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One Full-scale Municipal Wastewater Treatment and Reclamation Plant in China

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ABSTRACT

Wastewater reclamation and reuse technology provides a viable solution for water crisis. This paper introduces a full-scale municipal wastewater treatment (200,000 m^3/d) and reclamation (110,000 m^3/d) plant in China. It is biologically treated by modified oxidation ditch process, and further polished by flocculation, V-type filter, finally disinfected by ClO_2 for reuse. The biologically treated water could reach class I-B criteria of Chinese municipal wastewater discharge standard (GB/T 18918-2002). The advanced treated water could meet Chinese urban reuse standard (GB/T 18920-2002). It has been reused as landscape water (50,000 m^3/d) for 7 years, and would be reused as recycling water for one thermal power plant (60,000 m^3/d) in 2013. The full-scale wastewater treatment and reclamation plant may provide a visible and feasible solution to China's water shortage.

Keywords: Wastewater reclamation; modified oxidation ditch; flocculation; V-type filter

1. INTRODUCTION

In the past, treated wastewater was discharged to the environment and generally considered as a waste. However, due to the deterioration of the water environment and water crisis, treated wastewater effluent should be regarded as a resource from which high quality water for reuse can be produced (Comerton et al., 2005; Bixio et al., 2008; Miquel, 2008). Consequently, wastewater treatment and reuse technology, such as chemical coagulation (Gökhan et al., 2011), sand filtration (Avner and Takashi, 1998), constructed wetland (Rousseau et al., 2008; Zhang et al., 2012), even membrane technology (Qin et al., 2006; Mutamim et al., 2012), has been increasingly developed and applied in various fields (House et al., 1999; Tam et al., 2007; Lin et al., 2011).

In this paper, we introduce a large-scale municipal wastewater treatment (200,000 m^3/d) and reclamation (110,000 m^3/d) plant in China, which is biologically treated by modified oxidation ditch process (one anaerobic tank prior to oxidation ditch process for better phosphorus removal), and further polished by chemical flocculation and sand filtration, finally disinfected by ClO_2 for reuse. It may be one feasible and economical wastewater treatment and reclamation process and demonstration for the present water shortage.

2. MATERIALS AND METHODS

2.1 Description of the full-scale wastewater treatment and reuse plant

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The large-scale wastewater treatment and reuse project (Figure 1), Wulongkou municipal plant, located in Zhengzhou, Henan province, China. Its footprint was about 13 hm^2. It serviced 27 km^2 and 370,000 persons approximately. The project was constructed in two stages. Its total capacity for biological wastewater treatment was 200,000 m^3/d (100,000 m^3/d for each stage), and the total capacity for advanced purification was about 110,000 m^3/d (50,000 m^3/d and 60,000 m^3/d for the first and second stage, respectively).

The project was treated biologically by modified oxidation ditch process, and further polished by chemical flocculation with lattice vibration, then V-type filter with silica sand, finally disinfected by ClO_2 for reuse. The process flow was presented in Figure 2.

2.2 Wastewater monitoring and analysis

Samples were taken every day from the feed wastewater, biologically treated effluent, and advanced treated water, and analyzed for chemical oxygen demand (COD), biological oxygen demand (BOD), ammonia-nitrogen (NH_4^+-N), total nitrogen (TN), total phosphorus (TP), suspended substance (SS) according to Chinese NEPA standard methods (NEPA, 1997).

Figure 1 The on-site picture of the full-scale municipal plant

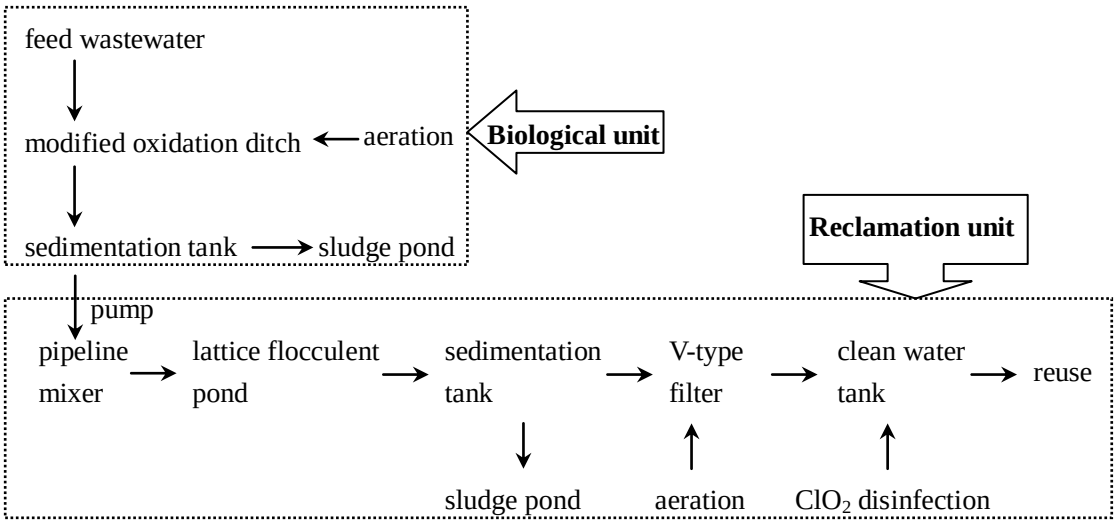

Figure 2 The wastewater treatment and reclamation process of the municipal plant

Table 1 The raw wastewater, biological effluent and reclamation requirement

Items	COD	BOD_5	SS	NH_4^+-N	TN	TP
Raw wastewater	<500	<220	250	<40	<55	<4.0
Biological effluent requirement	<60	<20	<20	<8	–	<1.5
Reclamation requirement	–	<10	<5	<10	–	–

Table 2 The biological effluent water and municipal wastewater discharge standard

Time	COD (mg/L)	BOD (mg/L)	SS (mg/L)	NH_4^+-N (mg/L)	TP (mg/L)
2006 Jan	50.0	14.0	19.0	0.6	1.0
2006 Feb	45.0	14.0	20.0	1.6	2.0
2006 Mar	44.0	11.0	21.0	1.1	1.2
2006 Apr	47.0	15.0	19.0	3.8	1.2
2006 May	27.0	7.0	16.0	0.3	1.2
2006 Jun	26.0	5.0	13.0	1.2	1.4
2006 Jul	23.0	4.0	14.0	0.6	1.4
2006 Aug	21.0	3.0	12.0	0.3	0.9
2006 Sep	23.0	3.0	14.0	0.9	0.9
2006 Oct	29.0	7.0	17.0	1.5	1.5
2006 Nov	31.0	7.0	16.0	1.0	1.3
2006 Dec	43.0	12.0	19.0	2.1	1.3
GB/T 18918-2002 (I-B)	<60	<20	<20	<8	<1.5

Table 3 The advanced treated water and reuse standard

Time	COD (mg/L)	BOD (mg/L)	SS (mg/L)	NH_4^+-N (mg/L)	TP (mg/L)
2006 Jan	25.5	2.2	2.2	0.6	0.5
2006 Feb	23.9	0.0	1.4	1.7	1.0
2006 Mar	22.2	0.0	0.8	1.7	0.5
2006 Apr	22.0	2.0	2.2	2.2	0.5
2006 May	16.0	0.0	2.5	0.5	0.6
2006 Jun	15.4	1.2	2.4	1.8	0.4
2006 Jul	13.9	0.0	2.9	1.0	0.6
2006 Aug	14.8	0.0	3.2	0.6	0.4
2006 Sep	14.8	1.0	1.9	0.7	0.5
2006 Oct	17.9	2.3	1.6	1.4	0.9
2006 Nov	18.2	1.8	1.9	1.0	0.6
2006 Dec	15.0	2.0	1.0	1.8	0.6
GB/T 18918-2002 (I-A)	<50	<10	<10	<5	<1.0
GB/T 18920-2002	–	<10	<5	<10	–

2.3 Raw wastewater and reuse standard

The municipal plant was operated continuously with the domestic wastewater covering the west Zhengzhou distinct. The raw wastewater, biological effluent and reclamation requirement was listed in Table 1.

3. RESULTS AND DISCUSSIONS

3.1 The performance of the full-scale plant

The municipal wastewater treatment and reclamation plant was constructed in two stages. The work of the project for the first period had been completed and operated regularly since 2005, and 100,000 m^3/d wastewater had been biologically treated, 50,000 m^3/d of which had been further treated and reused as landscape water for Golden Water River in Zhengzhou. The expansion of the project for the second period had been completed and operated regularly since 2010, and 200,000 m^3/d wastewater had been biologically treated, 110,000 m^3/d of which had been further treated by chemical flocculation and sand filtration for reuse. So far, 50,000 m^3/d advanced treated wastewater has been reused as landscape water for Golden Water River in Zhengzhou for about 7 years, and the rest of 60,000 m^3/d would be reused as recycling water for one thermal power plant in 2013.

As listed in Table 2 (taking 2006 for example), modified oxidation ditch process significantly reduced the biodegradable components, such as COD, BOD, NH_4^+-N, etc., and the biologically treated water could reach class I-B criteria of Chinese municipal wastewater discharge standard (GB/T 18918-2002). Over the long-term operation, the biological system showed better performance in pollutants removal, but a little decrease for COD, BOD removals with a little sludge bulking from December to April because of the low temperature in Zhengzhou district (Table 2). It was noted that the oxidation ditch process showed perfect and stable in NH_4^+-N removal.

As listed in Table 3 (taking 2006 for example), lattice vibration flocculation, V-type filtration and ClO_2 disinfection further improved the end water quatlity, especially TP, and the advanced treated water could meet class I-A criteria of Chinese municipal wastewater discharge standard (GB/T 18918-2002) and Chinese urban reuse standard (GB/T 18920 -2002).

3.2 Economic feasibility and public benefits

The initial construction investment of the biological wastewater treatment plant was about 41.43 million US dollars, and the initial construction investment of the advanced treated water reclamation plant was about 13.38 million US dollars. The subsidy from the government was 0.15 US dollars per cubic reclamation water from June, 2005. Thus far, considering the recycling water of 50, 000 m^3/d discharging into Golden Water River, the recovering capital in the past 7 years has reached about 19.16 million US dollars. All the cost of the reclamation plant has been recovered. If the recycling water is 110,000 m^3/d, the benefit of reclamation water will be about 6.0225 million US dollars per year. Additionally, 40,150,000 m^3 tap water will be saved per year.

This reclaimed water reuse project not only alleviated the water shortage in Zhengzhou to some extent, but also significantly improved the total water environment. Apparently, the water quality of Golden Water River was more clarificatory than before, with little uncomfortable odor. On the other hand, the reclaimed water reuse project reduced more pollutions such as COD, BOD, SS, NH_4^+-N, etc., which was beneficial to relieve the depression

of water eutrophication. The full-scale wastewater treatment and reclamation plant also provided a visible and feasible solution to China's water crisis.

CONCLUSIONS

The combined oxidation ditch, chemical flocculation and V-type filter process may be one viable wastewater treatment and reclamation technology.

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