Rural Domestic Sewage Treatment Technology Application in Conghua District of Guangzhou under the Rural Revitalization Strategy

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Abstract. The paper analyzes the current situation and characteristics of rural domestic sewage treatment in Conghua District, Guangzhou city. It takes the river system as the vein and the administrative village of characteristic town as the node, which pays great attention to the overall planning of the water environment. In this area, the rural domestic sewage on both sides of the Liuxi River is selected as the research object, and the rural sewage treatment of the Yadong River Basin is taken as a project case to explore the applicability of rural sewage treatment technology, hoping to achieve a beautiful countryside with clear water and beautiful scenery, and then promote the revitalization and development of the beautiful village, which provides reference value for ecological and social benefits.

1. Research purpose
Rural domestic sewage treatment is a centennial plan project, to ensure the safety of water use in rural areas, improve the water environment, which is related to the health and quality of life of rural residents, as well as a major livelihood event. After years of development, most of the rural areas still have a relatively unbalanced social and economic level, and the sewage treatment and discharge are not in place, which poses a serious threat to the rural ecological environment. In recent years, many cities have implemented the concept of “Lucid waters and lush mountains are invaluable assets”, and actively promoted the treatment of rural domestic sewage. Conghua area of Guangzhou city has many hills and mountains, scattered natural villages and underdeveloped areas. Water control projects are multifaceted, especially pipe network construction, which are all underground projects, so how to ensure the quality of the project has become an urgent problem to be solved. In order to coordinate the planning of water pollution treatment technology and application, establish applicable water pollution control measures, and improve the quality of rural water supply, in 2020, Conghua district of Guangzhou City will take rural water supply transformation as an important task to implement the rural revitalization strategy and promoting the improvement of rural human settlements. The purpose of the important task is to carry out rural water supply transformation in 40 administrative villages, so that the collection rate of rural domestic sewage in the Liuxi River Basin of this area can reach more than 90%[1], so as to optimize the rural ecological environment and promote rural economic development.
2. Characteristics of rural domestic sewage discharge in Conghua District of Guangzhou

According to statistics, urban and rural tap water in Guangzhou has been fully popularized. There are 1,144 administrative villages in the city, with a rural population of 2.43 million. Drinking municipal tap water is 2.076 million people, accounting for 85.4% of the total rural population; drinking mountain spring water is 28 million people, accounting for 11.5%; drinking groundwater is 76,000 people, accounting for 3.1%[2]. The quality of water is related to the life safety of the masses. The establishment of a technical system for comprehensive treatment of domestic sewage is an important measure for sustainable development. At the same time, the applicability of rural domestic sewage treatment helps to improve the application effect of rural domestic sewage treatment technology[3]. In this area, the characteristics of rural domestic sewage discharge are mainly manifested in four aspects:

First, the collection rate of rural domestic sewage in Conghua District has not up to the standard. There are many mountains, scattered villages, many and scattered rural tourist attractions and farm catering restaurants, and the concentration of sewage is high. The collection rate of rural domestic sewage in some districts has not reached the quantitative target of 90% of the government planning.

Second, there is a lack of funds for the construction of sewage treatment facilities. The municipal drainage pipes in some villages were blocked by a large amount of garbage, and the domestic sewage passed around the village on the ground, which makes the village smelly and the sewage treatment effect is poor.

Third, it is difficult to coordinate land use for construction of sewage treatment facilities. The construction of rural domestic sewage treatment facilities generally adopts the method of borrowing and renting land. However, some villagers have insufficient awareness of environmental protection and have no strong sense of social responsibility. They do not cooperate with the provision of construction corridors, and they arbitrarily increase the compensation for young crops and land rent. Villagers in a few villages obstruct the construction of sewage facilities, which greatly increases the difficulty of sewage purification project.

Fourth, the management and maintenance of some facilities are not in place. The garbage left over during the construction of some facilities was not cleaned up in time, resulting in poor water flow and poor plant growth in the constructed wetland system near the Liuxi River, which affected the benefit of wetland landscape.

3. Conception of rural sewage treatment system

Conghua district is the largest administrative district in Guangzhou city, with a total area of 1985 square kilometers, 199 small and medium-sized rivers with a total length of 1275 kilometers, and a total of 2.8 billion cubic meters of water resources. There are 63 rivers and lakes in the second-class and above protected zone, which has the reputation of “Guangzhou back garden”. In order to promote the rural domestic sewage treatment work, the local government departments proposed the construction of “one axis, six basins, two corridors and eight towns” (Figure 1), and continguously planning the linear project of the simultaneous treatment of Liuxi River water body and rural sewage plan in a centralized way, so as to create a demonstration project with clear water and beautiful scenery. At the same time, the government invested 610 million yuan to comprehensively renovate the rural water system in the region from 2018 to 2020, with a flood control benefit area of 520 million square meters. The construction fund for rural domestic sewage treatment is based on the standard of RMB 1,000 per person of permanent population, so as to ensure the implementation of sewage infrastructure construction costs.

For the special action plan of rural domestic sewage treatment in this district, it is necessary to strengthen the concept of sewage treatment as an important environmental governance task, practice through a variety of rural sewage treatment technologies, make full use of the original drainage system of the villages, and adopt centralized and decentralized methods according to local conditions to improve the efficiency of sewage treatment. Decentralized sewage treatment technologies such as constructed wetlands and ecological floating islands are more practical for rural sewage treatment[4]. Anaerobic digestion technology and integrated technology have their own advantages. Practical
sewage treatment technologies could be selected according to the current situation of the village, and become a highlight project of water environment treatment work, and achieve win-win situation of three lives (ecology, production and life)[5].

4. Application of core technology for rural domestic sewage treatment

Rural domestic sewage is mainly formed by kitchen sewage, washing sewage, bathroom sewage and other ways. The main considerations of domestic sewage pollutants are as follows: one is the key issue of eutrophication, and the other is the key pollution factors such as nitrogen and phosphorus and the total emission reduction of pollutants. At present, there are three main types of rural domestic sewage operation models: village collective independent operation, accounting for 10%-20%; village collective + professional company operation, accounting for 30%-50%; third party professional company operation, accounting for 30%-60%. Four common rural domestic sewage process modes: anaerobic biological treatment + ecological engineering; anaerobic biological treatment + aerobic biological treatment + ecological engineering; biogas digester + anaerobic biological treatment + aerobic biological treatment + artificial wetland + agricultural irrigation; Integrated complete equipment[6]. And taking the Yadong River Basin sewage treatment plant in Liangkou Town, Conghua District, Guangzhou City as an example, the practice of rural domestic sewage treatment technology is carried out.

4.1 Overview of sewage treatment project in tributary of Yadong River

The sewage treatment plant is located in the plot north of Yadong River, Liangkou Town, Conghua District, and east of 105 National Road. The total land area is 40000 square meters, and the artificial wetland area is 13381 square meters, which is in the “L” shape layout. The plant area is divided into four functional zones: pretreatment area, sludge treatment area, sewage treatment area and management area. There are also two supporting projects for lifting pump stations. The construction project is mainly engaged in sewage treatment and recycling. The annual operation time is 365 days and the daily operation time is 24 hours.

4.2 Sewage treatment process

This sewage treatment system is for the treatment of rural domestic sewage with high sewage organic matter, and its treatment system (Figure 2) is suitable for the development of villages on the tributaries
of the Yadong River. The entire sewage treatment process can be divided into four links: pretreatment, oxidation ditch treatment, advanced treatment, and constructed wetland treatment (Table 1). For the non-process wastewater in rural life, it is mainly recycled by the pump house, and the main pollutants are CODcr, BODs, and ammonia nitrogen. For the initial rainwater treatment, it is mainly collected through pipelines and ditches. After the rainwater is fully settled in the sedimentation tank, it is discharged into the Yadong River through the rain and sewage diversion equipment. For the constructed wetland system, considering the inherent requirements of water purification and aesthetics, a number of unit pools with different water velocity and volume were divided, and reeds or thalia dealbata fraser flowers were planted in different wetland pools. The construction of corridors and retaining walls around the wetland plays a role of space division on the one hand, and on the other hand as a passage for inspection work, and the passage with wetland sightseeing will be gradually opened to the public.

![Sewage treatment technology](image)

**Figure 2. Schematic diagram of rural domestic sewage treatment system in Yadong River Basin.**

| Technological links   | Specific process                                                                 |
|-----------------------|---------------------------------------------------------------------------------|
| Pretreatment          | Sewage grid and sedimentation                                                   |
| Oxidation ditch treatment | Anaerobic, anoxic and aerobic three stages to degrade organic matter, deoxidize and remove phosphorus |
| Advanced treatment    | High efficiency filtration of suspended solids and total phosphorus              |
| Wetland treatment     | Effluent                                                                        |

Table 1. Sewage treatment process in Yadonghe Villages.

For the treatment of sludge in the remaining sewage, the sludge machinery will thicken and dehydrate (Figure 3) to reduce the release of phosphorus in the sludge liquid to reduce air pollution. When the moisture content of the sludge is less than 80%, the sludge is transported to the company of environmental protection technology for professional recycling. The dried and pelleted sludge ball is widely used as compound fertilizer, soil amendment, fuel and building raw materials for making bricks and tiles.
4.3 Engineering treatment effect

The design production capacity of the first phase of the sewage treatment plant project in this region is 11,000 tons m\(^3/d\), the actual production capacity reaches 7000 m\(^3/d\), and the sludge production is 1867kg/d. In June 2018, the plant entrusted Guangdong Bytest Testing Technology Co., Ltd. to carry out environmental protection acceptance monitoring for the completion of the project. During the operation of the project, the wastewater is treated by the secondary biochemical process of oxidation ditch, and then the effluent is further treated by the constructed wetland system.

Sewage treatment in this area is based on the daily average value of wastewater monitoring at the outlet of the sewage plant on June 29, 2018. Sampling is taken every two hours on the same day for 24 hours continuously. The main use of acidity meter, biochemical incubator, UV-visible spectrophotometer, Infrared spectrophotometer, electrothermal constant temperature incubator, current meter, gas chromatograph, inductively coupled plasma emission spectrometer and other tools to detect suspended solids, CODcr, BOD\(_5\) and other items, the results show: pH value was 6.88-7.24, suspended solids was Nd (lower than the detection limit), COD was 18, ammonia nitrogen was 0.230, animal and vegetable oil was 0.11, total phosphorus was 0.09, and total nitrogen was 6.69. The treated water quality reached the “Discharge standard of pollutants for municipal wastewater treatment plant” (GB 18918-2002) and the first class standard of the local standard of Guangdong Province, “Discharge standard of water pollutants for rural sewage treatment”) DB 44/2208-2019” (Table 2). The wastewater discharge had a certain impact on the water quality of Yadong River, but basically met the water quality standard of Yadong river.

| Number | Control item          | Limit standard:mg/L(Except for pH) | Grade I | Grade II | Grade III |
|--------|-----------------------|-----------------------------------|---------|----------|-----------|
| 1      | pH value              |                                   | 6-9     |          |           |
| 2      | Suspended matter      |                                   | 20      | 30       | 50        |
| 3      | Chemical oxygen demand|                                   | 60      | 70       | 100       |
| 4      | Ammonia nitrogen\(^1\) |                                   | 8(15)   | 15       | 25        |
| 5      | Animal and vegetable oils\(^2\) |                           | 3       | /        | 5         |
| 6      | Total phosphorus\(^3\) |                                   | 1       | /        | /         |
| 7      | Total nitrogen\(^4\)  |                                   | 20      | /        | /         |

\(^1\)The values in brackets of total nitrogen and ammonia nitrogen are the control indexes of water temperature ≤ 12 °C;

\(^2\) Animal and vegetable oil indicators are only implemented for domestic sewage treatment facilities of rural tourism projects that provide catering services;

\(^3\) The total phosphorus index is only applicable to the domestic sewage treatment facilities in which the effluent is discharged into the closed water body or the total phosphorus exceeds the standard;

\(^4\) The total nitrogen index is only implemented for the domestic sewage treatment facilities in which the effluent is discharged into the closed water body or the total nitrogen exceeds the standard.
The three indicators of discharge water stability, management and operation difficulty, and noise level are relatively important indicators for the applicability evaluation of rural sewage treatment technology[7]. In the process of rural domestic sewage treatment, measures such as collection and biological filtration are used to purify the odor from the biological reaction tank, grille, sludge storage tank, pump house and dehydration machine room. The treated exhaust gas meets the second-level emission standard; for the impact of noise from sewage treatment equipment such as dehydrators and water pumps, various measures such as sound absorption, shock absorption, and sound insulation have been adopted to ensure that the boundary noise reaches Class 4a standards.

In order to create a project with clear water and beautiful scenery (Figure 4), many rural areas in this district continue to carry out rural water supply renovation. Sewage facilities in Shalang Village in Conghua District will undergo in-depth renovation in 2020. The daily sewage treatment volume reaches 120 tons. After purification, the sewage can be discharged into the pond in the form of fountains through underground pipelines (Figure 5), which is clean and tidy, and fishes wandered freely. Based on the characteristics of scattered settlements, Nanping Village introduced the buried integrated sewage treatment equipment, and effectively treated rural domestic sewage by MBR process and traditional constructed wetland pool (Figure 6-7), the plants in the constructed wetland pool are flourishing and blooming, reaching class A discharge standard and improving rural ecological environment.
5. Conclusion
(1) In the case, the sewage treatment plant in Liangkou Town in the Yadong River Basin uses oxidation ditch technology and constructed wetland system to treat rural domestic sewage, which is in line with the actual situation of local rural sewage treatment. The effluent is recycled and reused. The secondary biochemical process is reliable and reaches the discharge standard, which basically meets the water quality requirements of Yadong River and Liuxi River.

(2) The reasonable sewage treatment engineering technology should be selected in Conghua district according to the topography, population density, economic status, hydrological characteristics, and discharge indicators of each village. Funds are the guarantee for the green treatment of rural life pollution[8]. Special funds must be used to increase management efforts, promote the Internet of things and remote monitoring, strengthen incentive mechanism of rewards and punishments and popular science education[9], formulate emergency measures for sewage treatment, and then improve the environment risk prevention matters.

Strengthening rural domestic sewage treatment is not only a long-term task, but also an important measure to build a beautiful village. It reflects the concern for ecological civilization and needs to be continued in depth to protect the rural ecological homeland.

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