

PAPER • OPEN ACCESS

Assessment of river network water quality based on sluice gate control strategy in Wenzhou

To cite this article: Junmin Wang *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **227** 062023

View the [article online](#) for updates and enhancements.

Assessment of river network water quality based on sluice gate control strategy in Wenzhou

Junmin Wang¹, Lei Fu^{1,2,3} and Haibo Xu¹

¹ Zhejiang Institute of Hydraulics & Estuary, Hangzhou, China, 310020;

² University of Regina, SK, Regina, Canada, S4S0A2.

³ Email: f51@qq.com

Abstract. Nowadays, an ecological water diversion project is executed in Wenzhou city for the purpose of river network water quality improvement. Due to the flow rate of the water diversion project is relatively low, the utilization of sluice gates along Oujiang River becomes important, which can help to accelerate the flow velocity and redirect the water flow in river network. In this study, an experiment is designed and executed near Huiqiao sluice gate, both water flow and water quality are observed at three monitoring sections before and after the sluice gate's opening. The comparison between background and measured data shows the improvement of water quality in experimental area, which confirms the function of Huiqiao sluice gate. A comprehensive sluice gate regulation and control plan is anticipated in the future to further improve the river network water quality in Wenzhou city.

1. Introduction

As a water insufficient city, the government of Wenzhou city has focused on the river network water quality for years [1-3]. Recently, an ecological water diversion project is applied in Wenzhou to improve the regional river network water quality [3-6]. In this study, attentions are paid mostly on the districts near the sluice gate along Oujiang River as shown in Figure 1, where the river network water quality is deteriorating compared to the upstream districts because it is the downstream of Wenzhou city downtown area. An experiment is designed and executed based on the regular sluice gate control strategy in this study to verify the water quality improvement [7-8]. Both background and experimental data are collected and analyzed. Based on this study, a more efficient and environmental friendly sluice gate control strategy will be established, and further improvement of river network water quality in Wenzhou city is anticipated [8-12].

2. Experiment setup

2.1. Sluice gates and monitoring sections

After decades of construction, the river network in Wenzhou city has initially formed a water conservancy infrastructure system integrating flood control, drainage, flood control, drought resistance, water supply, irrigation, power generation, tourism, and ecological environmental protection [13].



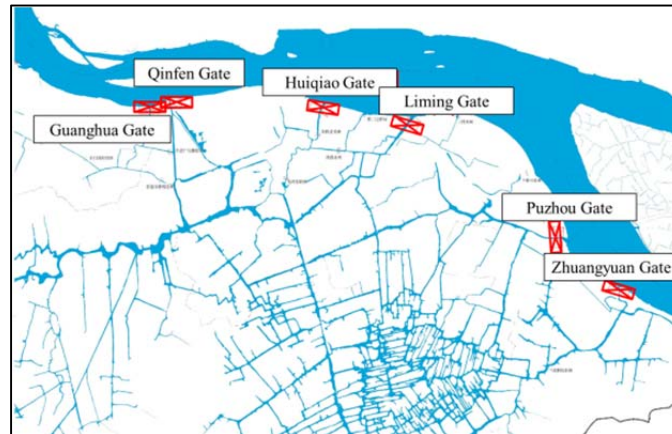


Figure 1. Six sluice gates along Oujiang River in Wenzhou city.

In this study, area closes to Huiqiao sluice gate is focused. Three monitoring sections are set in the experimental area, as listed in Table 1. The distance between each section to Huiqiao sluice gate is almost the same. Both water flow and water quality are monitored. Flow direction, flow rate and flow velocity are measured as water flow indices. Additionally, COD_{Mn} (Potassium permanganate index), DO (Dissolved oxygen), $\text{NH}_3\text{-N}$ (Ammonia nitrogen) and TP (Total phosphorus) are measured as water quality indices. The comparison between background and measured data show the acceleration of flow velocity and the improvement of water quality in these three sections, as shown in Figure 2.

Table 1. Name and location of monitoring sections.

Sluice gate	Section number	Monitoring section name	Rivers which monitoring section located
Huiqiao sluice	S1	Jingu Bridge	Huangyangjia River
	S2	Shangcun Bridge	Gui River
	S3	Zhinong Bridge	Hongdian River

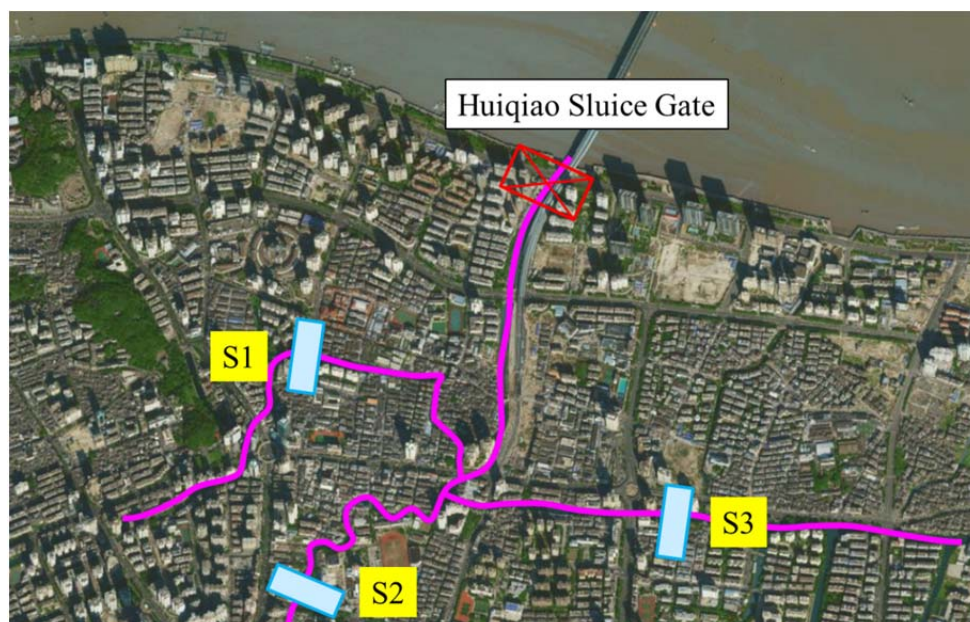


Figure 2. Monitoring sections in each experimental area.

2.2. Experimental scheme

Firstly, background water quality monitoring is carried out at each section before the opening of Huiqiao sluice gate. After Huiqiao sluice gate's opening, the water flow and water quality of each section near the sluice gate are synchronously monitored. The monitoring time is determined according to the opening time of Huiqiao sluice gate.

According to the experimental plan, the opening time is 14:00 on Nov, 27th, 2018. Hence, the synchronous monitoring of the affected rivers near Huiqiao sluice gate is then organized and executed at 13:00, 14:30, 15:00 and 15:30. The hydrological monitoring adopts the three-vertical-line flow rate monitoring method, both flow rate and the river section morphology are measured. The water quality monitoring adopts the top-bottom-double-layer monitoring method, four different water quality indices such as COD_{Mn}, DO, NH₃-N and TP are measured and analyzed.

3. Experimental results and discussion

3.1. Monitoring results

The influences of Huiqiao sluice gate on Huangyangjia River (Section 1), Gui River (Section 2) and Hongdian River (Section 3) will be measured and analyzed in this study. When Huiqiao sluice gate opens, the flow velocity of these three rivers has increased simultaneously. After 1 hour of the sluice gate's opening, the flow rate of the river near Huiqiao sluice gate begins to decrease because the drainage flow rate of the gate is much greater than the upstream water flow rate of each river. Among these three rivers, the flow rate of Gui River and Hongdian River increase significantly in the initial stage of the experiment, while the flow rate of Huangyangjia River only increases a little because of its narrow river section. The monitored flow rate is shown in Table 2, and the distribution of water flow volume of these three rivers is shown in Figure 3.

Table 2. Hydrological monitoring data (m³/s).

Sluice gate	Section name	River name	First monitoring	Second monitoring	Third monitoring
Huiqiao sluice	Jingu Bridge	Huangyangjia River	2.18	1.18	1.01
	Shangcun Bridge	Gui River	2.50	3.20	3.71
	Zhinong Bridge	Hongdian River	1.70	1.62	1.13

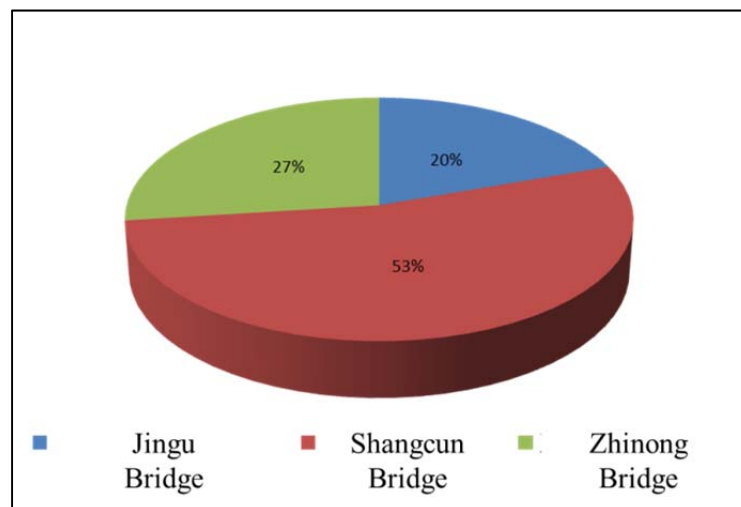


Figure 3. Distribution of the water flow volume of three different rivers.

It can be seen from the above figure that after Huiqiao sluice gate's opening, the flow volume of Gui river accounts for 53% of the total flow volume, which indicates that Gui River is the main channel to replenish water flow in the experimental area. The Huangyangjia River has the smallest flow volume due to its narrow river section and small upstream flow rate. Generally, these three rivers have different flow volume, which lead to different water quality improvement at each monitoring section, as will be discussed later.

3.2. Water quality data and analysis

According to the monitoring results, the water quality at three monitoring sections all show great improvements compared to background data. From the perspective of these rivers, take Huangyangjia River as an example, as shown in Figure 4, the concentration of COD_{Mn} , $\text{NH}_3\text{-N}$ and TP reduced by 26%, 32% and 43%, respectively. While DO concentration is 38% more than background data. Similar water quality improvements are observed at the other two sections in Gui River and Hongdian River, which confirms the function of Huiqiao sluice gate in water quality improvement during the experiment. The improvement of river network water quality in the experimental area in this study is significant compare to the research provided by Du et.al [5] and Cai et.al [11]

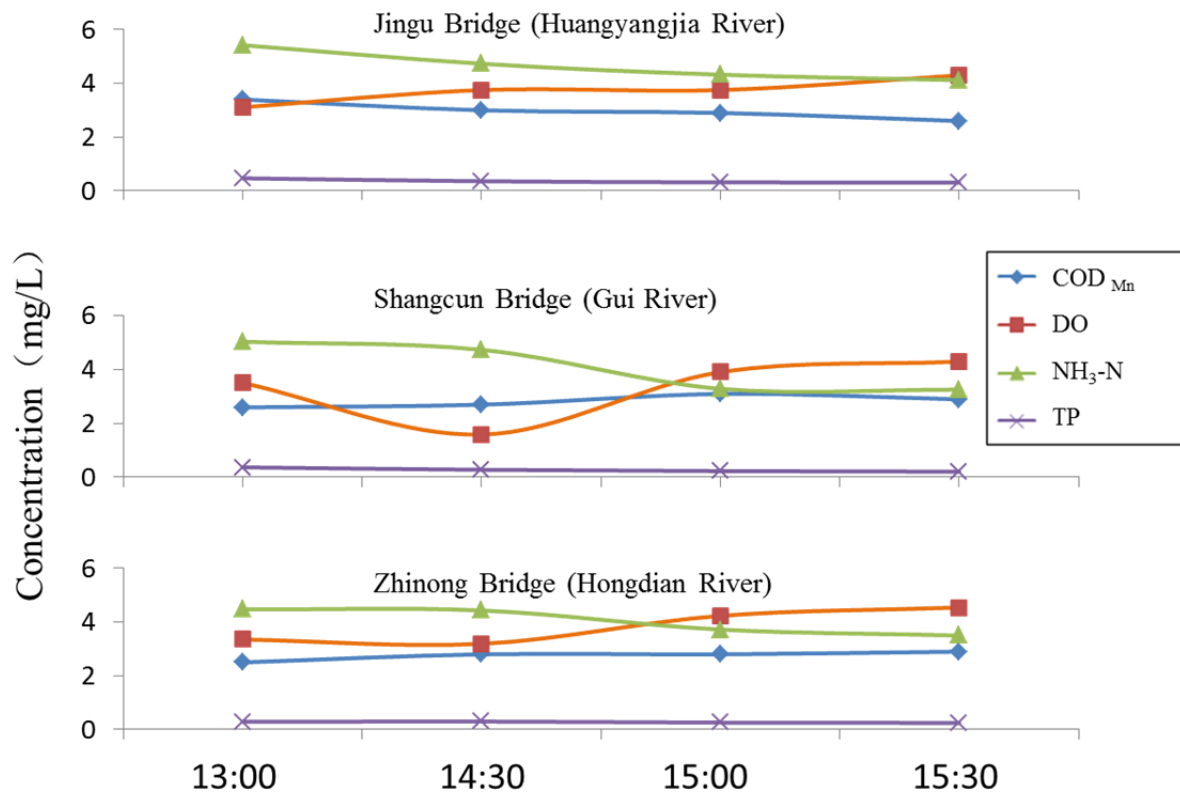


Figure 4. Variation of water quality in different sections during the experiment.

Additionally, from the above figure, the background water quality represented by COD_{Mn} , DO, $\text{NH}_3\text{-N}$ and TP in three sections are similar although the water quality of Huangyangjia River is slightly worse than the other two rivers. However, when Huiqiao sluice gate opens, the water quality improvements behaved differently in each section due to the fact that different river has different flow rate and upstream replenish flow quality.

3.3. Water quality comparison

In this study, water quality is also monitored on different layers, while the vertical flow velocity distribution on the central vertical line is calculated according to Eq (1) [13-15].

$$u_y = u_m \left(\frac{y}{h} \right)^{1/6} \quad (1)$$

where U_y is the velocity at location y (m/s), U_m is the surface flow velocity(m/s), y is the distance above river bottom(m), h is the water depth(m). The comparison of flow velocity and water quality on both surface and bottom layers are shown in Figure 5.

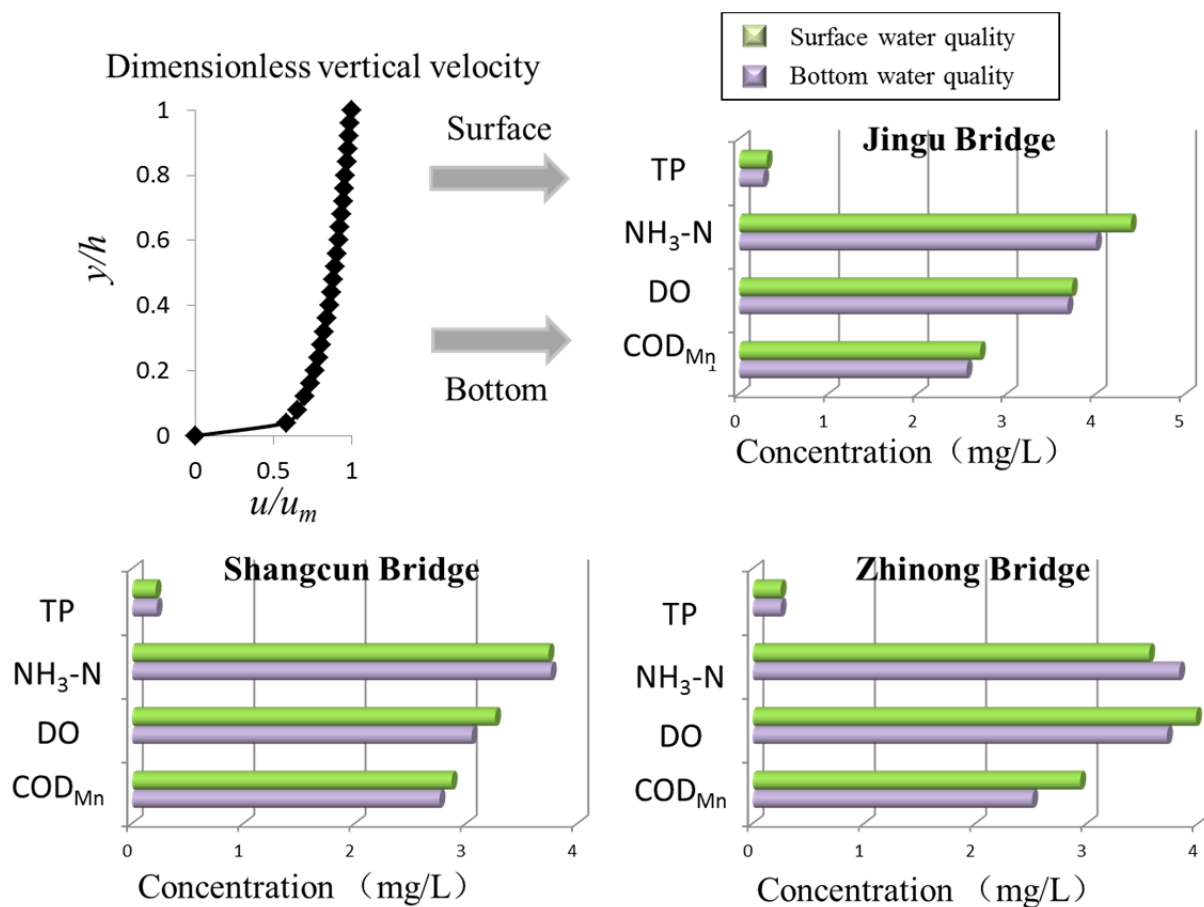


Figure 5. Comparison of flow velocity and water quality from water surface to bottom at different monitoring sections.

As can be seen from Figure 5, the overall performance of surface water quality is slightly better than the bottom water quality. From the comparison, the dissolved oxygen concentration in the surface water of the river is slightly higher than the bottom water, while the ammonia nitrogen concentration in the surface water body is slightly lower. However, the difference between these two indices is not obvious, similar phenomenon is observed in previous studies provided by Xu et.al [13] and He et.al [14]. It also shows that in the case of small water depth, although the water quality of the river will vary from surface to bottom, the convective diffusion of the water body itself will promote the mixing of the surface and bottom water bodies, which indeed minimizes the water quality difference between the upper and lower layers.

4. Conclusions

In this study, an experiment is executed near Huiqiao sluice gate in Wenzhou city, both water flow and water quality are monitored at different sections in the experimental area. When Huiqiao sluice gate opens, the water quality of the surrounding rivers has improved at all the monitoring sections compared to the background data. It also indicates that besides the good fluidity, the water quality improvement is also related to the water quality of the upstream flow and the endogenous source of the river sediment.

The overall performance of surface water quality is slightly better than the bottom water. However, from the comparison, the water quality difference between surface and bottom layers is hard to be distinguished. It also reveals that in the case of small water depth, although the water quality of the river will vary from surface to bottom, the convective diffusion of the water body will promote the mixing of the upper and lower water bodies. Therefore, the water quality difference between the upper and lower layers is not obvious.

Indeed, the comparison between background data and measured data in this study shows the improvement of water quality in the experimental area, which confirms the function of Huiqiao sluice gate in river network water quality improvement. A comprehensive sluice gate regulation and control plan is anticipated in the future to further improve the river network water quality in Wenzhou city.

Acknowledgment

This research was supported in part by the National Natural Science Foundation of China(51709237), the science and technology plan project of Department of Water Resources of Zhejiang Province (RA1604), and the science and technology plan project of Wenzhou (W20170008).

References

- [1] Defu H, Ruirui C, Enhui Z, Na C, Bo Y, Huahong S 2015 Toxicity bioassays for water from black-odor rivers in Wenzhou, China *Environmental Science & Pollution Research International* **22(3)** 1731-41
- [2] Zhang M, Zhang M 2007 Assessing the impact of leather industries on the quality of water discharged into the East China Sea from Wenzhou Watersheds *Journal of Environmental Management* **85(2)** 393-403
- [3] Nikita B, Shikha G, Amrita M, Kunwar P S 2010 Linear and nonlinear modeling for simultaneous prediction of dissolved oxygen and biochemical oxygen demand of the surface water — A case study *Chemo-metrics and Intelligent Laboratory Systems*, **104(2)** 172-180
- [4] Ma X, Shang X, Wang L, Dahlgren R A, Zhang M 2014 Innovative approach for the development of a water quality identification index—a case study from the Wen-rui tang river watershed, china *Desalination & Water Treatment* **10** 1-11
- [5] Du W, Chen L, Chen L, Jin Q, Zhou F, Tian C 2018 Application of hydrodynamic and water quality model to reduction of pollution load discharged into river network of Wen Huang Plain *Water Resources and Hydropower Engineering* **49(6)** 109-117
- [6] Mei K, Zhu Y, Liao L, Dahlgren R, Shang X, Zhang M 2011 Optimizing water quality monitoring networks using continuous longitudinal monitoring data: a case study of wen-rui tang river, wenzhou, china *Journal of Environmental Monitoring* **13(10)** 55-62
- [7] Ji X, Dahlgren R A, Zhang M 2016 Comparison of seven water quality assessment methods for the characterization and management of highly impaired river systems *Environmental Monitoring & Assessment* **188(1)** 15
- [8] Takeoka H 1987 Water exchange in a time varying transport field *Journal of the Oceanographical Society of Japan* **43(5)** 21-27
- [9] Ghosh N C, McBean E A 1998 Water quality modeling of the Kali River, India *Water, Air, and Soil Pollution* **(102)** 1-2
- [10] Stewart A 2000 Overview of water quality models Shanghai International Urban Toxics&Water Quafity Modeling Workshop, May 4th, Shanghai, China

- [11] Cai M, Lin M, Ma N 2018 Discussion on joint dispatching model of water environment in plain river network area based on ordered flow *Pearl River* **39(2)** 60-64
- [12] Kunwar P, Singh A, Malik D, Mohan S, Sinha V K S 2004 Chemometric data analysis of pollutants in wastewater—a case study *Analytica Chimica Acta* **532(1)** 15-25
- [13] Xu H, Fu L, Lin T 2017 Analysis of the ecological water diversion project in Wenzhou city International Conference on Energy Engineering and Environmental Protection, Nov 20-22nd, Sanya, China
- [14] He X, Wang C, Ru X, Ding B 2018 Study on water environment dispatching model in tidal river net controlled by sluice gates *Journal of North China University of Wtiter Resources and Electric Power(Natural Science Edition)* **39(2)** 86-92
- [15] Xu Y, Wang W, Zeng W, Li Y, Lai Q, Yin X, Zhang S 2018 Simulation on improvement of water environment in plain river network by water diversion *Water Resources Protection* **34(1)** 70-76