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An enhanced denitrifinal membrane bioreactor -A case study for Taihu Lake of Changzhou

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Abstract: *In recent years, with the rapid development of the economy of villages and towns and the improvement of the living standards of residents, the rural sewage discharge tends to be concentrated and the discharge increases. People begin to pay attention to the treatment and reuse of rural sewage gradually. However, due to the backward rural economy and the low level of technical management, the progress of sewage treatment is slow. In this paper, a new wastewater treatment and recovery process, which is mainly denitrification, is developed for the area with small water environment capacity, which is enhanced denitrification MBR process. The system not only has the advantages of the original membrane bioreactor, but also is convenient to use, and can carry out the sewage evolution treatment for the domestic sewage of the individual households, which improves the flexibility of the sewage treatment. The results of effluent test show that MBR process effluent meets the first level B standard in GB18918-2002, and has high efficiency in removing ammonia nitrogen, COD, BOD and other pollutants, which plays a significant role in improving the water quality of the drainage basin and region, and has important value for the improvement of the water quality in rural areas.*

Keywords: *rural, wastewater treatment, nitrogen removal, MBR, membrane bioreactor*

1. Introduction

In recent years, due to the continuous promotion of new rural construction, China's rural infrastructure has been greatly improved. But at the same time, the environmental problems caused by the disorderly discharge of rural sewage have gradually attracted people's attention. (Qi Yao et al., 2008) In contrast, the research on rural sewage treatment abroad was carried out earlier. For example, the United States started the construction of rural sewage treatment facilities in the middle of the 19th century, Japan started the construction of rural drainage projects in 1973, and Denmark made legislation on rural domestic sewage discharge in 1987. (Qian Haiyan et al., 2014)These countries have relatively mature technology in rural sewage treatment. In order to improve the backward situation of rural sewage treatment in China, the state has issued a series of policies. The 13th Five-Year plan for ecological environment protection issued in 2016 pointed out that during the 13th Five-Year Plan period, it is necessary to promote the comprehensive environmental improvement of 130000 administrative villages and promote the rural domestic sewage treatment in echelon; the three year action plan for rural living environment improvement issued in 2018 proposed "rural garbage, sewage treatment and village appearance improvement should be the main direction to accelerate the improvement of rural living environment". Therefore, speeding up the rural sewage treatment is the key to improve the status quo of disorderly discharge of rural sewage and the living environment of rural people, and promote the development of rural basin and regional water environment. (Bian S., 2020) At present, there are many domestic technologies used in decentralized treatment of rural sewage. There are mainly the following categories: the first category is to miniaturize the traditional secondary biochemical process of urban sewage treatment plant, so as to apply it to rural sewage treatment. Such as oxidation ditch, anaerobic reactor, A^2/O process, MBR, etc.; the second is some relatively simple ecological sewage treatment technology, such as constructed wetland, etc.; the third is anaerobic treatment technology. For rural sewage, but for the situation that the water quality and quantity of rural wastewater fluctuate greatly, the traditional process is difficult to ensure the stable effluent quality. (Zhang Qing., 2020; Lu Sensen et al., 2020) Therefore, for the area with small environmental capacity and high effluent quality requirements, the treatment effect of the existing process is often difficult to meet the expected requirements under the

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condition of obvious fluctuation of water quality and quantity.

Taihu Lake, Jiangsu Province, located in the core area of the Yangtze River Delta, is the most densely populated and economically active area in China. (Guo Lei., 2018) The level of regional urbanization, rural economy and farmers' income are relatively high, but most villages are scattered, water flushing toilets are common, rural domestic sewage discharge is large, and the overall utilization rate and treatment efficiency of sewage treatment facilities are not high. At the same time, the eutrophication problem of Taihu Lake Basin is becoming more and more serious in recent years, and rural domestic sewage is also one of the important sources. Therefore, in the areas with small environmental capacity, large population base and serious water quality pollution, it is urgent to develop a rural sewage treatment technology which is suitable for the characteristics of water quality and has stable nitrogen and phosphorus removal effect. A MBR process based on denitrification is developed in this paper. It is a new wastewater treatment and recovery process which combines membrane separation technology with traditional biological treatment technology and takes denitrification as the main technology. Through membrane bioreactor, the efficiency of solid-liquid separation is greatly improved, and the microorganism is intercepted in the bioreactor, and the loss of activated sludge is greatly reduced. The system has the characteristics of good effluent quality, small floor area, high pollutant removal rate, less surplus sludge, low operation and management cost, which is of great significance for further improvement of rural sewage treatment process.

2. Routing

A membrane bioreactor (MBR) is a combination of membrane filtration and biological treatment of activated sludge (MervynC et al, 1996; Wang et al, 2013; Zhang et al, 2001). The membrane filtration process separates the microorganism which is the base of the biological treatment process from the biological medium liquid (the mixed liquid), which acts as a substitute for the traditional activated sludge. Thus, the microorganisms can be retained in the biochemical reaction tank, and the effluent water is basically free of microorganisms and other suspended matter. The membrane Bioreactor can effectively overcome the restrictive conditions related to the sludge settling performance, and act as a substitute for the secondary settling tank, in pursuit of clarification and sterilization.

MBR can maintain a high biomass concentration, usually MLSS of 8 ~ 10g/L, up to 10 ~ 15g/L, and conventional activated sludge of MLSS of 3 ~ 5g/L. Therefore, the occupation area of MBR process is only 1/2 ~ 1/3 of that of conventional treatment. At the same time, the nitrification and denitrification (Wang YY, et al 2003) were carried out alternately in this process, which enhanced the denitrogenation ability of the system. The pre-positioning of the aerobic tank also reduces the risk of membrane fouling. The process flow is as follows (figure 1):

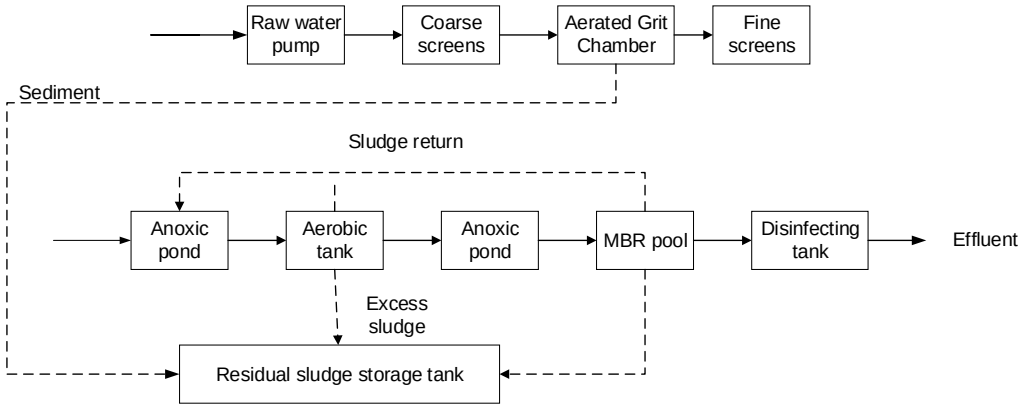

Figure 1: Process flow diagram

After the sewage is delivered from the raw water pump to the crude grid, after filtering the large suspension, enter the aerated sanding tank, so that some organic contaminants attached to the grit can be removed, and the sewage is filtered after filtration, and then enter an anaerobic pool - The oxygen pool-hypoxic pool allows the denitrifuginal to have sufficient organics as a carbon source for denitrification and phosphorus, and then remove the sewage into the MBR reaction tank to remove the microorganisms and other suspended matter to finally disinfect and out of water. Among them, some sludge in the oxygen pool and the MBR pool reflux into the hypoxic pool, and the remaining sludge enters the residual sludge storage pool.

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3. Research area

Zou district town is located in the west of Changzhou City, close to the Beijing Hangzhou Grand Canal. Zou district town covers a total area of 66.18 square kilometers. It has 17 administrative villages including Zou District village, Yangzhuang village, Longtan Village, Daizhuang village and Anji village, and 4 communities (neighborhood committees) including Zou District, Zou new garden, Boge and Tai Village. It has 453 villager groups and 117 resident groups.

The people's Government of Zou district has always attached great importance to the problem of water environment. Since 2007, Zou district has started the construction of Zou District sewage treatment plant and large-scale construction of sewage pipe network. The main problems are: the coverage rate of sewage pipe network is low, the construction of sewage pipe network is seriously lagging behind, and the diversion of rainwater and sewage has not been put on the agenda. The second phase construction of the sewage treatment plant lags behind, and the sewage treatment capacity does not match the economic development. The industrial enterprise wastewater has the phenomenon of over standard discharge and illegally discharged into the river. (Shi Chong et al.,2018)

Therefore, the local water environment is seriously damaged. In recent years, the eutrophication problem of Taihu Lake Basin is becoming more and more serious. Therefore, it is necessary to develop a new type of wastewater treatment and recovery process based on nitrogen removal.

4. Experimental steps and results discussions

The experimental steps are as follows:

(1) The lifting pump begins to enter the water, and then adding the active sludge from the nearby sewage treatment plant to add a good oxygen pool, the aeration cycle is 3 days, and the carbon source is added at the same time;

(2) Observe the growth of activated sludge, when the oxygen sludge concentration reaches 2000-3000 mg / L, normal water, the oxygen pool is added to the hypoxidized bacteria, improve the system-denitrification resistance;

(3) The equipment is normal to enter and exit water, and the bacteriostain will be replenished at any time, and the SV is maintained at around 30%, and the equipment is operating normally. After testing, the experimental results are shown in Table 1:

Table 1: Retrieval of water quality *mg/L*

index	COD	BOD_5	Ammonia nitrogen	Total phosphorus	SS
S1	400	200	40	3	150
S1’	13	3.2	0.03	0.192	3
Removal rate%	96.8	98.4	99.9	93.6	98
S2	360	210	40	2.8	165
S2’	11	2.7	0.140	0.093	2.5
Removal rate%	96.9	98.7	99.7	96.7	98.5
S3	420	226	36	2.9	155
S3’	13	3.0	0.103	0.044	3
Removal rate%	96.9	98.7	99.7	98.5	98.6
Standard	60	20	8	1.5	3

Experimental summary:

(1) Water-water conditions, throughout 12.17 - 19th, continuous water detection, each contaminant indicator can be GB18918-2002 primary B standard.

(2) The removal rate of pollutants such as COD, ammonia nitrogen is high, and the average removal rate of ammonia nitrogen has reached 99.8%. The average removal rate of COD has reached 96.9%, and the removal rate writes the specific value, counts one.

(3) The overall process is small, and there is no secondary pollution.

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5. Conclusions

(1) Membrane bio-reactor-biological (denitrification strengthen) is suitable for rural distributed domestic sewage treatment, and the effluent stability reaches the first-class A standard in GB18918-2002.

(2) Technology has strengthened the biological nitrogen removal based on traditional MBR, realized the two-way flow of nitrification and denitrification, greatly improved the efficiency of nitrogen removal, and significantly improved the effect of nitrogen removal.

(3) The process equipment was applied in Changzhou City, Jiangsu Province. The water quality of the inlet and outlet water showed that the average removal rates of COD_{CR}, NH_3-N, TP and SS by the process were 93.4%, 97.7%, 92.5% and 88.4%, respectively, with high removal rates for various pollutants.

(4) This technology has low construction cost, small footprint, flexible use, and can provide a reference for decentralized domestic sewage treatment technology.

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