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Original Paper

Design of Relocation and Reconstruction Project for a Water Purification Plant in an Eastern Chinese City

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Abstract

With economic development and growing water demand in an eastern Chinese city, the current production capacity of No.1 Water Plant can no longer meet requirements, and there is an urgent need to expand its production scale. The newly constructed water purification plant has a design capacity of 50,000 m³/d for the near term and 100,000 m³/d for the long term. The project is implemented in phases, with the first phase construction at 50,000 m³/d. The effluent quality meets the requirements of the Standards for Drinking Water Quality (GB5749-2006). The water pressure at the end of the urban distribution network shall not be less than 0.28 MPa, and 0.14 MPa at the end of township distribution networks. The water treatment process adopts biological pretreatment + enhanced conventional treatment + ozone + activated carbon advanced treatment process. The plant layout features reasonable zoning, clear functions, smooth water flow, and reserved land for future expansion. The project covers an area of 6.49 hectares with a total investment of approximately 178 million yuan. Since its commissioning in 2021, the plant has operated stably, with water volume and pressure meeting both design and actual requirements.

Keywords

urban water purification plant, engineering design, ozone contact tank, activated carbon flap valve filter

1. Project Background

The city in eastern China covers a total area of 1,963 km², including 1,175 km² of land and 788 km² of water (accounting for 40.14%). Geologically, it is located in the main part of the Gaoyou Depression and extends across parts of the Dongdang, Liubao, and Lingtang low uplifts. The terrain is dominated by plains, with a small proportion of low hills and flat mounds. The terrain is higher in the southwest and lower in the northeast. The Lingtang, Tianshan, and Songqiao areas in the southwest feature low hill and flat mound landforms, which are accumulative-erosion terraces formed since the Quaternary period, marking the tail end of the junction between the Zhenyi-Liu low mountains and hills and the plain.

The city currently has two water purification plants: No.1 Water Plant and No.2 Water Plant. No.1 Water Plant was built in 1976 and has been expanded through several renovations to a capacity of 45,000 m^3/d, with two north-south water production lines. No.2 Water Plant is located at the intersection of Lingbo Road and Wenyou Road in the northwest of the urban area, covering 3.7 hectares. The first phase of No.2 Water Plant was put into operation in 1999 with a capacity of 50,000 m^3/d, and expanded to 100,000 m^3/d in 2015. Currently, the combined water production capacity of the two plants is 145,000 m^3/d.

According to water quality monitoring data, compared with the Class III limits of the Environmental Quality Standards for Surface Water (GB3838-2002), the intake of No.1 Water Plant recorded 2 exceedances of total phosphorus and 2 exceedances of total nitrogen in 2015; 9 exceedances of total nitrogen in 2016; and 1 exceedance of petroleum and 8 exceedances of total nitrogen in 2017. Other major water quality indicators meet Class III standards, and the effluent consistently meets the requirements of the Standards for Drinking Water Quality (GB5749-2006).

With economic development, population growth, and increasing water demand, the current production scale of No.1 Water Plant can no longer meet requirements, necessitating urgent expansion. Meanwhile, after more than 40 years of operation, No.1 Water Plant is approaching its design service life, with severely aging equipment and structures. It employs a conventional treatment process of "coagulation + sedimentation + filtration + disinfection" without any advanced treatment. According to the Implementation Opinions on Strengthening Urban Infrastructure Construction issued by the Jiangsu Provincial Government, all urban water plants must implement advanced treatment by 2015, but there is no space within the current plant boundary for advanced treatment retrofitting. Therefore, it is highly necessary and urgent to implement the relocation and reconstruction project for No.1 Water Plant to improve urban water supply quality, meet urban water supply development needs, and enhance water supply security.

2. Project Scale and Objectives

2.1 Project Scale

Based on water supply planning and water demand forecasting, the city's water demand will be 150,000 m^3/d in the near term (2020) and 200,000 m^3/d in the long term (2030). The current supply capacity of No.2 Water Plant is 100,000 m^3/d. Therefore, No.1 Water Plant will have a capacity of 50,000 m^3/d for the near term (2020) and 100,000 m^3/d for the long term (2030), achieving a balance between supply and demand. This project adopts a self-water consumption coefficient of 1.1, a daily variation coefficient of 1.3, and a peak hourly variation coefficient Ks of 1.4.

Table 1. Water Demand Forecast

Year	Comprehensive water consumption indicator per capita in urban areas	Mathematical and statistical analysis method	Average value(m^3/d)
2020	15.31	13.60	14.46
2030	19.79	20.13	19.96

2.2 Project Objectives

(1) Current Influent Water Quality

Based on testing data provided by the laboratory and compared with Class III limits of the Environmental Quality Standards for Surface Water (GB3838-2002), the main exceedances at the No.1 Water Plant intake from 2015 to 2018 are total phosphorus and total nitrogen, while other major indicators meet Class III standards. In 2015, TP had one or two severe exceedances and otherwise fluctuated near the limit value, while TN consistently exceeded the standard with a maximum value approaching 2.5 mg/L.

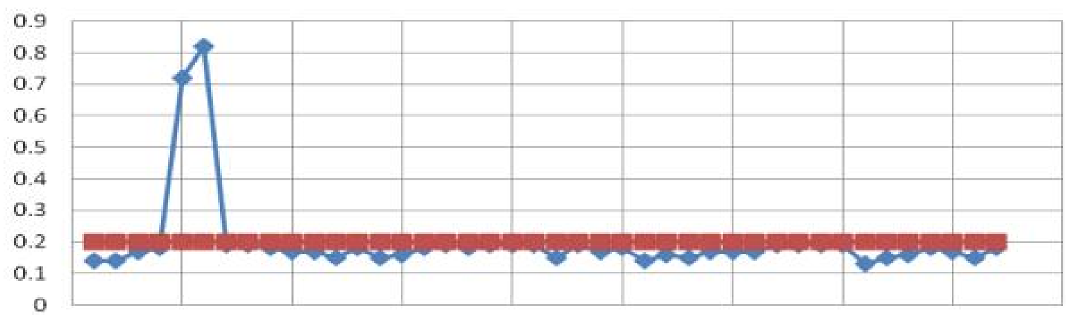

Figure 1. Raw Water TP Statistics

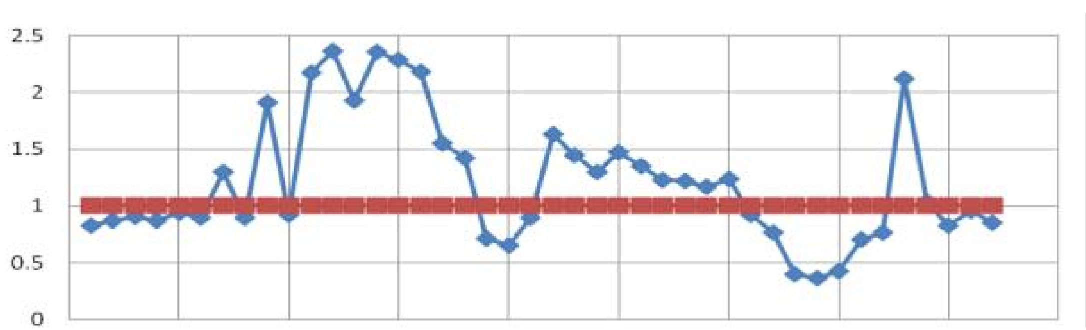

Figure 2. Raw Water TN Statistics

(2) Current Effluent Water Quality

Based on testing data from the laboratory and compared with the Standards for Drinking Water Quality (GB5749-2006), the main issue since 2015 has been occasional exceedances of oxygen consumption in effluent, with values close to the limit.

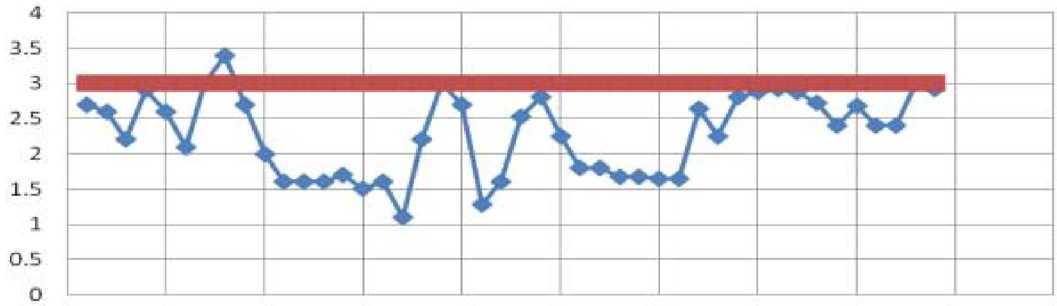

Figure 3. Effluent Oxygen Consumption Statistics

(3) Water Volume Objective

The total scale of the No.1 Water Plant relocation and reconstruction project is 100,000 m³/d (by 2030), with the first phase at 50,000 m³/d (by 2020). Self-water consumption coefficient is 1.1, daily variation coefficient is 1.3, and peak hourly variation coefficient Ks is 1.4.

(4) Water Quality Objective

Effluent quality shall meet the requirements of the Standards for Drinking Water Quality (GB5749-2006). Turbidity control requirements for each treatment stage: settled water < 3 NTU; filtered water (finished water) ≤ 0.5 NTU.

(5) Water Pressure Objective

Water pressure at the end of the urban distribution network shall not be less than 0.28 MPa, and 0.14 MPa at the end of township distribution networks.

3. Treatment Process

3.1 Selection of Pretreatment Process

The main pretreatment technologies for water purification plants include chemical oxidation, biological pretreatment, and adsorption pretreatment. Considering the characteristics of the water source in this project, indicators such as ammonia nitrogen are relatively low and better than Class III water quality standards. However, earthy-musty odor was detected in the water in 2015 and 2016. Therefore, biological pretreatment is not considered. Based on the operational experience of existing water plants and mature experience in Jiangsu's water treatment industry, this project proposes to adopt ozone pretreatment.

3.2 Selection of Conventional Treatment Process

Analyzing the raw water quality, effluent quality requirements, commonly used domestic water treatment processes, engineering experience, and local conditions, and comprehensively considering process layout, water quality, water volume, types and quantities of dosing chemicals, and maintenance conditions, this project recommends mechanical mixing. The sedimentation effluent turbidity is stably below 1 NTU. Considering the project scale, operational experience of the operating unit, operating costs, and the difficulty and requirements of maintenance and management, this project recommends horizontal flow sedimentation tanks. Filtration adopts air-water backwash filters with uniform grain filter media.

3.3 Selection of Advanced Treatment Process

Advanced treatment follows the conventional treatment process and uses appropriate methods to further remove pollutants and disinfection byproduct precursors that cannot be effectively removed by pretreatment and conventional treatment, thereby improving water supply safety and ensuring drinking water quality. Widely applied technologies include biological activated carbon advanced treatment, membrane separation, and ozone-biological activated carbon (O3-BAC) advanced treatment. O3-BAC is currently the most widely used advanced treatment technology in water purification plants. In Europe and America, most surface water plants use the ozone-activated carbon process. Many water plants in China have also adopted this technology with good operational results. Therefore, this project adopts the post-ozone contact tank + biological activated carbon process for advanced treatment.

4. Engineering Design

4.1 Process Flow

Based on raw water quality, operational requirements, engineering experience, and local conditions, this project adopts the pre-ozone + conventional treatment + O3-BAC process flow, which achieves thorough water quality improvement but involves higher investment and operating costs.

4.2 Plant Layout Plan

Considering the plant topography, existing access road, plant boundary, and the location of existing intake structures, the layout of this project is as follows:

The overall layout is divided into two zones: the administration area and the production area. The administration area is located on the west side of the entire plant, adjacent to the access road. The production area is located east of the administration area, separated by hedges and gates. Conventional treatment structures are arranged from south to north: pre-ozone contact tank, flocculation-sedimentation tank, and air-water backwash filter. Advanced treatment structures are located north of the conventional treatment area, arranged from south to north: intermediate lift pump house, post-ozone contact tank, and activated carbon flap valve filter. The activated carbon flap valve filter is close to the clear water reservoir on the west side, resulting in shorter effluent pipelines and smooth water flow. The production wastewater treatment area is located at the easternmost part of the plant, far from the administration area, with drainage and sludge discharge tank, thickener, and thickening-dewatering workshop arranged from north to south. The specific layout is shown below:

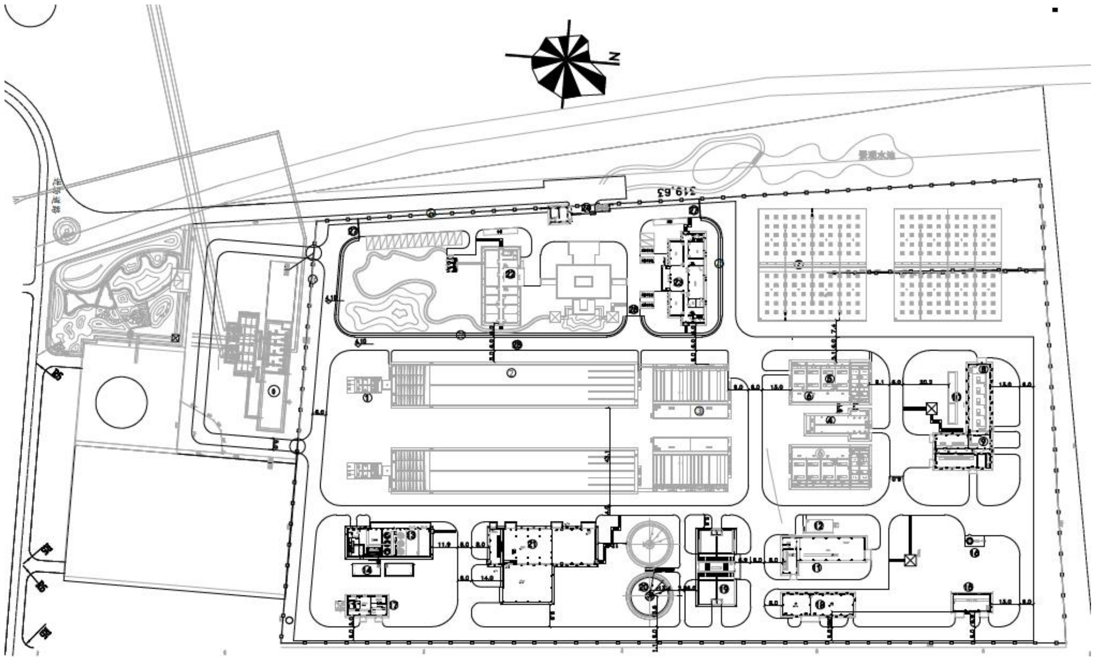

Figure 4. General Layout Plan of the Plant

4.3 Structure Design

(1) Intake Pump House

The existing intake pump house is a dry rectangular pump house, with civil works completed for a capacity of 100,000 m³/d. This design plans to install three centrifugal pumps, two in operation and one on standby.

Q = 1,094 m³/h, H = 3-7 m, motor power 220 kW, three units (2 operating + 1 standby).

(2) Pre-Ozone Contact Tank

One pre-ozone contact tank is provided, divided into 2 groups, each with a treatment capacity of 50,000 m³/d. Overall plan dimensions: 12.2 × 7.2 m, tank depth 6.4 m. O3 dosage: 0.5–1.0 mg/L, contact time: 2–5 min. Each pre-ozone tank is also equipped with 2 off-gas destruction devices, one in operation and one on standby.

(3) Flocculation-Sedimentation Tank

The pre-ozone contact tank is adjacent to the mixing tank, and the flocculation-sedimentation tank is constructed jointly with the mixing tank, with a capacity of 50,000 m³/d. The flocculation tank has 4 groups, and the sedimentation tank has 2 groups, each with a capacity of 50,000 m³/d.

① Mechanical Mixing Tank

Mixing time: 2.21 min, effective water depth: 5.3 m, equipped with one set of D = 1.5 m mixer.

Plan dimensions of each mixing tank: 4.4 × 4.5 m.

② Flocculation Tank

Vertical flow folded-plate flocculation tanks are adopted, constructed jointly with horizontal flow sedimentation tanks. Design parameters:

Design flow: $Q = 0.6076\ m^3/s$

Flocculation time: $T = 18.2$ min

Effective water depth: $H = 3.8$ m

③ Horizontal Flow Sedimentation Tank

Sedimentation time: 2.45 hr, horizontal flow velocity: 10.2 mm/s, tank depth: 4.0 m (including 0.20 m reserved sludge depth and 0.30 m freeboard, effective water depth 3.5 m). The flocculation-sedimentation tank is jointly constructed, with plan dimensions of 18.7 × 94.6 m per unit.

(4) Air-Water Backwash Filter

Civil works for 50,000 m^3/d, equipment for 50,000 m^3/d, with one additional unit to be added in the long term.

Design parameters: filtration rate 6.8 m/h, filtration cycle $T = 24$ h. The filter adopts a backwashing sequence of air-only washing → combined air-water washing → water-only washing. Backwash intensities: air-only washing at 15 $L/s \cdot m^2$; combined air-water washing at 15 $L/s \cdot m^2$ (air) and 3 $L/s \cdot m^2$ (water); water-only washing at 6 $L/s \cdot m^2$. Surface sweep washing is also performed at approximately 2.0 $L/s \cdot m^2$.

Backwash duration: air-only 1.5 min, combined air-water 4 min, water-only 6.5 min; total duration 12 min.

(5) Intermediate Lift Pump House

Civil works of the intermediate lift pump house are built for the long-term capacity of 100,000 m^3/d, while equipment is installed for 50,000 m^3/d. In the near term, 3 pumps are installed (2 operating + 1 standby), all with variable frequency drives. Each pump has a flow rate of 304 L/s, head of 7–4 m, and power of 37 kW.

Net plan dimensions of the lift pump house: 8.4 × 28 m, pump room depth 4.9 m, effective water depth 3.0 m, effective volume 253.8 m^3, equivalent to 13.9 minutes of discharge from a single pump.

(6) Post-Ozone Contact Tank

Near-term design capacity 50,000 m^3/d, both civil works and equipment for 50,000 m^3/d, with one additional unit for the long term. Plan dimensions: 18.11 × 8.4 m, divided into two cells that can operate independently. Design parameters: O_3 dosage 1.0–2.0 mg/L, contact time 11 min, divided into three series stages, each consisting of contact and reaction sections. Contact-reaction times for the three stages are 3.3 min, 3.3 min, and 4.4 min respectively (excluding connecting channels). Ozone dosage distribution across the three stages is 50%, 30%, and 20% sequentially. Two off-gas destruction devices are installed on the tank top, one in operation and one on standby.

(7) Flap Valve Activated Carbon Filter

Near-term design capacity 50,000 m^3/d, both civil works and equipment for 50,000 m^3/d, with one additional unit for the long term. Design parameters: filtration rate 10.02 m/h, contact time 13.18 min, divided into 4 cells. Filtration plan dimensions per cell: 9.1 × 6.0 m, filtration area per cell: 54.6 m^2.

Backwash cycle:

Air-only: intensity 15 L/s·m², t = 2 min

Combined air-water: air intensity 15 L/s·m², water intensity 4 L/s·m², t = 4 min

Water-only: intensity 12 L/s·m², t = 1.5 min

(8) Clear Water Reservoir

Civil works for 50,000 m³/d, equipment for 50,000 m³/d. Plan dimensions of each clear water reservoir: 49.7 × 47.7 m, tank depth 4.25 m, effective water depth 3.8 m, regulating volume 8,751.4 m³ (17.5% of daily capacity). One clear water reservoir is provided in the near term. To ensure no impact on residential water supply during maintenance, a DN1000 bypass pipe directly to the water supply pump house is installed.

(9) Water Supply Pump House

Civil works for 100,000 m³/d, equipment for 50,000 m³/d. Considering an hourly variation coefficient of 1.48, five pump positions are provided in the pump house. In the near term, four pumps are installed: three large pumps (2 operating + 1 standby) and one small pump. Each large pump has a design flow rate of 1,542 m³/h and head of 55 m, with a matching motor power of 315 kW. The small pump has a design flow rate of 542 m³/h and head of 55 m, with a matching motor power of 160 kW. During peak hours on the maximum day, two large pumps are operated; during average hours, one large and one small pump are operated.

(10) Backwash Pump House

The backwash pump house is a supporting structure for the filters.

Design parameters: calculated based on backwash design parameters of both the V-type filter and activated carbon flap valve filter.

Main equipment: blowers, 80 m³/min, outlet pressure 50 kPa, 75 kW, 1 operating + 1 standby.

Backwash pumps: Q = 786–867 m³/h, H = 9–10 m, 37 kW, 4 units (3 operating + 1 standby).

(11) Chemical Dosing Room and Sodium Hypochlorite Dosing Room

Design parameters: coagulant system, maximum dosage 20 mg/L, average dosage 10 mg/L. Coagulant aid dosing system, maximum dosage 0.5 mg/L. Post-filtration chlorination: maximum chlorine dosage 3.0 mg/L, dosing point at the inlet pipe of the clear water reservoir. Effluent supplementary chlorination: maximum dosage 3.0 mg/L, dosing point at the suction side of the water supply pump house.

(12) Potassium Permanganate and Powdered Activated Carbon Dosing Room

Powdered activated carbon (PAC) dosing system: design parameter Q = 1.22 m³/s (long term), maximum dosage 30 mg/L, one set of PAC dosing system provided.

Potassium permanganate dosing system: potassium permanganate can be dosed when organic micropollutants, algae, or odor control are detected in raw water. Design dosage 2.0 mg/L. One set of 5 kg/h potassium permanganate dosing system is provided, with an additional set to be added in the long term.

(13) Ozone Generation Room

Civil works for 100,000 m³/d, equipment for 50,000 m³/d. Design parameter: average dosage 1.5 mg/L.

Main equipment: ozone generator, Q = 5 kg/h, N = 50 kW, 1 operating + 1 standby; liquid oxygen tank, V = 30 m^3.

(14) Drainage and Sludge Discharge Tank

Civil works for 100,000 m^3/d, equipment for 50,000 m^3/d. Design parameter: meets the drainage requirements of two filter backwashes. Main equipment: submersible sewage pumps Q = 104 m^3/h, H = 11 m, N = 5.9 kW, 3 units (2 operating + 1 standby); submersible sewage pumps Q = 94 m^3/h, H = 10 m, N = 5.9 kW, 3 units (2 operating + 1 standby).

(15) Sludge Thickener

Civil works for 50,000 m^3/d, equipment for 50,000 m^3/d, with one additional unit for the long term. Design parameter: sludge loading rate 1 kg DS/(m^2·h). Main equipment: peripheral drive full-bridge thickener, Φ18 m.

(16) Sludge Dewatering Workshop

Civil works for 100,000 m^3/d, equipment for 50,000 m^3/d. Design parameter: total long-term dry sludge quantity 24.06 t/d, near-term dry sludge quantity 12.03 t/d.

Main equipment: plate and frame filter press, filter plates: 1250 × 1250 × 72 mm.

5. Operational Performance Analysis

The total investment of this urban water purification plant project is approximately 178 million RMB. After design, construction, and trial operation, it was officially put into service in 2021. Since commissioning, the effluent quality, water volume, and water pressure have stably met standards, greatly enhancing water supply security and providing a solid foundation for local economic development.

References

Chen, H. J., Xiao, Y. G., & Huang, G. L. (2011). Removal characteristics of organic pollutants in micro-polluted raw water by O3-BAC process. *China Water & Wastewater*, *27*(17), 18-21.

Gong, X. J. (2018). Purification performance of bio-enhanced activated carbon process for micro-polluted raw water. *Water Purification Technology*, *37*(4), 71-76.

Li, Y., & Huang, X. D. (2019). General layout and phased expansion design of urban waterworks. *Water & Wastewater Engineering*, *45*(8), 18-22.

Qiao, T. J., An, N., You, Z. L. et al. (2006). Long-term operation performance of ozone-biological activated carbon process in Meilin Water Plant. *China Water & Wastewater*, *22*(13), 10-13.

Yang, Y. Q., Zhang, D., & Lü, X. W. (2016). Ozone dosing optimization and organic matter removal in O3-BAC process. *Chinese Journal of Environmental Engineering*, *10*(3), 1295-1299.

Zhang, S., & Wang, Z. S. (2010). Design and operation parameters of flap activated carbon filter in surface water treatment plant. *Environmental Science*, *31*(9), 2087-2092