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Original Article

The application of membrane Bio-Reactor for East Java Domestic waste water treatment

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Abstract

Membrane bioreactors for wastewater treatment research have been carried out. In this system, membrane replaces the function of the sedimentation tank. Until recent time, fouling was still the main problem for membrane processes. This research has investigated the effect of MLSS concentration and back flushing on external membrane bioreactor performances such as COD and BOD reduction, and the back flushing effect for domestic wastewater treatment. Polyacrylonitril hollow fiber membrane with pore diameter 0.1-0.01 m, surface area 0.075 m^2 was used in this research. This process was at HRT 5 hour, no sludge disposal, intermittent operation, and permeate exiting from membrane shell side. Optimum condition was obtained at a transmembrane pressure (TMP) of 1.45 bar. Back flushing was conducted for 10 minute at 3.0 bar pressure. Effective back flushing was shown after operation at MLSS of 7500 and 10000 mg/l. The result of this research shows that COD and BOD in the domestic wastewater decreased almost 98%. MLSS and MLVSS degradations were 98.6% and 98%, respectively.

Keywords: hollow fiber membrane bioreactor, ultra filtration, fouling, back-flushing

1. Introduction

In East Java, Indonesia, the total volume of waste water is 1,836,105,690 m^3/year and Domestic Waste Water (DWW) is 84.4% of the total volume. The COD-BOD content of DWW is 63% higher than in other sources (Wijaya, 2000). DWW content of organic substance was BOD_5^{20} 110-400 mg/l, COD 150-600 mg/l, and total solid concentration 350-750 mg/l, but with no content of heavy metal a toxic substances (Veenstra, 1995)

Recently, the domestic waste water treatment process has used activated sludge, which requires a long time is process and large space of plant. Effluent quality also depends on the hydrodynamic state in the sedimentation tank and the characteristics of the activated sludge and a high biomass concentration causes biomass dissociation from effluent get more difficult to conduct because the speed of activated sludge precipitation becomes progressively slower (Witzig *et al.*, 2002). These are the disadvantages of activated sludge precipitation.

Waste water treatment processing by Membrane Bio-Reactor (MBR) separates biomass from effluent by a membrane, so the characteristics of the activated sludge precipitation have no effect on the effluent quality. The high activated sludge concentration could generate problems related is viscosity, flux of membrane, and oxygen transfer (Van Dijk and Roncken, 1997).

The development of MBR technology with ultra filtration process was evaluated in *Water Factory 21, USA* for the first time using a crossed a stream membrane module, where permeate emits a stream through the membrane, while concentrate (retentive) is returned to the bioreactor. The application of an external MBR for the domestic waste water

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treatment has been tried on a laboratory scale and also on a pilot plant scale, but there are still some problems with the high operational energy requirement and membrane fouling which disturb its application (Chriemchaisri, 1994; Cicek, 1998; Trouve, 1994). Energy requirement of conventional domestic waste water treatment is about 0.3-0.4 kWh/m^3, while MBR is 6-8 kWh/m^3 (permeate) (Van of Dijk and Roncken, 1997). This high energy required by external MBR is used for the aeration pump, piping system, and sludge return (Zhang *et al.*, 2003). From the above description, this research investigated the effect of the MLSS concentration, and the backflushing effect on COD and BOD reduction.

2. Membrane Bio-reactor

Membrane technology has an important role is overcoming various problems like biocatalyst dissociation, product dissociation, effect of product inhibition, and conversion rate. Membrane application in bio-catalytic processes is called bioreactor membrane. The advantages of membrane bioreactor application compared to conventional bioreactor are as follows:

- Better solid-liquid separation
- Small foot print
- Low pressure system
- Hybrid with biochemical processes
- Concentrated sludge
- Relatively easier cleaning procedure
- Reduced sludge disposal
- No phase change occurs;

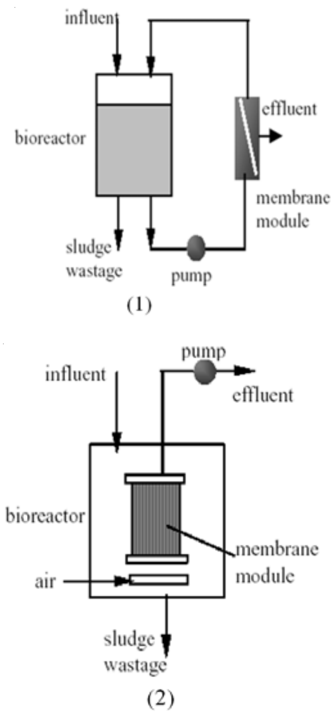

Figure 1. Scheme of external re-circulation membrane bioreactor system (1) and submerged membrane (2)

Membrane bioreactor function represents the combination of two basic processes—biological degradation and membrane filtration—in one process where suspended solid (SS) and micro-organisms are responsible for dissociating organic matter biologically followed by membrane separation (Mallevialle *et al.*, 1996).

Membrane bioreactor functions as a reactor and separator, where the reaction is usually catalysed by enzyme immobilized in the membrane matrix.

Membrane bioreactor can be grouped into two types external re-circulation and membrane bioreactor submerged (MBRs), as shown in Figure 1.

Based on the characteristics of waste water from both industrial disposal and domestic waste water treatment, the most efficient and effective way to treat it is by applying membrane process in a bioreactor.

The objective of this research was to investigate the long-term performance of a pilot scale ultra-filtration membrane bioreactor (MBR) external hollow fibber for domestic wastewater treatment. The impact of operational parameters, such as COD, BOD, MLSS, and membrane flux on effluent quality, was evaluated. Contribution of the bioreactor and membrane module to the removal efficiency was examined.

3. Experiment

The research was conducted in two stages, preparation stage and main experiment stage. The preparation stage comprised seeding, acclimatisation, and membrane characterization. In the main experiment stage, the inflow domestic waste water was with COD at 500 mg/l in the activated sludge with a variety of MLSS concentrations, namely: 5000, 7500, and 10000 (mg/l). The outflow of organic waste water which was degraded with activated sludge was filtrated externally by the membrane.

The membrane had a capillary type configuration; made of poly-acrylonitrile; optimum pH: 7-7.5; maximum operational temperature 50°C; crossflow system; pore dia-

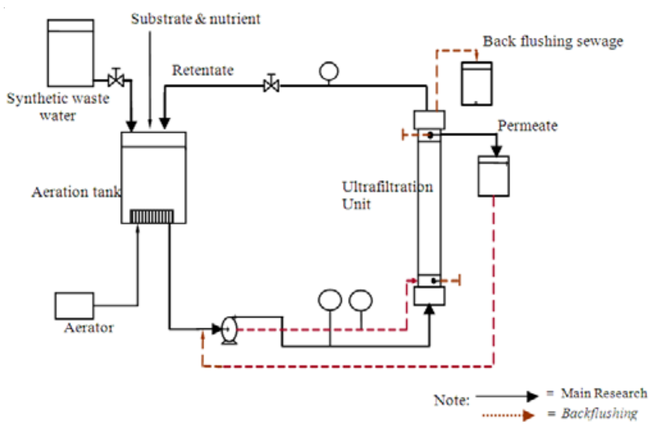

Figure 2. Schematic diagram of external hollow fiber membrane bioreactor.

meter: 0.1-0.01 m; surface area: 0.075 m^2; fibre dimension ID 1.0 mm and OD: 0.5 mm, and thickness 0.5 mm. Module dimensions were diameter 5 cm and length 35 cm.

Figure 2 shows the schematic diagram of the membrane bioreactor system which was used in the research. This research used a 5 litre volume bioreactor tank (aeration tank). The experiment was conducted by mixing synthetic domestic waste water into the activated sludge at HRT 5 hour. During the operational time, membrane was operated at optimum TMP, which was obtained in the membrane characterization phase. Each attempt at a particular MLSS was conducted for 3 hours, and every hour the membrane was backflushed for 10 minute using the permeate produced. The pressure of backflushing was 3.0 bar. The parameters analysed was the level of COD, BOD, and MLSS in the bioreactor and permeate, as well as the flux observation data during the operation.

4. Results and Discussion

The results and presented as graphs showing the relation between flux and operating time for various MLSS (Figures 3, 4, and 5). From the graphs, the influence of back flushing on the flux increases after the process can be seen. In figure 4 and 5, each shows the operation of the crossflow membrane at MLSS 7500 and 10000 mg/l. At MLSS 7500 mg/l operation, the flux is higher than previously due to the effect of backflushing. It indicates that the influence of backflushing is very effective to recover the flux, is an even higher level than before.

Table 1 shows the analysis results of the percentage of COD, BOD, and MLSS in permeate. From the table it can be seen that high MLSS concentration indicates high microorganism ability in the bioreactor (aeration tank) to degrade organic waste water. The separation of COD and BOD level by membrane is still high enough, as shown in the table. This indicates that the membrane is able to retain the organic content in waste water which is in the form of suspended solids, while the remaining COD-BOD in the permeate is caused by the escape of dissolved organic content which cannot be filtrated by the ultra filtration membrane used in this research.

Figure 6 shows the effect of operating time on the level of biomass concentration and COD degradation by activated sludge-membrane. From the graph it can be seen that the ability of micro-organism to degrade the COD content in the waste water with various concentration of MLSS in bioreactor (aeration tank) combined with the ultra-filtration membrane is high.

5. Conclusion

This research concludes the following: (1) membrane optimum condition is obtained at cross-membrane pressure of 1.45 bar, (2) back-flushing pressure of 3.0 bar was quite effective for the MLSS 7500 and 10000 mg/l, (3) the effectiveness of COD and BOD exclusion was high enough, that is 98%, (4) the degradation of MLSS was 98.6%

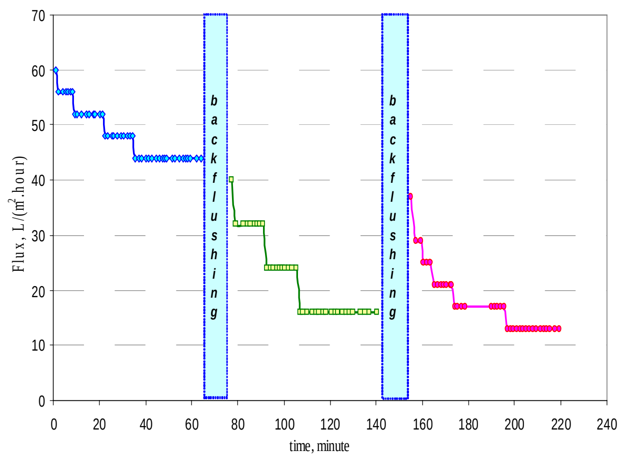

Figure 3. Influence of back flushing on flux at MLSS 5000 mg/l.

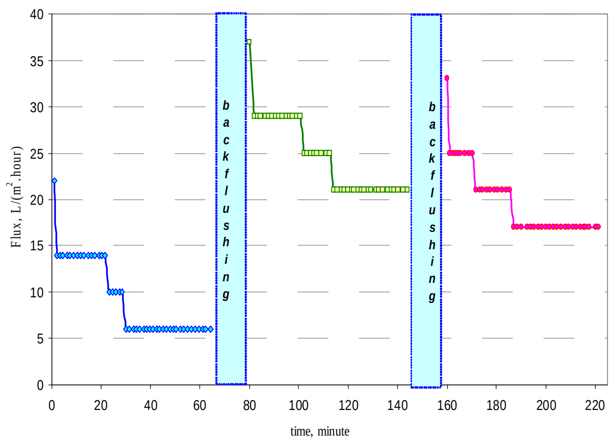

Figure 4. Influence of back flushing on flux at MLSS 7500 mg/l.

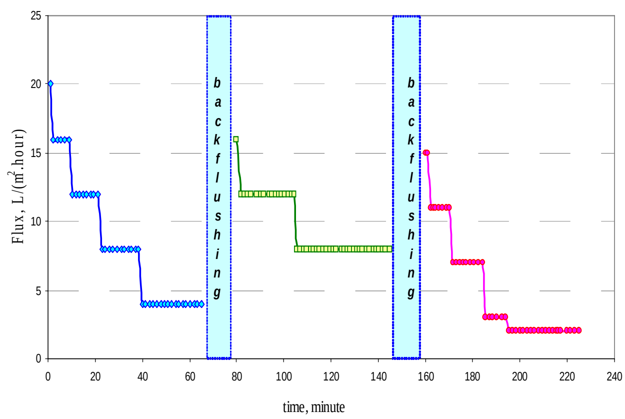

Figure 5. Influence of back flushing on flux at MLSS 10000 mg/l.

Table 1. The percentage of COD, BOD, and MLSS exclusion of external MBR

Operation time (hour)	Feed (mg/l)		Aeration tank (mg/l)			Permeate (mg/l)			Separation (%)		
	COD	BOD	COD	BOD	MLSS	COD	BOD	MLSS	COD	BOD	MLSS
1	357	125	126	44.97	5600	11.50	2.11	70	96.78	98.31	98.75
2	357	125	62.13	24.88	6110	7.39	3.46	54	97.93	97.23	99.12
3	357	125	51.30	28.13	7400	6.93	1.17	52	98.06	99.06	99.29
1	386	154	81.14	50.22	8315	2.33	1.38	240	99.39	99.10	97.11
2	386	154	38.39	18.62	11910	4.54	2.92	94	98.82	98.10	99.79
3	386	154	34.5	16.73	14260	6.78	1.27	24	98.24	99.18	99.34
1	616	246	52.5	32.69	10650	2.94	1.39	122	99.52	99.43	98.85
2	616	246	31.62	15.34	17310	3.27	1.59	28	99.47	99.35	99.84
3	616	246	30.08	14.59	18200	1.68	0.97	32	99.73	99.61	99.82

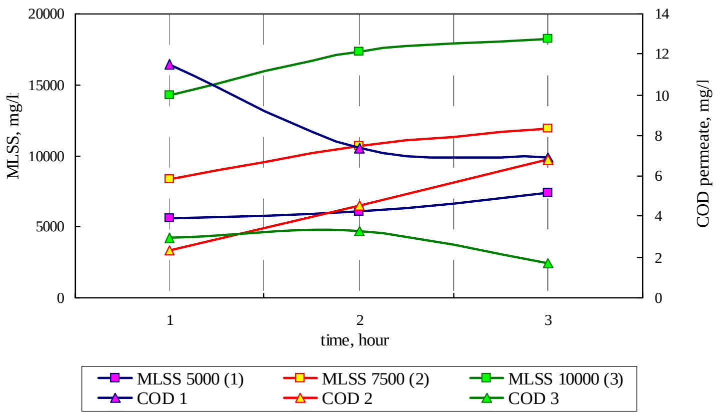

Figure 6. The effect of external MBR operating time on MLSS and permeate COD concentration

References

APHA. 1992. Standard Methods for Examination of Water and Wastewater, American Public Health Association, 18th edition, Washington.

Bodzek, Michal., Debkowska, Zuzanna., Lobos, Ewa., Konieezny, Krystyna, 1996, Bio-membrane Waste-water Treatment by Activated Sludge Method, Journal of Desalination, pp. 83-95, 1996.

Chriemchaisri, C., and Yamamoto, K. 1994. Performance of Membrane Separation Bioreactor at Various Tempera-ture for Domestic Wastewater Treatment, Journal of Membrane Science, 87, pp. 119-129, 1994.

Cicek, N., Winna, H., Suidan, M.T., Wirenn, B.E., Urbain, V., Manem, J. 1998. Effectiveness of The Membrane Bioreactor in The Biodegradation of High Molecular Weight Compounds, Water Research, 32, pp. 1553-1563.

Fane, A. and Chang, S. 2002. Membrane Bioreactors: Design & Operational Options, Filtration and Separation, pp. 226-229.

Metcalf & Eddy. 1993. Wastewater Engineering Treatment Disposal Reuse, Mc Graw Hill Comp, New York.

Mallevialle, Jo l. 1996. Water Treatment Membrane Processes, McGraw-Hill, New York.

Mulder, M. 1996. Basic Principles of Membrane Technology, 2nd Ed., Kluwer Academic Publishers, Netherlands.

Trouve, E., Urbain, V., Manem J. 1994. Treatment of muni-cipial wastewater by a membrane bioreactor: result of a semi-industrial pilot-scale study. Water Science and Tecnology, 30, 151-157.

Van Dijk, L., Roncken, G. C. G. 1997. Membrane bioreactors for wastewater treatment, Water Science and Tech-nology, 35, pp.35-41.

Veenstra. 1995. Wastewater Treatment. IHE Delf.

Wijaya, Danu., 2000, Klasifikasi Limbah/Pencemaran dan Penanganannya di Jawa Timur, Makalah Pada Dialog Interaktif, Forum Lingkungan Hidup Indonesia (FPLHI).

Witzig, Z., Manz, W., Rosenberg, S., Kruger, U., Krame, M., Szewzyk, U. 2002. Microbial Aspect of a Bioreactor with Submerged Membranes for Aerobic Treatment of Municipal Wastewater, Water Research, 36, pp. 394-402.

Zhang, S., *et al.* 2003. Sewage treatment by low energy membrane bioreactor. Journal Bioresources Techno-logy. Elsevier Science.