, summer and autumn of Yihe River water body: waters of riverway > waters of island with trees > waters of island with grass (Fig. 2(D)). The chlorophyll a content in spring of Yihe River water body: waters of island with grass > waters of island with trees > waters of riverway. The chlorophyll a content in summer and autumn: waters of island with grass > waters of riverway > waters of island with trees (Fig. 2(E)).

## 4. Discussion

The phytoplankton Shannon–Wiener index, Margalef index, Pielou index and cell density have been used in studies to evaluate the water quality of Yihe River. The results showed that Yihe River is mild pollution– $\beta$ –moderate pollution type [14]. Further study found that temperature is not the only one of the limiting factors that affect the phytoplankton in Yihe River [14].

The annual average values of water temperature, pH, TN, TP and Chla of waters around island of Yihe River were  $19.2^\circ\text{C}$ , 7.63,  $3.07 \text{ mg L}^{-1}$ ,  $0.09 \text{ mg L}^{-1}$  and  $53.57 \mu\text{g L}^{-1}$ , and it was P restrictive. The island of Yihe River increased the water TN content while reducing the water TP content.

The islands in lakes or rivers are often excluded from the goal of water environmental protection. As they are sensitive areas

for non-point source pollution in the watershed, it is important to maintain water purification functions in ecosystems [15,16]. These islands should be strictly limited to the introduction of entertainment facilities and recreational activities [21].

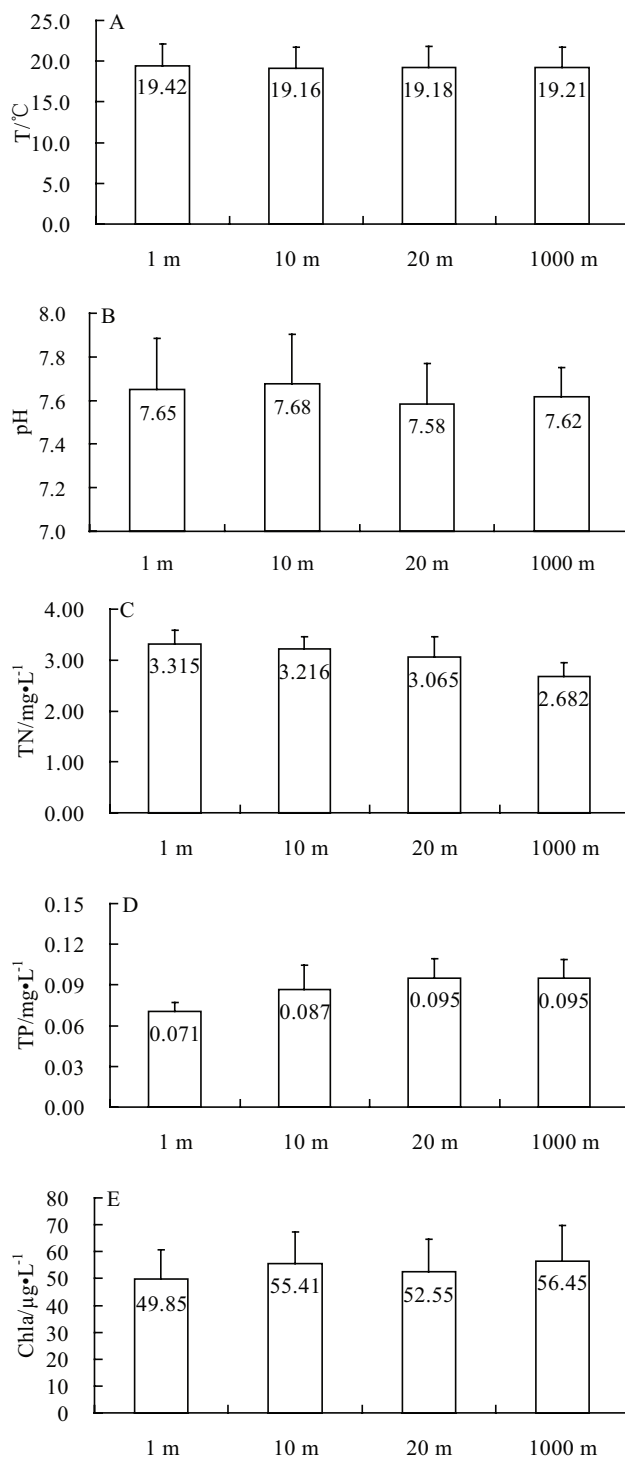


Fig. 1. Distance effect on the impact of island on water temperature (A), pH (B), TN (C), TP (D) and Chla (E) of Yihe River, China (average + standard error).

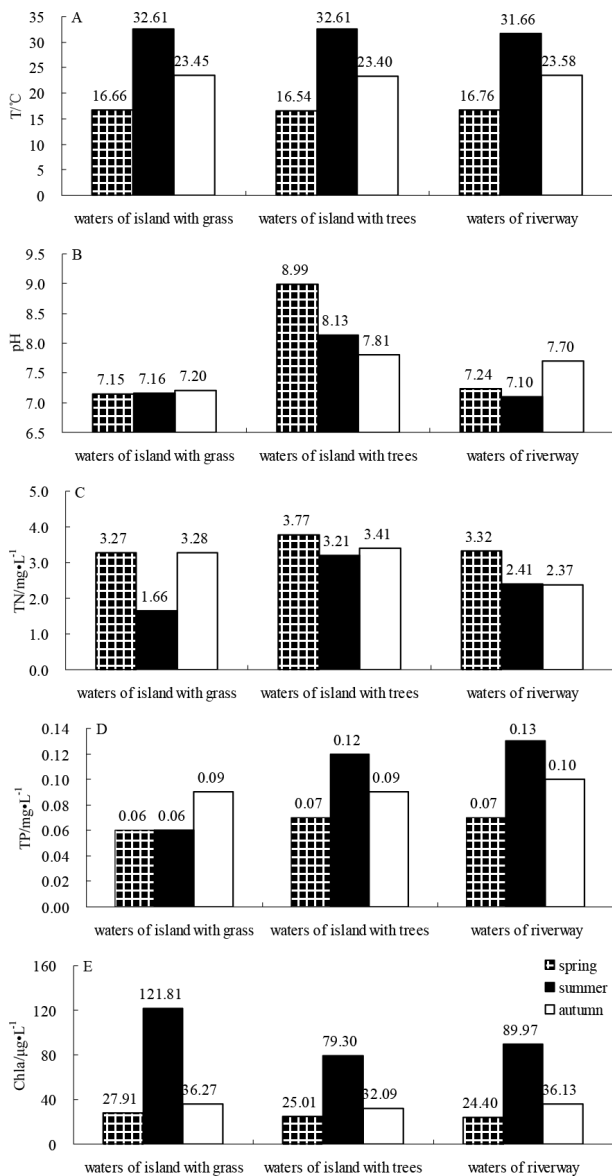


Fig. 2. Changes of water temperature (A), pH (B), TN (C), TP (D) and Chla (E) in spring, summer, autumn of waters of island with grass, waters of island with trees and waters of riverway.

At present, the island with grass and the island with trees in Yihe River have lush vegetation with ecosystem in good operation. The survey results showed that, as a whole, the water temperature of Yihe River, waters of riverway > waters of island with grass > waters of island with trees. pH and TN are the highest in waters of island with trees. The TP content, waters of riverway > waters of island with trees > waters of island with grass. The chlorophyll a content is the highest in waters of island with grass.

## 5. Conclusion

(1) The island with grass and the island with trees can reduce the water temperature nearby, and the effect of island with trees is smaller than the island with grass. (2) The island with trees can obviously increase water pH and TN content

nearby. (3) The island with grass and the island with trees can reduce the water TP content nearby, and the effect of island with grass is smaller than the island with trees. (4) The island with grass can significantly increase the content of chlorophyll a nearby. Suggestions: (1) protect the existing island with grass and the island with trees in the shallow waters of Yihe River, improve plant coverage, restore the ecology of native wetlands and enhance interception and purification of nitrogen and phosphorus. (2) Release purifying fish such as chub, bighead; control the growth of algae and improve the self-purification ability of water bodies. (3) Pay attention to the purification effect of the wetlands on the island with grass and the island with trees so as to achieve a win-win situation between economic development and environmental improvement.

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