Reconstruction and Extension Project of Wastewater Treatment Plant in Beijiang Area, Tianjin Port

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Abstract. The original East Pier wastewater treatment plant in Beijiang Area, Tianjin Port, was built in 1992 to treat the wastewater produced locally. As required by the environmental protection department and owners, the output quality after treatment should meet the first class-A standard in "Pollutant discharge standard for urban sewage treatment plant (GB/T18918-2002)". Furthermore, water quality should meet the standards on city greening, road cleaning and fire water in "Urban sewage regeneration and utilization-water quality for multiple uses in city (GB/T18920-2002)" So the plant should be reconstructed and extended. Based on the analysis on the quantity of wastewater in Beijiang Area, the proper treatment processes were adopted. After this reconstruction and extension project, this waste water treatment plant can treat sewage about 1.4 million tons per year. Currently, annual quantity of water used for city greening and road cleaning in Beijiang Area, Tianjin Port is about 5,000,000 tons each year, which will be substituted by the water treated from this waste water treatment plant, so that this project helps to greatly save water and bring an excellent economic performance.

1 Project description

The original East Pier wastewater treatment plant in Beijiang Area, Tianjin Port, was built in 1992 to treat the wastewater produced locally, including both domestic and industrial wastewater. The system used oxidation ditch technology as the major biochemical treatment method, and was designed with a capacity of 2000m^3/d.

This reconstruction and extension project of the original East Pier wastewater treatment plant plans to treat all the wastewater in Beijing Area, Tianjin Port, with a newly capacity of 4000m^3/d.

Based on the test results of wastewater samples collected from sewage pipe network and the entrance of East Pier waste water treatment plant, the quality of water input to this new project has been estimated (see Table 1). As required by the environmental protection department and owners, the output quality after treatment should meet the first class-A standard in "Pollutant discharge standard for urban sewage treatment plant (GB/T18918-2002)" [1]. Furthermore, water quality should meet the standards on city greening, road cleaning and fire water in "Urban sewage regeneration and utilization --- water quality for multiple uses in city (GB/T18920-2002)" [2].

Table 1. Quality of water input to the new waste water treatment plant

Chemical oxygen demand（COD_{cr}）	450mg/L
Biochemical oxygen demand（BOD_5）	190mg/L
Suspended solids（SS）	220mg/L
Ammonia（NH_3-N）	35mg/L
Total nitrogen（TN）	45mg/L
Total phosphorus（as phosphorus）	4mg/L
Total dissolved solids（TDS）	3500mg/L

2 Analysis on the quantity of wastewater in Beijiang Area

2.1. Analysis on water consumption of Beijiang Area in 2006 and 2007

The quantity of water used in Beijiang Area, Tianjin Port, was 2.84 million tons for 2006, and 2.37 million tons for eleven months in 2007. There are about 60 companies which are currently registered to use water in Beijiang Area and generally divided into four categories below.

(1) Enterprises, institutions and joint venture companies: majorly represented by No.1 Company, No.2 Company, Supply and Service Company of Tianjin Port Holding Corporation, Ltd.etc, which has huge demand of water usage including domestic, industrial, dust-cleaning and greening water.

(2) Functional departments such as Border Inspection, Police, Fire Departments: represented by the Border Inspection Station and No.2 squadron of Fire Department, which has relatively small demand of water usage majored for domestic and greening water.

(3) Greening Center and Greening Engineering Company of Tianjin Port: represented by greening center of Tianjin Port with a moderate demand of water majorly to green and domestic usage.

(4) Construction companies which are operating in Beijiang Area: represented by subordinate company of No.1 Engineering Company, Ltd, of CCCC First Harbor Engineering Company, Ltd, and Tianjin Port Construction Commodity Concrete Co., Ltd. These companies use water majorly for construction, concrete mixing and domestic usage.

2.2 Analysis on the usage of water for major companies in Beijiang Area

The quantity and usage of water consumed by companies which have a large demand of water will have heavy

influences on our plan of wastewater treatment plant in Beijiang Area. Therefore, we have analyzed the water usage of companies which has water demand more than 20,000 tons in 2006 and 2007, in order to provide instructions to choose technical scheme for this construction waste water treatment and recycle in Beijiang Area.

These major companies represented by No.1 Company and No.2 Company from Tianjin Port Holding CO. Ltd, have four characters in terms of the water usage in 2006 and 2007:

(1) Usage of water in office, dining hall and bathing room are maintained steady as about 34% of total water consumption;

(2) Usage of greening water increased from 11% in 2006 to 13% in 2007;

(3) Usage of dust-cleaning and road spraying dropped from 16% in 2006 to 12% in 2007;

(4) Leakage rate decreased from 11% in 2006 to 10% in 2007;

(5) Other usage of water such as engineering, heating and mechanical maintenance raised from 17% in 2006 to 21% in 2007;

Besides these major companies above, water usage of other companies whose water consumption are relatively small, are domestic (~25%) and greening.

2.3 Analysis on the potential water quantity received by the new waste water treatment plant in Beijiang Area

Based on analysis above, and existing pipe network in Beijiang Area, East Pier wastewater treatment centre is responsible to receive sewage from the eastern area of Sandi Road, boundary by Dongdi Road. This area could also be divided into two sections:

Section 1: Eastern area of Dongdi Road, including companies such as Tianjin Oriental Container Terminals, Five Continents Container Terminals and Border Inspection Station.etc.

According to results above, we have estimated the theoretical output of water is about 300 tons per day, considering the water demand in this area. Most of companies in this section have already modified their pipe network , so that their sewage could eventually flow to the East Pier waste water treatment center.

Section 2: East of Sandi Road, West of Dongdi Road, majorly including companies such container terminals, No.5 Company and the Second squadron of Fire Department.

Second squadron of Fire Department is originally connected with East Pier waste water treatment center, with an estimated output of 30 to 50 tons per day.

Sewage from No.5 Company flow through pipe network from No.5 Background and Sandi Road, eventually end to open sea with an estimated daily output about 350 tons per day.

Sewage from Container Terminals initially flow via original pipe networks to No.4 pump station, and eventually reach East Pier waste water treatment center by pressure pipe with a theoretical input of 400 tons per day. Currently, the No.4 pump station remains as manual intermittent function. The actual input to wastewater treatment center is about 100 to 200 tons per day, which will rise up to about 300~400 tons per day in wet season.

Based on the analysis above, we use data from East Pier wastewater treatment center in 2008 for calculation and draw conclusions below:

Firstly, sewage of East Pier waste water treatment center come from the eastern area of Dongdi Road and No.4 pump station, with an estimated flux about 550 tons per day;

Secondly, No.5 Company will modify its rain/sewage pipe network and connect it with No.4 pump station, to optimize the pipe network on the east of Dongdi Road in order to reach East Pier waste water treatment center;

Thirdly, after all the sewage from eastern area of Sandi Road end up to East Pier waste water treatment center, it will have a theoretical flux for about 1100 tons per day.

3 Treatment processes

Normally, the aim of secondary biochemical treatment is to remove organic pollutants and a small part of nutrients (N, P) via biosynthesis. The removal capacity is about BOD: N: P=100: 5: 1. The original concentrations of nitrogen and phosphorus are fairly high for this study. So even after the normal secondary biochemical treatment, water quality still could not meet the standards of output. According to the requirement from the standards, secondary biochemical treatment with nitrification and denitrification functions should meet our expectations. Therefore, this waste water treatment plant should use A/O method with function of biological removal of nitrogen.

Generally speaking, the possibility and economical efficiency of biological removal of phosphorus is better than other methods. However, engineering practice has proved that biological way to remove phosphorus is difficult to decrease the concentration of phosphorus under 1 mg/L. Hence, considering the situation of this project, we have decided to use chemical method to remove phosphorus. The adding spots of chemicals generally locate at the entrances of primary setting tank, air exposure tank and secondary setting tank. Because this project has a longer cycle of muck removal and no secondary setting tank due to A/O+MBR method, we put chemical add-in system at the primary setting tank to remove phosphorus by chemical coagulation sedimentation. Considering the lost of BOD as the same time removing phosphate, which could affect the denitrification process, we added equipment to help adding carbon manually in the chemical add-in system.

Finally, this project use “ortex-type grit chamber + horizontal sedimentation + A/O reaction tank + MBR tank + middle tank + advanced treatment (UF + RO)”.

Figure 1. Key technology process

4 Analysis on economic performance

4.1 Cost accounting

The cost of this reconstruction project consists of power fee, chemical fee (pretreatment chemical fee and muck treatment chemical fee), labor fee (management and maintenance, employee wage, benefits.etc), equipment maintenance fee, analysis test fee.etc.

The flux of sewage used in this calculation was 4000m^3/d, and for advanced treatment, 2000 m^3/d was used with an assumption that 1 year equals to 360 days.

- **Power Fee**

East Pier waste water treatment plant was designed with a capacity of 391.8 KW. According to the practical conditions, the daily power for operation was 300 KW with assumptions such as one year equals to 360 days, electricity price equals to ￥1/KWh, and total cost for power is ￥259,200,000.

- **Chemical Fee**

There are 5 kinds of chemicals required by East Pier waste water treatment plant:

(1) Coagulant --- Polymeric aluminium chloride (PAC): mostly added in horizontal sedimentation tank as 100 mg/L, the annual demand = 4000×100×360=144 tons. As the unit (per ton) price equals to ￥4000, total annual cost is ￥576,000.

(2) Coagulant aid, sludge concentrate --- Polyacrylamide (PAM): mostly used in horizontal sedimentation tank and sludge dehydrate room.

If the add flux of PAM is 5 mg/L in calculation, annual demand of PAM is 4000×5×360=7.2 tons. And using unit (per ton) price as ￥40,000, annual cost PAM equals to ￥288,000. Demand of PAM in sludge dehydrate room is relatively small as ￥12,000 per year. Therefore, total cost of PAM is estimated to be ￥300, 000.

(3) Antisludging reagent for UF/RO: with an adding flux as 6 mg/L and 2000 m^3 of waste water per day, the annual demand equals to 2000×6×360 = 4.32 tons. If the unit (per ton) is ￥40,000， total annual cost is ￥172,800.

(4) Bactericide for UF/RO --- require continuously adding of water via measure pump during operation process, with adding rate of 400 mg/L, about 30 minutes each time every 2 weeks. Similar to the calculation above, annual demand of bactericide is about 1 ton, and annual cost is about ￥45,000 due to the unit price of ￥45,000.

(5) Cleaning reagent for UF/RO --- annual demand is about 1 ton, and annual cost is about ￥45,000 due to the unit price of ￥45,000.

In summary, the annual chemical cost of waste water treatment plant is:

576,000+300,000+172,800+45,000+45,000=1,138,800

- **Equipment Maintenance Fee**

Equipment maintenance fee equals to 3% of total investment which is ￥15,000,000, so annual cost of equipment maintenance fee is:

15,000,000×0.03=450,000

- **Analysis Test Fee**

Similar to the calculation in engineer budget, daily cost of analysis test is estimated as ￥500, so the annual cost of analysis test equals to:

500×360=￥18,000

- **Sludge Deposit Fee**

This calculation is made based on the assumption that sludge has all been transferred and deposited appropriately outside of port area.

If the unit price is ￥500, the annual cost equals to 500×360=￥18,000.

- Labor Fee

The waste water treatment plant has 16 employees with monthly salary as ￥4,000, so the annual cost of labor equals to ￥768,000.

To sum up, the total cost of waste water treatment plant is listed as the table below:

Table 2. Analysis of the operational cost

NAME	TOTAL COST (×10000 YUAN)	CALCULATION	NOTE
Power Fee	259.2	with a capacity as 300Kw and unit price of electricity as ￥1/Kw.h	
Chemical Fee	113.88	see chapter 2 above	
Equipment Fee	45.0	3% of the total annual investment of equipment which is ￥15,000,000	
Sludge Deposit Fee	18.0	￥500 per day	Deposited as landfill
Labor Fee	76.8	16 employees with monthly salary as ￥4,000	
Analysis Test Fee	18.0	￥1,000 per day	Analogy calculation
Total cost：￥5,308,800, unit price for waste water treatment is ￥3.68/ton			

4.2 Economic Performance

After this reconstruction and extension project, this waste water treatment plant can treat sewage about 1.4 million tons per year. The water output will decrease the amount of pollutants fluxing to the adjacent sea and supply high quality water resource for multiple uses.

Currently, annual quantity of water used for city greening and road cleaning in Beijiang Area, Tianjin Port is about 5,000,000 tons each year, which will be substituted by the water treated from this waste water treatment plant, so that this project helps to greatly save water and bring an excellent economic performance.

References

[1] Minstry of Environemntal Protection of the People's Republic of China. *Discharge standard of pollutants for municipal wastewater treatmentplant* (GB 18918-2002. China Environmental Science Press, Beijing, China, 2002).

[2] Minstry of Environemntal Protection of the People's Republic of China. The reuse of urban recycling water--Water quality standard for urban miscellaneous water consumption (GB/T 18920-2002. China Environmental Science Press, Beijing, China, 2002).