Analysis of the impact on the water quality of Cixi by areas along the north line of water diversion from Cao'e river

Jianfen Fan¹, Huifang Guo²*, and Xiaofeng Xu¹

¹Qiantang River basin center of Zhejiang Province, Hangzhou 310020, China
²Zhejiang Tongji Vocational College of Science and Technology, Hangzhou 311231, China

*Corresponding author e-mail: 32970400@qq.com

Abstract. The north line of water diversion from Cao'e river is one of the six major water diversion projects in eastern Zhejiang Province. The project passes through three cities of YuYuCi. It mainly supplies water for Industry and agriculture, and takes into account the improvement of water environment. Cixi City is located at the end of the north line of water diversion from Cao'e river, and its water quality is affected by the nodes along the water diversion line. Using the least square method which can extract the main components of the independent variables on the dependent variables, the regression equations of the independent variables: Mushan sluice, Qitang sluice, Sitang sluice, Puqian sluice, xinsanjianqiu sluice and Luzhongwan pumping station are established, and the contribution values of each node to Luzhongwan pumping station under the indexes of permanganate, ammonia nitrogen, total phosphorus and dissolved oxygen are calculated. The results show that Sitang sluice has the greatest contribution to permanganate and total phosphorus of Luzhongwan pumping station, Puqian sluice has the greatest impact on ammonia nitrogen index of Luzhongwan pumping station, and xinsanjianqiu sluice has the greatest impact on dissolved oxygen index of Luzhongwan pumping station. Generally speaking, the stations which have the greatest impact on the water quality of Luzhongwan pumping station are Sitang sluice and Qitang sluice.

1. Introduction

The north line of water diversion from Cao'e river is one of the six major water diversion projects in eastern Zhejiang Province. The project passes through three cities of yuyuci. It mainly supplies water for Industry and agriculture, and takes into account the improvement of water environment. The average annual water diversion volume of the project is 420 million m³ (110 million m³ in Shangyu, 70 million m³ in Yuyao and 240 million m³ in Cixi). After entering Yubei river through Sanxing sluice, Cao'e River is divided into two branches: the north branch line flows into Sitang Hengjiang River and Qitang Hengjiang River in Yuyao through Puqian sluice, and then flows into Cixi River after passing through Sitang sluice and Qitang sluice; the south branch line flows into Yudong river through zhatouyan and then into Yuyao through Moushan sluice. The length of the water diversion line from Xiaoshan junction to Cixi in eastern Zhejiang is 147 km, of which the length from Xiaoshan junction to Cao'e River is about 62 km, the distance from Cao'e River to Cixi river is 85 km. Both sides of the water diversion line are economically developed and there are many enterprises. Cixi River, as the end
of the north line of water diversion from Cao'e River, greatly affects the water quality along the water diversion line. However, it is not known how much the impact of nodes along the water diversion line will have on its water quality. Based on the above reasons, partial least squares (PLS) method, which can calculate the importance of multiple input factors to output factors, is used to calculate the impact of the areas along the line on the water quality of Cixi river.

2. Distribution and selection of water quality stations along the line

There are nine automatic water quality monitoring stations along the main water diversion line of eastern Zhejiang water diversion project. Each water quality station has been in operation since September 2015. The data is daily monitoring, and a group of water quality data is obtained every four hours. This time, Mashan sluice, xinsanjian sluice, Sanxing sluice, Puqian sluice, Moushan sluice, Sitang sluice and Qitang sluice are selected as the sites affecting Cixi water quality, and Luzhongwan pumping station is selected as the representative station of Cixi City. The distribution of water quality stations is shown in the following figure:

![Figure 1. Distribution map of water quality stations](image)

3. Introduction of partial least squares

Partial least squares is the integration and development of multiple linear regression, canonical correlation analysis and principal component analysis. The partial least squares method extracts the main components of dependent variables by establishing the correlation model between input variables and output variables, and iteratively calculates the regression coefficients to achieve the target accuracy. The components extracted by PLS can not only survey the information in the independent variable system, but also explain the dependent variables well. It is a good principal component analysis tool. The method of partial least squares is used to extract the influencing factors of water quality in Cixi along the north line of water diversion from Cao'e river.

1. The water quality factor of Cixi City is set as dependent variable, and the water quality of Mashan sluice, xinsanjian sluice, Sanxing sluice, Puqian sluice, Moushan sluice, Sitang sluice and Qitang sluice is set as independent variable, and the regression equation is established.

2. The data of dependent variable and independent variable are standardized to make the center of gravity of sample point set coincide with the original coordinate.

3. According to the principle of principal component analysis and canonical correlation analysis, combined with Lagrange algorithm to solve the regression coefficient.

4. According to the order of regression coefficients, the contribution degree of each dependent variable to the independent variable is determined, and the main stations affecting the water quality of Cixi are selected.

4. Calculation process

Whether the water diversion project from Cao'e River to Cixi River diversifies water is determined by the water from Fuchun River upstream and the future rainfall situation along the line, which is not continuous and uninterrupted operation. The water quality data of water diversion is selected for this calculation. According to the actual data of the water quality station and the continuity of the data, the
water quality data from July 1 to July 31, 2017 is selected for calculation. During this period, the water diversion in eastern Zhejiang is all in water diversion. Since the Xinsanjiang sluice and Mashan sluice are opened in turn, the diversion section is mainly opened by the Xinsanjiang sluice, so only the water quality data of the Xinsanjiang sluice is used, but the data of Mashan sluice is not used. In order to explain the influence of each water quality index in detail, permanganate, ammonia nitrogen, total phosphorus and dissolved oxygen were selected to model respectively.

**Table 1 Permanganate**

| variable | Moushan sluice | Puqian sluice | Qitang sluice | Sanxing sluice | Sitang sluice | Xinsanjian g sluice |
|----------|----------------|---------------|---------------|----------------|---------------|---------------------|
| VIP value | 0.9087         | 0.5478        | 0.9867        | 0.7935         | 1.7599        | 0.4170              |

It can be seen from the above table that for permanganate index, Sitang sluice has the greatest impact on Luzhongwan pumping station, followed by Qitang sluice and Moushan sluice.

**Table 2 Dissolved oxygen**

| variable | Moushan sluice | Puqian sluice | Qitang sluice | Sanxing sluice | Sitang sluice | Xinsanjian g sluice |
|----------|----------------|---------------|---------------|----------------|---------------|---------------------|
| VIP value | 0.9873         | 0.7488        | 0.7957        | 0.8367         | 0.7992        | 1.5788              |

It can be seen from the above table that the Xinsanjian g sluice has the greatest impact on the Luzhongwan pumping station, followed by the Moushan sluice and Sanxing sluice.

**Table 3 Ammonia nitrogen**

| variable | Moushan sluice | Puqian sluice | Qitang sluice | Sanxing sluice | Sitang sluice | Xinsanjian g sluice |
|----------|----------------|---------------|---------------|----------------|---------------|---------------------|
| VIP value | 0.6823         | 1.2932        | 1.1412        | 0.4288         | 0.9631        | 1.2035              |

It can be seen from the above table that Puqian sluice has the greatest impact on Luzhongwan pumping station, followed by Qitang sluice and xinsanjian g sluice.

**Table 4 Total phosphorus**

| variable | Moushan sluice | Puqian sluice | Qitang sluice | Sanxing sluice | Sitang sluice | Xinsanjian g sluice |
|----------|----------------|---------------|---------------|----------------|---------------|---------------------|
| VIP value | 0.6979         | 1.0934        | 1.1792        | 1.1993         | 1.2122        | 0.1375              |

It can be seen from the above table that Puqian sluice has the greatest impact on Luzhongwan pumping station, followed by Qitang sluice and xinsanjian g sluice.

5. **Conclusion**

Cixi City is located at the end of the north line of water diversion from Cao'e river, and its water quality is affected by the nodes along the water diversion line. By using the least square method which can extract the main components of the independent variables on the dependent variables, the regression equations of the independent variables: Moushan sluice, Qitang sluice, Sitang sluice, Puqian sluice, xinsanjian g sluice and Luzhongwan pumping station are established, and the contribution values of each node to Luzhongwan pumping station under the indexes of permanganate, ammonia nitrogen, total phosphorus and dissolved oxygen are calculated. The results show that Sitang sluice has the greatest contribution to permanganate and total phosphorus of Luzhongwan pumping station, Puqian sluice has the greatest impact on ammonia nitrogen index of Luzhongwan pumping station, and xinsanjian g sluice has the greatest impact on dissolved oxygen index of Luzhongwan pumping station. Generally speaking, the stations which have the greatest impact on the water quality of Luzhongwan pumping station are Sitang sluice and Qitang sluice.
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