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WASTEWATER TREATMENT WITH PTFE MEMBRANE BIO-REACTOR

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Abstract:

Recently, the introduction of separation membranes is progressing in the field of sewage and industrial wastewater treatment. The treatment methods with membrane separation have many advantages. Firstly, the sedimentation tank has not been required for the sake of gravity sedimentation. It is possible that the reaction tank become compact. Secondly, suspended solids (SS) can be almost completely removed, and it is possible to produce clarified treated water for which even bacteria and viruses can be almost completely removed. For this research, a new and novel separation polytetrafluoroethylene (PTFE) membrane has been produced, and the membrane has been applied to membrane bioreactor and membrane separation coagulation sedimentation treatments on an actual sludge treatment center. The experiment data was obtained through continuous operation during over approximately one year, and did show the similar good performance to a chlorinated polyethylene (CPE) membrane. As a result, the fouling resistance was considerably improved when using the flat PTFE membrane compared to the flat CPE membrane.

Keywords: Wastewater treatment; membrane; bioreactor; PTF; CPE; Fouling.

1. Introduction

It is well known that one of the main objectives of wastewater treatment in general is to allow human and industrial effluents to be discharged without any harm to human health or unacceptable damage to the natural eco-system. Many techniques have been used to accomplish this aim for both small and large scales however in each technique there are limitations. For example, chemical treatment methods might produce secondary products sometimes more toxic than the waste itself therefore secondary treatment is needed. Biodegradation alone in term of cost is very cheap however longer time is needed in order to accomplish complete treatment, at the same time big space is necessary. Physical treatment combined with bio degradation considered to be promising technique where pore size of the membrane allows passage of certain constituents and the removed wastes will be utilize through microbial activities.

Compared to the conventional activated sludge method, the membrane bioreactor (MBR) method is capable of increasing the concentration of activated sludge (mixed liquor suspended solids: MLSS) within a reaction tank. Therefore, the MBR method has the advantage that the systems are more compact. Moreover, because it is possible to produce clarified treated water for which suspended solids (SS) and coliform bacteria can be almost undetectable, the membrane bioreactor method is also suitable for reuse. The first important factor relating to selection of the membrane material is the membrane strength [1-4].

Since membrane separation is performed through an extremely thin membrane surface, if the membrane surface is damaged, the separation performance will be worse, causing deterioration in quality of the treated water. Therefore, it is necessary to have a membrane module with high membrane strength. The second significant factor is recoverability of the membrane using chemical cleaning. Contamination (fouling) of the membrane inevitably advances with operation during over the long term [5-10]. For that reason, it is necessary to periodically clean the membrane with chemicals by doing clean in place (CIP) or immersion cleaning. Hence, a membrane material that can be cleaned using strong chemicals should be desired. Specifically, the membrane character to provide excellent strength and strong chemical resistance are advantageous for the membrane module used with MBR.

From the background described above, with this research, a novel PTFE separation membrane was produced, and this was applied to membrane bioreactor and membrane separation coagulation sedimentation treatments at an actual sludge treatment center. Furthermore, experimented data was obtained through continuous operation over approximately one year, a study was done comparing this to when using a flat CPE membrane, and from the experiment data, we attempted to put into mathematical formula form the relationship between the transmembrane pressure difference and the permeate flow rate.

2. Material and methods

PTFE membranes and CPE membranes were installed in a sludge treatment center (excreta and septic tank sludge) in Kyushu. This sludge treatment center is a relatively large treatment facility with a building area of 3993.37 m^2 and a total floor area of 5447.42 m^2. Summary of the treatment process and difference between conventional and membrane separation processes are shown in Figures 1 & 2.

The treatment capacity is excreta 115 m^3/day and septic tank sludge 61 m^3/day for a total of 176 m^3/day. Also, the effluent volume is 264 m^3/day. The membrane elements were installed in the biofilm raw water tank and the coagulation membrane raw water tank. In the biofilm raw water tank, 150 sheets of PTFE membranes and 1650 sheets of CPE membranes were installed, and in the coagulation membrane raw water tank, 150 sheets of PTFE membranes and 1050 sheets of CPE membranes were installed. Actual operation was started at the sludge treatment center where experiments were performed. The sewage inflow is composed of excreta and septic tank sludge exhausted from the vicinity, which are carried in by truck. For the diffuser tube, a 10mm diameter hole was opened in a rigid polyvinyl chloride pipe (outer diameter 48 mm, thickness 3.6 mm, inner diameter 40 mm), and air was diffused. The aeration conditions were 1.5 m^3/min for 1 unit (150 sheets), which is 10 L/min per sheet. The air bubble migration speed at this time was approximately 100 cm/s, and the buoyancy per membrane sheet was 200g. The permeate water quality evaluation was made according to biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), total nitrogen (TN), total phosphorous (TP), and chromaticity. As the membrane performance evaluation, the relationship between trans-membrane pressure difference and permeate flow rate was measured. Furthermore, the MLSS concentration and viscosity within the biofilm raw water tank and the coagulation membrane raw water tank were measured. With the membrane bioreactor treatment, operation was done at flux 0.5 m^3/m^2•day up to 213 days, and thereafter, operation was done at flux 0.3 m^3/m^2•day. The quantity of water to be treated for one unit (150 sheets) was 2.5 m^3/hour (flux 0.5 m^3/m^2•day) and 1.5 m^3/hour (flux 0.3 m^3/m^2•day). With membrane separation coagulation sedimentation treatment, operation was done at flux 0.5 m^3/m^2•day, and the quantity of water to be treated for one unit (150 sheets) was 2.5 m^3/day.

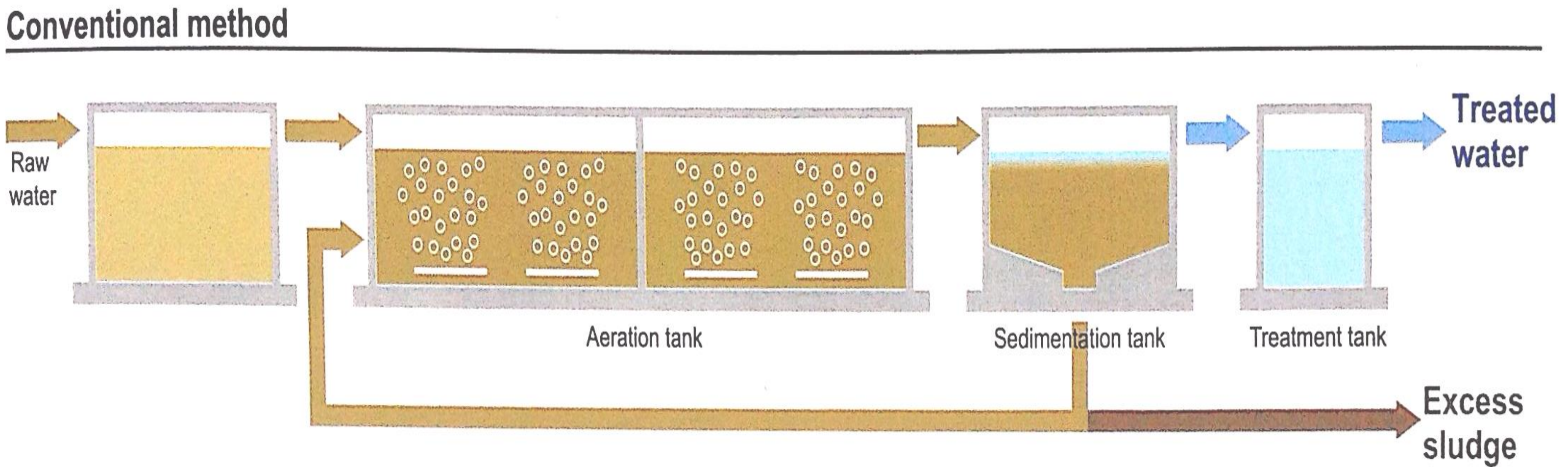

Figure 1. Treatment process in conventional separation processes

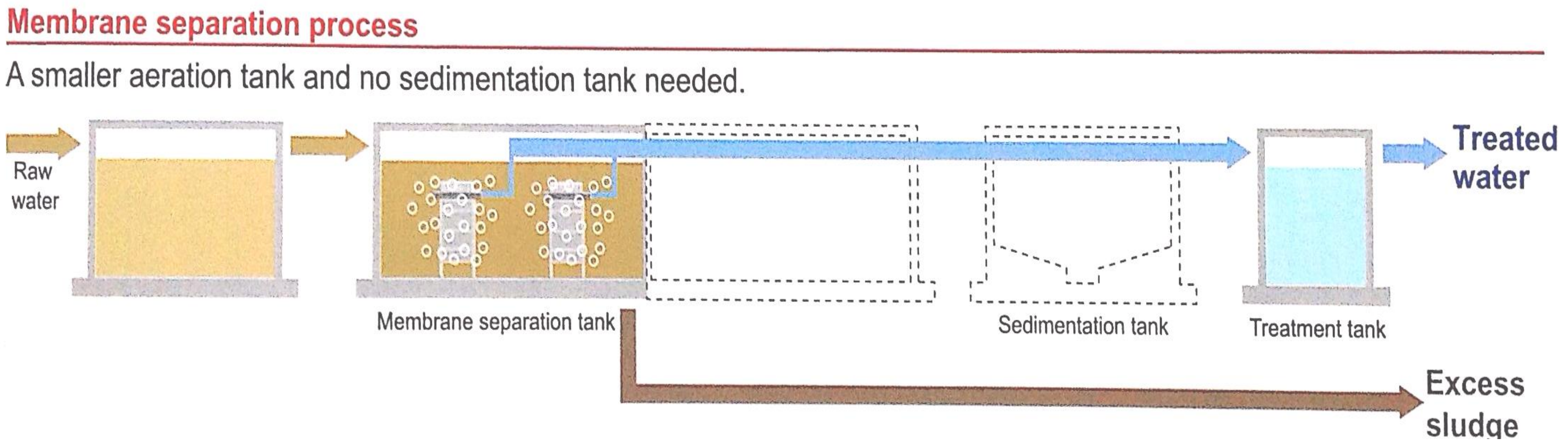

Figure 2. Treatment process in membrane separation processes

3. Results and Discussion

With this research, a new PTFE separation membrane was produced, and this was applied to membrane bioreactor and membrane separation coagulation sedimentation treatments at an actual sludge treatment center. Experimented data was obtained through continuous operation for approximately one year, and a study was done comparing this to when using a CPE membrane. Following is a summary of the obtained findings.

(A) With the membrane bioreactor method, to maintain a constant permeate flow rate, compared to the PTFE membrane, the CPE membrane exhibited a clearly higher transmembrane pressure difference. This indicates that membrane fouling occurs more easily with the CPE membrane, making the chemical-cleaning cycle shorter. Also, for both membranes, there was an increase in the transmembrane pressure difference exhibiting constant flux as the number of days of operation increased.

(B) With the membrane separation coagulation sedimentation treatment as well, in order to maintain a constant permeate flow rate, the CPE membrane exhibited a clearly higher transmembrane pressure difference, compared to the PTFE membrane. However, for both membranes, even when the number of days of operation increased, there was almost no change in the transmembrane pressure difference indicating constant flux.

(C) For both the PTFE membrane and the CPE membrane with this system, we found that the membrane flux (permeate flow rate) followed a filtration equation (Darcy's law).

(D) By doing clean in place with chemicals three times, both the PTFE membrane and CPE membrane could be recovered almost to their initial state.

Up to now, there was almost no obtaining of experimented data with continuous operation using a PTFE membrane, and we were able to obtain significant data indicating the effectiveness of the PTFE membrane.

4. Conclusion

Significant improvement was achieved in the fouling resistance when flat PTFE membrane was used compared to the flat CPE membrane. Gravity sedimentation when using PTFE membrane bioreactor became unnecessary as a result significant reduction in the operation cost. The technology used in this work could contribute and provide safe and clean eco-system environment.

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References

[1] Das N and Maiti HS. Formation of pore structure in tape-cast alumina membranes: Effects of binder content and firing temperature. J Membr Sci. 1998; 140(2): 205-12.

[2] Zheng MP, Hou YD, Ge HY, Zhu M-K, Yan H. Effect of NiO additive on microstructure, mechanical behavior and electrical properties of 0.2PZN−0.8PZT ceramics. J Eur Ceram Soc. 2013; 33(8): 1447-56.

[3] Sarbatly R. Effect of Kaolin/PESF Ratio and Sintering Temperature on Pore Size and Porosity of the Kaolin Membrane Support. J Appl Sci. 2013; 11(13): 2306-12.

[4] Yuan Q, and Pu Y. Effects of $K_{0.5}Bi_{0.5}TiO_3$ addition on dielectric properties of $BaTiO_3$ ceramics. Ceram Int. 2013; 39(4): 3507-10.

[5] Lin H, Zhang M, Wang F, Meng F, Liao BQ, et al. A critical review of extracellular polymeric substances (EPSs) in membrane bioreactors: characteristics, roles in membrane fouling and control strategies. J Memb Sci. 2014; 460: 110–25.

[6] Meng F, Liao B, Liang S, Yang F, Zhang H. Morphological visualization, componential characterization and microbiological identification of membrane fouling in membrane bioreactors (MBRs). J Memb Sci. 2010; 361(1-2): 1–14.

[7] Liang S, Liu C, Song L. Soluble microbial products in membrane bioreactor operation: behaviors, characteristics, and fouling potential. Water Res. 2007; 41(1): 95–101.

[8] Sun FY, Li XY. Evaluation of the importance of various operating and sludge property parameters to the fouling of membrane bioreactors. Water Sci and Technol. 2011; 64(6): 1340–6.

[9] Sun FY, Wang XM, Li XY. Change in the fouling propensity of sludge in membrane bioreactors (MBR) in relation to the accumulation of biopolymer clusters. Bioresour Technol. 2011; 102(24): 4718–25.

[10] Sun FY, Wang XM, Li XY. Effect of biopolymer clusters on the fouling property of sludge from a membrane bioreactor (MBR) and its control by ozonation. Process Biochem. 46(1): 2011; 162–7.