Spatio-temporal distribution and correlation analysis of river water quality in City Center of Pinghu

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Abstract: Based on the historical data of river water quality in the central city of Pinghu from 2014 to 2018, the temporal and spatial distribution of river water quality changes and its influencing factors were analyzed, and the correlation between the main monitoring factors was identified by linear regression. The results show that water quality of the main rivers has improved significantly, and the concentrations of COD, NH3-N and TP in most rivers can reach the class III standard of surface water. In recent years, the water quality of the rivers shows a significant improvement trend, and the improvement effect of NH3-N concentration is the most obvious. The water quality of general rivers tends to improve, but the effect of treatment is relatively insufficient. Spatially, the water quality in the northern part of the flood control area is worse than that in other areas, and the main river is better than the general river. The fitting effect of COD, NH3-N and TP is good, and there is a significant correlation between the main river.

1. Introduction
As the carrier of water and the lifeblood of urban economic development, urban rivers are closely related to social development, and play an important role in water supply, ecological environment beautification, flood control and drainage. At the same time, urban rivers are also the constraints of urban development. In recent years, the accelerating urbanization has led to the serious deterioration of urban water environment. Domestic sewage and rainfall non-point source pollution make pollutants enter the receiving water body, and the pollution of urban rivers is becoming increasingly serious. Therefore, it is an important task to eliminate class V water activities and promote urban water governance to maintain river health and sustainable development in the new era. With people's attention to the current situation of water environment and the improvement of water environment quality requirements, many scholars have studied the changes and correlation of river water quality.

Shen [3] took the plain river network area in the lower reaches of the Yangtze River as the research object, analyzed the current situation of river water quality and prominent pollution factors in the basin, and concluded that domestic pollution sources and livestock breeding are the main components of non-point source pollution in the basin, and total phosphorus and ammonia nitrogen are the main pollution factors. He et al. [4] Based on the water quality monitoring data of 21 monitoring sections of 7 main rivers in Hangzhou, comprehensively evaluated the water quality of main rivers in the urban area. Yang [5] took the Mudi River in Chengdu as the research object, evaluated the current situation of water quality and investigated the pollution sources. The main pollutants in the water body were COD, NH3-N and TP, and the correlation analysis of these three indicators was carried out. Based on the data of river water quality and rainfall in Jiaxing City, Lou et al. [6] analyzed the change trend and influencing factors of river water quality. River water quality is positively correlated with upstream
water quality, and has complex response characteristics with rainfall. Ma et al. [7] analyzed the role and effect of dredging, outfall regulation and garbage cleaning on improving water quality by tracking and monitoring the river water quality during the implementation of inland river regulation project. Song et al. [8] preliminarily estimated the amount of pollutants into the river by using the annual emissions of COD, TN and TP in the main urban area of Harbin, and concluded that the river pollution is mainly concentrated in the suburban areas, and the pollutants mainly come from rural living sources and farmland non-point sources.

Pinghu City is located in the developed area of Hangjiang river network. The river water quality is easily affected by various factors. Therefore, it is necessary to study its water quality change trend, influencing factors and treatment effect. According to the water quality monitoring results of the river in the central city of Pinghu, this paper studies the change trend of water quality index and its influencing factors, and analyzes the influence of the change trend of water quality on the water quality of the river in Pinghu City. The research results can provide reference for urban water environment treatment and ecological restoration.

2. Study area
Pinghu City (geographic coordinates between 30°35′-52′N and 120°57′-121°16′E) is located on the coast of the East China Sea. It is located in the northeast of Zhejiang Province, the intersection of the diamond diagonal of "Shanghai, Hangzhou, Suzhou and Ningbo". It is adjacent to Shanghai in the north and Hangzhou Bay in the south. The area is low and flat with an average altitude of 2.8m and dense water network. The geographical location of Pinghu central city is shown in Figure 1. According to the spatial distribution of water body, Pinghu central city is divided into three study areas, namely the north part of urban flood control area, the south part of urban flood control area and the area outside urban flood control area. The north part of urban flood control area includes the area north of Jiefang Road Shihe, east of jiashan Tang, south of Fuzhen road and west of shanghai Tang, with a total area of 2.82 km². The southern part of the urban flood control area is bounded by Huancheng East Road and nanshai road in the East, Huaiju road in the south, Pinghu Avenue and 07 provincial road in the west, and Jiaxing Tang Jiefang Road Shihe in the north, with a total area of 12.34 km². The area outside the urban flood control area is the area outside the urban flood control enclosure of the central urban area, with a total area of 11.58 km².
3. Water quality

3.1. Section layout

According to the setting principle of monitoring section, monitoring points are set in 19 sections. It is mainly concentrated in the north of urban flood control area (4), the south of urban flood control area (6) and the outside of urban flood control area (9).

The layout of monitoring section is shown in Figure 1, and the details of monitoring section are shown in Table 1. According to the environmental quality standard for surface water (GB 3838-2002), there are 24 surface water quality monitoring items. Among them, COD reflects the degree of water pollution by reducing substances, and is one of the comprehensive indicators of the relative content of organic matter; NH₃-N is the nutrient element in the water body, and is also the main oxygen consuming pollutant in the water body; TP is the index of water rich in organic matter, which can reflect the state of water eutrophication. The single factor evaluation mode is adopted for the evaluation of monitoring factors, and the single factor pollution index 1.0 is taken as the basic dividing line of whether the factor pollutes the environment or not. If it is greater than 1.0, the water quality of the monitoring waters has been polluted by the factor and does not meet the requirements of the functional area.

Table 1. Water quality monitoring sections of main rivers and general rivers

| S/N | Main rivers | General rivers |
|-----|-------------|----------------|
|     | Section | River | S/N | Section | Community |
| 1   | Chengxi Gang management station | Jiaxing Tang | 1 | Jishui Gang | Beihelou |
| 2   | Jiaxing Tang Bridge | Jiaxing Tang | 2 | Yangjiabang | Nanshi |
| 3   | Mengjia Bridge | Jiashan Tang | 3 | Yuchitou | Dongsheng |
| 4   | Intersection of caochong Gang and Nanshi River | Caochong Gang | 4 | Jiuqu Gang | Fenghuang |
|     | Shanghai Tang Guangchen Tang Huanggu Tang | 5 | Huoshengmiao | Fenghuang |
| 6   | Guan Bridge | Zhaopu Tang | 6 | Yangjia Bridge Nanshi Gate Sluice Station | Fenghuang |
| 7   | New Daxing bridge (entry) | Haiyan Tang | 7 | Nanxi Gate Sluice Station | Nanhetou |
| 8   | Liudian Bridge | Nanshi River | 8 | Xiaoge Bridge | Binhu |
| 9   |Beisanjia Village | Dongshi River | 9 | Gaozhaobang | Ruyi |
| 10  | Sanguantang No.1 Bridge | Xingang River | | | |

3.2. Water quality of main rivers

There are 11 main rivers in the downtown area of Pinghu, including Jiaxing Tang, Jiashan Tang, Nanshi River, Dongshi River, shanghai Tang, Guangchen Tang, huanggu Tang, zhaopu Tang, Haiyan Tang, caochong Gang River and Xingang River. Taking the East Lake as the center, it is radially distributed, and the Nansha River and the Dongshi River are connected end to end, which encircles the central city into a semicircle.

Comparing the water quality monitoring from 2014 to 2017, it is shown in Figure 2. From the time distribution, it can be seen that the water quality of the main rivers in the central urban area is obviously improving, among which 7 rivers such as jiashan Tang are improved from inferior class V in 2014 to class III in 2017, and 4 rivers such as zhaopu Tang are improved from inferior class V in 2014 to class IV in 2017. In 2014, the main over standard factors were NH₃-N and TP. The section with the most serious over standard of NH₃-N was Mengjia bridge in jiashan Tang, and the section with the most serious over standard of TP was the intersection of caochong Gang and nanshi River. In 2017, the water quality of each region generally improved with little difference. The concentration
of NH$_3$-N was less than 1mg/L, and the concentration of TP was less than 0.3mg/l, which met or better than the water quality requirements of water function areas. It can be seen that during this period, through the construction of zero direct discharge area of sewage, the action of eliminating inferior class V water quality, the collection and treatment of balcony sewage and wastewater in urban area, the collection and treatment of catering sewage, and the dredging of river course, the anti pollution treatment effect of water pollution is obvious.

From the perspective of spatial distribution, the water quality of each region is quite different, and the relative pollution load of the north part of the urban flood control area is relatively large, which indicates that there are many dwellings in the north part of the river, a large number of domestic sewage is directly discharged into the river without treatment, and the sewage discharge is relatively concentrated, which exceeds the self purification capacity of the river water body.

![Figure 2. Temporal and spatial distribution of water quality in main rivers](image)

### 3.3. Water quality of general rivers

During the period of eliminating inferior class V water, the monitoring of small and micro water bodies in the central urban area was strengthened at the same time, and the monitoring was carried out twice in 2017 and 2018 respectively. Among them, in 2017, the comprehensive monitoring and drainage of small and micro water bodies in the region was carried out, and in 2018, the tracking and monitoring of the results were carried out. In 2017, there were 32 rivers with inferior class V water, accounting for 48%; in 2018, the proportion of inferior class V rivers decreased to 18%. The following mainly analyzes the river monitoring results of the main inferior class V water bodies in 2018.

As shown in Figure 3, from the perspective of spatial distribution, NH$_3$-N and TP are the main over standard factors of class V water body in general rivers, which are quite different in different regions. The water quality in the areas outside the urban flood control area is better than that in the south of the urban flood control area, and the water quality in the north of the urban flood control area is relatively poor.

Based on the analysis of water quality monitoring data of the main rivers and general rivers in the central city, it can be concluded that the water quality problems of the main rivers in the central city are more obvious than those of the general rivers. The main reasons are as follows: the first is that the sewage interception pipe is not complete, and the local pollution is serious; the second is that there are a large number of beheaded river, and the water connectivity is poor; the third is that the flow velocity of plain river network is low, and the water self purification capacity is poor; the fourth is that the river regulation project is not ecological.
4. Correlation Analysis of water quality parameters

At present, many domestic scholars have carried out research and discussion on the correlation of water quality parameters of different rivers or lakes [9,11]. The results show that under different water areas and hydrodynamic conditions, the relationships among these factors are different, and there are highly correlated, correlated and uncorrelated situations. In order to better analyze the change characteristics of these factors in Pinghu central urban area and provide more reference for water quality monitoring in the future, the correlation analysis of three water quality data measured in main rivers and general rivers is further carried out. Figure 4 and Figure 5 are the regression curves of the main river and general river.

It can be seen from Figure 4 that in the main river, there is a linear relationship between NH$_3$-N and TP ($R^2 = 0.6411$), between NH$_3$-N and COD$_{Mn}$ ($R^2 = 0.5798$), and between TP and COD$_{Mn}$ ($R^2 = 0.7762$), which indicates that these pollutants basically come from the same kind of pollution source, domestic pollution source, and the emission of pollution source is relatively stable. As can be seen from Figure 5, in general rivers, there is a linear relationship between NH$_3$-N and TP ($R^2 = 0.8199$), the correlation between NH$_3$-N and COD$_{Mn}$ is not significant ($R^2 = 0.2187$), and the correlation between TP and COD$_{Mn}$ is not significant ($R^2 = 0.0751$), which indicates that the general rivers are relatively more strongly disturbed by human activities. In order to master the water quality change law of general rivers, more detailed and long-term investigation is needed. At the same time, the general river is also the main object of pollution control.
5. Conclusions

(1) NH$_3$-N, TP and COD$_{Mn}$ are the main pollution factors in Pinghu City, in which NH$_3$-N and TP are the main over standard factors. The northern part of the urban flood control area has the largest relative pollution load, and the domestic pollution source is the main pollution source in the central urban area.

(2) During the period of Eliminating Class V water, the water quality of main rivers improved significantly, meeting the water quality requirements of water function areas; although the water quality of general rivers improved in different areas, the improvement of water quality needs to be further strengthened.

(3) The correlation of NH$_3$-N, TP and COD$_{Mn}$ was significant in the main channel, but poor in the general channel. It shows that the general river is strongly disturbed by human activities, and the purification effect of river water quality is poor.

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