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Water Pollution in Old Towns Affecting the Environment and Ecological restoration

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ABSTRACT

In order to solve the problem that the traditional activated sludge method is not effective in recovering the ecological process of water pollution in urban areas, the membrane bioreactor-based sewage treatment process was studied experimentally. Two flat-plate ultrafiltration membranes were used to form the ultrafilter tank in the experimental device sampled, and the processes of nitrate cycle and sludge cycle were adopted. Ozonation and granular activated carbon filtration were adopted to treat the micropollutants. After repeated experiments in 17 experimental cycles, the obtained experimental data were analysed, and it was found that under different sewage treatment loads, the treatment quality of the device could reach p concentration < 0.2mg/L and n concentration < 6mg/L. Compared with the traditional sewage treatment process, the experimental device can better remove the common nutrient rich substances and micro-pollutants in urban sewage, better control the greenhouse gas emissions, and meet the demand for efficient ecological recovery of urban sewage.

INTRODUCTION

Urban water environment metabolic system is a cycle chain of urban water resources utilization and protection composed of water source, water supply, water use and drainage, and is the source of urban life and vitality. Its overall function is to meet the reasonable water demand of the city, that is, the living and social water demand of urban residents, the production water demand of urban development and the environmental water demand of urban landscape and municipal administration. With the improvement of people's requirements on environmental quality and their attention to the urban ecological environment, the urban water environment system, as an important subsystem, has become the green lifeline of the urban system, which can effectively weaken the urban "heat island effect" and reduce the degree of pollution, and is of great significance to the construction of high-grade ecological city. Due to the growth of urban population and stricter water quality requirements, the urgency of ecological restoration of water pollution in urban areas has increased. The main passive means of water ecological restoration is the removal of drug residues, suspended micro-solids, microorganisms, nitrogen and phosphorus and other nutrient-rich substances in regional water bodies by using efficient sewage treatment equipment (Zhou et al. 2018). Because the traditional sewage treatment plant usually cannot effectively remove drug residues and some organic pollutants in the polluted water in cities, substances such as pesticides, antibiotics, biological agent, pose a threat to aquatic organisms, aquatic food webs and higher biological potential negative effects, to our environment, health and society, so there is a need to adopt effective treatment means to remove them. (Yang et al. 2018, Koch et al. 2018, Stanford et al. 2018). In this paper, the wastewater treatment process based on membrane bioreactor is studied in view of the problem that the traditional activated sludge method is not effective in recovering the ecological process of water pollution in urban areas.

EARLIER STUDIES

A study evaluated the impact of land use and point source on water quality in the river system of Shunde district from 2000 to 2010 by using Pearson regression analysis, redundancy analysis and multiple regression analysis. Garner et al. (2018) used EFDC model to analyse the scope, time and degree of pollution damage of sudden water pollution event under different hydrological conditions in Shenzhen estuary. A method is proposed to accurately analyse the main hydrodynamic factors in sudden water pollution events in estuaries (Tao et al. 2017). Kalogianni et al. (2017) studied the effects of water level and nitrogen load (ammonium nitrogen and nitrate nitrogen) on seedling emergence and regeneration of riparian seed banks in this basin. Another increasingly important issue for sewage treatment is greenhouse gas emissions. In the process of sewage treatment, the emission of greenhouse gases with nitrous oxide (N_2O) as the main component is usually not taken seriously. However, the greenhouse effect of N_2O is 298 times higher than that of carbon dioxide (CO_2). At the same time, in the process of incomplete nitrification and denitrification, the emission of N_2O cannot be avoided. For this reason, new solutions with high efficiency, high capacity and flexible municipal wastewater treatment technology are needed. A study calculated the water footprint grey component (GWF P) of the four most common drug compounds (CBZ, DCF, KTP and NPX).In addition, GWF C of major conventional pollutants (nitrate, phosphate and organic matter) was also calculated (Martínezalcalá et al. 2018). A research evaluated water quality with comprehensive nutritional status index (TLI) and Shannon-Wiener diversity index (H) (Chen et al. 2017).

Membrane bioreactor (MBR) will be used to replace the existing traditional activated sludge process (CAS), and the treatment capacity of the MBR based sewage treatment device will be verified through experiments. MBR technology has been used in the chemical industry for decades, but only in the past decade has it gained more application in the ecological restoration of polluted water bodies in urban areas. This is mainly due to the cost of membrane greatly reduced and process optimization development reduces the demand for energy. Existing research data show that MBR combines bioactive sludge process with membrane separation, and it has obvious advantages over CAS. Advantages include significantly better particle water (osmosis) quality, disinfection capability due to membrane pore size, higher sludge concentration in organisms, higher volume load, smaller footprint, and flexibility of influent change process. The disadvantages of the MBR process are the high energy consumption in the aeration process and the need to use cleaning chemicals in the filtration process to inhibit the fouling on the membrane surface to improve the membrane permeability. Based on the consideration of introducing MBR into urban sewage ecological restoration process, this paper studies the availability and resource utilization efficiency of MBR technology in the field of sewage treatment, and focuses on the removal effect of MBR technology on the most important pollutants in urban sewage (including nutrients, micro-pollutants and greenhouse gas emissions). The proposed framework incorporates the mean urban storm event concentration (EMC) data into the existing LCA impact category to illustrate the environmental impacts associated with urban land occupation over the entire system life cycle (Matta et al. 2018).

MATERIALS AND METHODS

At present, the common techniques for improving water quality of urban landscape water at home and abroad include physical restoration, chemical restoration and biological-ecological restoration. Biofiltration technology (percolation biofilm technology) on the surface of aquatic plants, sand and sediments in rivers usually has a layer of biofilm that can degrade and purify organic pollutants. It is mainly composed of algae, bacteria and protozoa, which are called peripheral plexus organisms. In order to strengthen the removal of organic pollutants from river water by surrounding organisms, a percolating biofilm purification bed can be constructed on the beach or riverbank with pebbles as the filler. Due to the different materials and particle sizes of the packing materials, the seepage biological membrane purification bed may have physical adsorption, sedimentation, filtration and other effects in addition to the biological degradation of organic matter, to remove suspended matter and nitrogen, phosphorus, heavy metals and so on. The permeable biofilm purification bed is suitable for small rivers with less serious organic pollution. The percolation biofilm purification bed technology has been studied and applied in the river purification of Edogawa, Sakagawa and Jingdu in Japan, Liangzechuan in Korea and Thailand, and has achieved good results.

The process flow of membrane biological reaction experiment applied to water pollution treatment in urban areas is shown in Fig. 1.

The experimental device shown in Fig. 1 is a membrane bioreactor with a total volume of about $29m^3$, which is composed of pre-aerated sedimentation tank, main sedimentation tank, nitrification zone and denitrification zone, and $13.2m^3$ ultrafilter tank. Sewage flows into the equipment through a 3mm filter. The nitrate begins to circulate from the post-denitrification zone to the pre-denitrification zone, and the sludge begins to circulate from the ultrafilter tank to the pre-denitrification zone. A separate degasifier was used to reduce oxygen concentration in the returned sludge through nitrification and respiration. Supernatant from sludge dewatering is added continuously to the pre-denitrification zone. The ultrafiltration tank is composed of two ultrafiltration modules, and the ultrafiltration module adopts the flat membrane type MFM100. The ultrafiltration module is running for 10 minutes and needs an interval of 2 minutes. The nominal pore size of ultrafiltration membrane is 0.2 micron, and the minimum and maximum pore sizes are 0.17 micron and 0.26 micron respectively. The total membrane area of each module is 79.64 square meters, distributed on 44 diaphragms. Transmembrane pressure (TMP) control strategy was used for membrane operation. Membrane cleaning is performed when the permeability decreases by approximately 30% from the initial value. Sodium hypochlorite is used to remove organic matter and oxalic acid from inorganic coating in membrane cleaning operation.

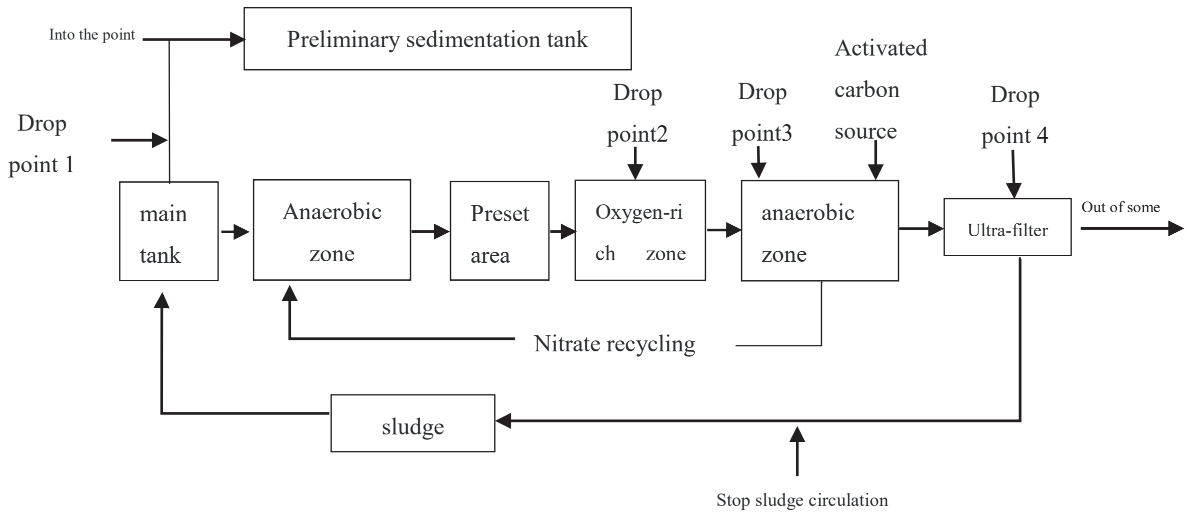

Fig. 1: Sewage treatment process.

Data sampling: In the course of the experimental study, the sampling varies according to the assessment emphasis. The sampling points were concentrated in the inflow point, the main sedimentation tank, the drug delivery point, the flow outlet, the membrane bioreactor and the ultrafilter tank. Standard parameters analysed included total organic carbon (TOC), biological oxygen demand (BOD_7) after 7 days, total phosphorus (TP), phospho-phosphorus (PO_4-P), suspended solid (SS), volatile suspended solid (VSS), total dissolved solid (TDS), ammonium nitrogen (NH_4-N), nitrate nitrogen (NO_3-N), nitrite nitrogen (NO_2-N), and total nitrogen (TN). Online measurements of POQ-P, NO_3-N, NH4-N, dissolved oxygen (DO), SS, pH, REDOX, water and air flow, temperature, pressure and water level were used at several locations in the pilot for process monitoring and control.

Collection of exhaust emission data in the experiment: In order to study the N_2O exhaust emission in MBR process, the main sedimentation tank, biological reactor and ultrafilter were screened twice. The wastewater from sludge dehydration was not added to RAS DeOx in the first time, and the wastewater from sludge dehydration was added to RAS DeOx in the second time. In the two operations, the experimental running conditions were the same and the experimental time was P13.All treated gases were measured and analysed for each reactor cell using the Teledyne analytical instrument (model GFC-7002E).Field emissions of total nitrogen (TN), ammonium (NH_4-N) and nitrate (NO_3-N) were analysed at the beginning and end of each reaction tank measurement period. Total emissions are calculated using measured concentrations of air and exhaust gases. The exhaust gas collection and test method in the experiment is shown in Fig. 2.

Treatment efficiency of contaminated microorganisms: The experiments included studies on the removal efficiency of various micro-pollutants in the MBR process. In the experiment, the MBR process was configured by ozonation process and biological activity filtration process based on granular activated carbon in different experimental cycles. The micropollutants studied include a wide range of related drugs and other emerging substances, such as the estrogen effect, bacteria and microplastics. The experimental method is shown in Fig. 3.

RESULT ANALYSIS AND DISCUSSION

Experimental Data

During one period of the experiment (8 weeks, P1-P8), the focus of the study was the concentration of nitrogen (6mg TN /L) and phosphorus (0.2mg TP /L) in the treated water under different loads and administration conditions. During the second experiment (P9-P17), the focus was on optimizing the processing efficiency of the whole system, especially the efficiency of phosphorus removal. The second experimental cycle was based on different dose-control strategies for precipitating chemicals. In the experimental cycle of P1-P9, sodium acetate (NaOAc) was used as the external carbon source after denitrification. Starting with the experimental cycle P10, proprietary hybrid blumpuls was used. Experimental data are shown in Table 1.

In Table 1, C represents constant flow and D represents dynamic flow, which is controlled by experimental signals. In the injection position, F represents the fixed area, and Q represents the injection point at the proportional flow.

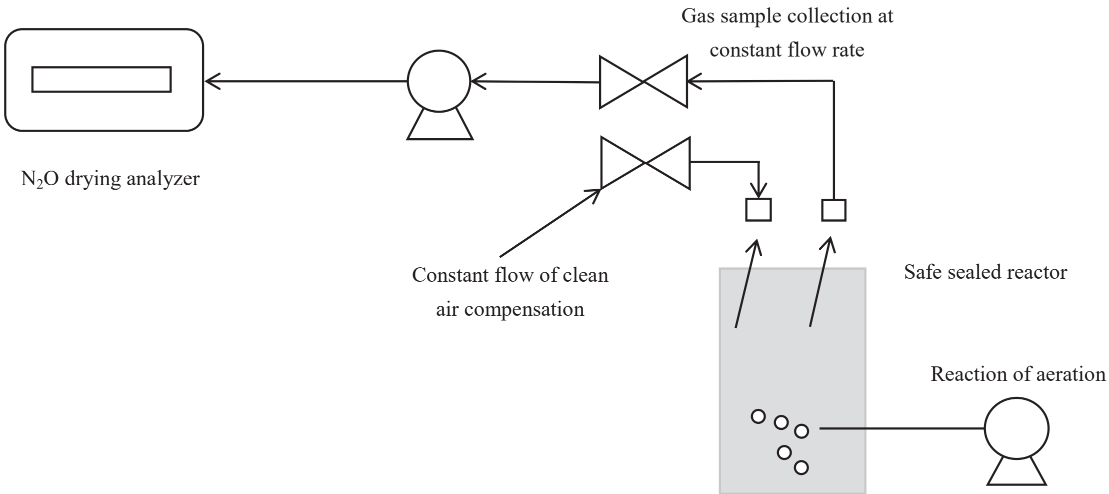

Fig. 2: Waste gas measurement process.

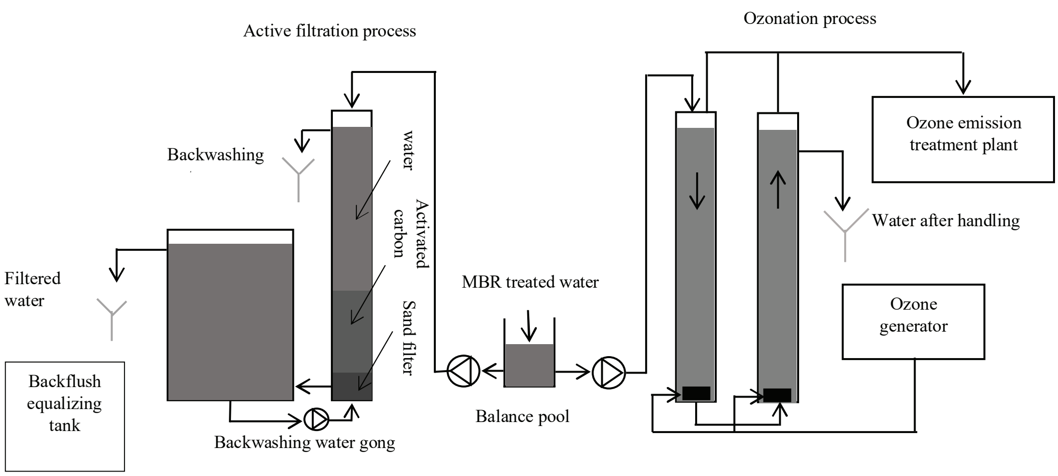

Fig. 3: Process for the treatment of two microorganisms.

Treatment of Nitrogen and Phosphorus

The removal efficiency of nitrogen and phosphorus is shown in Figs. 4 and 5. Due to the different concentration levels of pollutant load during the experiment and the occasional interruption in the experiment operation, the nitrogen and phosphorus reduction shown in the figure did not fall below the expected target level during the 100% experiment time. The mean concentration of nitrogen and phosphorus in the treated water was 4.2 mgTN/L and 1.42 mg TP/L, respectively, for the periods P1 to P4, 4.1 mgTN/L and 0.24 mg TP/L for the periods P5 to P13, and 4.6 mgTN/L and 0.26 mg TP/L for the periods P14 to P17.

During the experiment period from P1 to P4, no precipitation chemicals were added, so the concentration of nitrogen and phosphorus in the effluent water increased. In the subsequent experiment, the precipitation chemical agent was added, and the added dose was continuously increased until the concentration of nitrogen and phosphorus in the experimental effluent water was effectively controlled. The experimental device began to increase the inflow of sewage in the P10 cycle, resulting in a 10% increase in the total nitrogen load and a temporary increase in the total nitrogen concentration of effluent. After P12 weeks, the carbon input was increased to control the increased nitrogen load and the

Table 1: Details of the 17 cycles of experimental data.

Experimental Cycle	Traffic m^3/h	Organic load m^3/h	Sludge content mg/L	Carbon inputs mg/L	Drug dosage mg/L	Agent location
P1	2.5 C	3.2	3500-6000	5~15	6~12 $FeSO_4$	1Q
P2	2.5 C	3.2	4500-6000	15	12$FeSO_4$	1Q
P3	4.3 D	5.5	8000	30	20$FeSO_4$	1Q
P4	2.75 D	3.5	6000	-	15$FeSO_4$ 5$FeCL_4$	1F 1Q
P5	2.8 D	3.6	5000	-	20$FeCL_4$	1Q
P6	2.8 D	3.6	5000	50	30$FeSO_4$	1F
P7	2.8 D	3.6	5000	45	20$FeSO_4$	4Q
P8	2.8 D	3.6	5500	55	12$FeSO_4$	1Q & 3Q
P9	2.8 D	3.6	5500	65	10$FeSO_4$ 18$FeCL_4$	1Q 3Q
P10	2.8 D	3.6	5500	80	10$FeSO_4$ 5$FeCL_4$	1Q 3Q
P11	2.8 D	3.6	5000	—	9$FeSO_4$ 11$FeCL_4$	1Q 3Q
P12	2.8 D	3.6	5000	55	15$FeSO_4$	2F
P13	2.8 D	3.6	6500	30	11$FeSO_4$ 4$FeCL_4$	2F 3P
P14	2.8 D	3.6	5500	8	14$FeSO_4$	2F & 3Q
P15	3.2 D	4.0	5500	55	10$FeSO_4$	1F
P16	3.2 D	4.0	5500	60	8$FeSO_4$	1F & 2Q
P17	3.2 D	4.0	5500	—	18$FeSO_4$ 1$FeCL_4$	1F & 2Q 3Q

effluent nitrogen concentration was decreased again. The increase in sewage concentration during P14 weeks was due to the absence of added carbon. Fig. 4 shows that 14 membrane cleanings were performed during the whole experiment. This high-frequency membrane cleaning operation was due to the high dose of precipitating chemicals put into the MBR device in the experiment, and the membrane permeability remained basically the same in different experimental cycles.

N_2O Emission

The test results of the N_2O emission data showed the highest N_2O emission in the autonomous sedimentation tank, which was explained by the high nitrogen load and dissolved N_2O stripping. The second aeration zone and the aerated ultrafilter also have high emissions, but because the nitrogen load of these reactors is lower than that of the first aeration zone, the total emissions are also lower. The anoxic zone showed no significant emissions except for the first biotreated zone and the main sedimentation tank. Experimental data showed that a total nitrogen load of about 0.02% and 0.09% was taken as N_2O emission, respectively. This is significantly lower than the variation in N_2O emissions between 0.8% and 6.5% in a typical wastewater treatment plant. Compared with other sewage treatment research systems, the increase of biological activity during MBR may lead to some low emissions. However, the explanation of low exhaust emission is supported by clear data in this experiment, which requires further experimental research.

Treatment of Micropollutants

Compared with the traditional activated sludge process, the MBR process provides high quality, granular wastewater. The MBR process effectively removes all bacteria larger than the membrane pore size from the wastewater, including multi-resistant bacteria. However, extremely low concentrations of bacteria (65cfu /100 mL) were still detected in the MBR effluents, but it was not possible to determine whether these bacteria were derived from sample contamination or osmotic

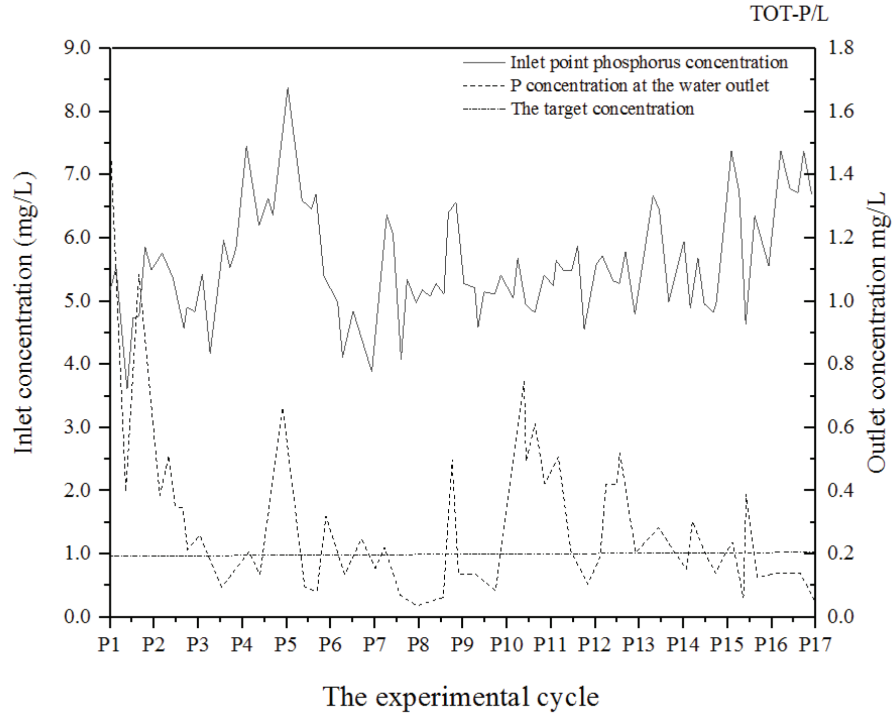

Fig. 4: Concentration of phosphorus in inlet and outlet water.

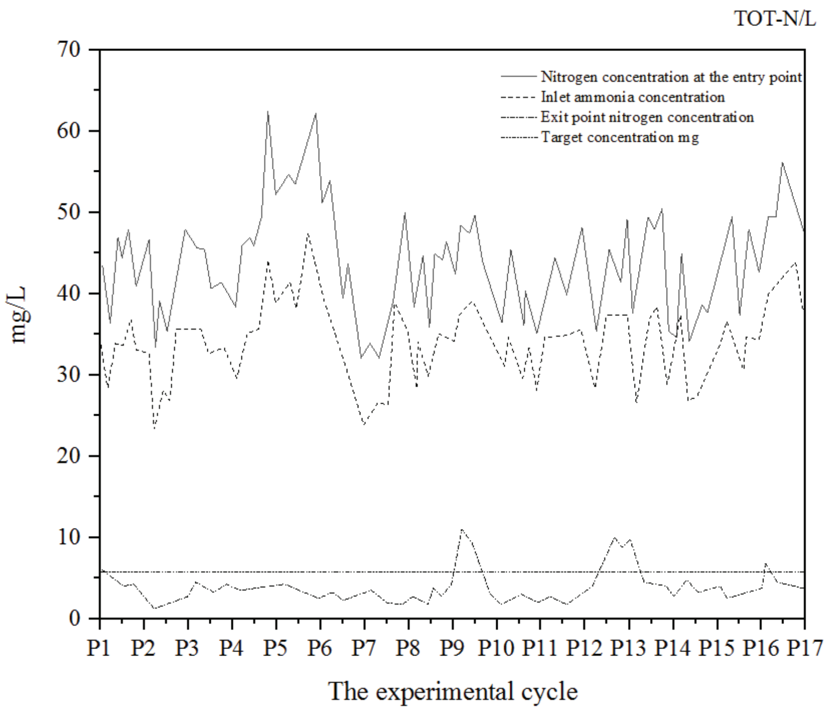

Fig. 5: Experimental nitrogen concentration in influent and effluent.

contact with the atmosphere, because in the sewage treatment environment, it is almost impossible to absolutely guarantee that the sample is free from external pollution. No single elastic particles (100% removal efficiency) were detected in the MBR effluent bodies, while the effluent from the full-size CAS process consisted of a final sand filter containing plastic fibres and plastic debris (90.7% removal efficiency).Non-synthetic fibres were found in both MBR and the treated water by the universal activated sludge process (CAS).Analysis of drug residues in the MBR effluent water showed similar levels to those in the CAS effluent water (except amlodipine and sertralin, which were reduced to slightly higher levels during the MBR process). This indicated that the effect of MBR on drug removal was not increased compared with the CAS method. Other microorganisms and estrogen effects in MBR effluent water were treated with ozonation or total coliform supplementation. All microorganisms sampled and measured can only be removed by more than 90% through the supplemental treatment step. The phenolic compounds triclosan and bisphenol A studied in the experiment were reduced below the detection threshold by ozonation or biological activity filter. Approximately 80% of total coliforms were ozonated in the treated MBR effluents and approximately 85% were treated with bioactive filter technology. Compared with the low cost of similar CAS treatment of microorganisms in the effluent water, a certain amount of ozone dose is required in the membrane treatment experiment to achieve a high reduction of the persistent substances during the ozonization period, and the bioactive filter needs to increase the washing frequency of the filter membrane in the treatment of MBR effluent water. However, both of these aspects increase the cost of membrane bioreactor-based wastewater treatment to some extent.

CONCLUSION

The wastewater treatment experiment of membrane bioreactor shows that the treatment quality of this device can reach the phosphorus concentration < 0.2mg /L and nitrogen concentration < 6mg /L under different sewage treatment loads. At the same time, experiments show that relatively high precipitated chemicals and external carbon dose are required under the maximum sewage treatment load. The membrane exhibited high average permeability and the suspended solids were completely removed in the whole experimental cycle. Therefore, bioremediation technology is a technology with broad development space. Although there are some limitations, but it has less investment, small impact on the environment, the permanent elimination of pollutants and other technology cannot be compared with the advantages. Although the landscape water body is a small water body system, according to the specific conditions, it will be a better development direction for the future landscape water pollution control to adopt the optimization combination method with the core of bio-ecology technology.

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