The Influence of Various Concentrations of MLSS and COD on the Performance of the MBR to Eliminate the Organic Materials and Nitrogen

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Abstract

The high nitrogen content in the wastewater can also inhibit the performance of microorganisms. It can be overcome by Membrane Bioreactor (MBR) combined with anoxic tanks. Use of membrane can be set aside and the organic materials with high concentrations of nitrogen. From this research are expected to know the influence of various concentrations of Mixed Liquor Suspended Solid (MLSS) and Chemical Oxygen Demand (COD) on the performance of the MBR to eliminate the organic materials and nitrogen in the anoxic condition. This study used activated sludge from wastewater treatment Surabaya Industrial Estate Rungkut (SIER) as an inoculant and 'synthetic' wastewater as the MBR influent. Research variable is the concentration of COD in mg/L and Sludge Retention Time (SRT). The results showed that the overall performance of the MBR is relatively stable and good. % COD removal obtained at the highest permeate COD concentration of 1800 mg/L, reaching 90%. Total number N in permeate is smaller than 0.5 of the amount of total N in influent or % removal > 50%, then the process of denitrification can be said to be successful. For turbidity removal reached 98.47 up to 98.85%. The flux is getting dropped because fouling due to particles that accumulate on the surface layer of the membrane.

Keywords : *Activated Sludge, Anoxic, COD, Membrane Bioreactor, MLSS*

1. INTRODUCTION

Wastewater treatment with aerobic activated sludge (activated sludge) is a biological process using microorganisms to degrade organic materials contained in wastewater at aerobic condition. Activated sludge process in the aeration basin is equipped with a sedimentation section for separate the sludge from wastewater that has been treated. Effluent quality depends on the character-forming activated sludge microorganisms, among others, the nature of its deposition and sedimentation basin conditions (William, 1999).

Biological processes in the processing of organic wastewater, require nitrogen (N) and phosphorus (P). However, excess N and P in the wastewater effluent will cause pollution to the environment that would adversely affect the ecological balance and human health. To treat wastewater containing excess N and P activated sludge process is usually carried out include the anoxic.

Activated sludge process is relatively simple, but for wastewaters containing organic materials, N and P with high concentrations, these processing methods have several problems, among others, could potentially result in 'bulking sludge' due to the presence of filamentous microorganisms and inhibit the process of sedimentation. Similarly, the efficiency of the process decreases when the organic load of wastewater that is processed too volatile.

An activated sludge process that comes by using a Submerged Membrane Bioreactor (SMBR) can be tried to overcome the drawbacks of the conventional activated sludge system. SMBR concept is technically almost identical to conventional biological wastewater treatment, except the separation activated sludge process with the effluent were performed using membrane filtration instead of sedimentation process. Use of MBR were able to process organic materials with high concentrations and loads fluctuate. The quality of effluent water will be improved with minimal content of suspended solids, viruses, and bacteria inside (Chang et al, 2002). In recent years, the integration of the activated sludge process and SMBR is known as one of the innovative waste treatment processes that have the potential to get the water recycling industry (Katayon, 2004).

Some authors argue that the membrane fouling problem due to the presence of microorganisms related to the concentration, particle size and microbial products are SMBR operating constraints. Various strategies have been proposed and membrane cleaning by washing or tried backwashing to keep the permeate flux in the system MBR maintained. (Marrot. et. al., 2004).

So far, the contribution of oxygen in the membrane bioreactor is still not widely reported, but the presence of O_2 cannot be ignored. Several researchers have indicates the greater presence of MLSS will require more O_2 supply, so it will reduce the capacity of the existing aeration on biological systems. Furthermore, increasing the concentration of activated sludge suspension will cause a rise in the viscosity of the liquid. This condition can lead to inhibition of the transfer of O_2 into water and then into microbes (Marrot. et. al., 2004).

Constraints that occur in industrial-scale wastewater treatment is the higher concentration of MLSS is expected to be able to reduce waste pollutants greater. However, with the high concentration of biomass will lead to decrease in the mixing process by the air (O_2) flow, and precipitation as well as the mass flux occurs more rapidly dropped due to membrane fouling.

Based on the above information it is necessary to study to enhance the performance of SMBR in order to obtain better operating conditions ensure smooth processing of industrial wastewater.

2. METHODS

Research on the performance of the MBR is done by using an activated sludge biological reactor units are equipped with a membrane separation process. Acclimatized activated sludge using synthetic wastewater to stable prior to the research. Preparation of synthetic wastewater by mixing water from the taps were added glucose mixture as in Table 1. Composition of synthetic wastewater was designed to have a COD 1800 mg /L.

Table 1. Composition of Synthetic Wastewater

No	Component	Concentration (mg/L)
1	Glucose *	1125
2	KH_2PO4*	53,03
3	Urea $((NH_2)_2CO)$*	325,714

*It can be adjusted by changing the concentration to raise or lower the COD

In this study the primary tool used like this chart:

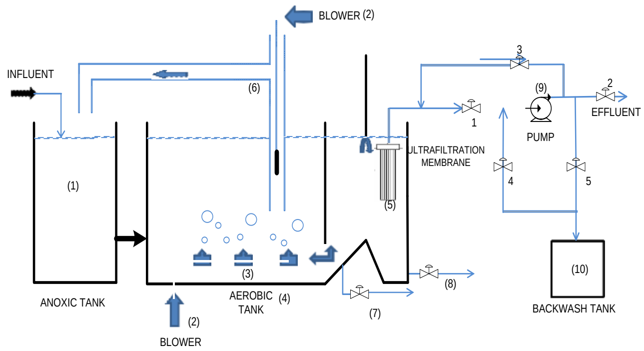

Figure 1. Schematic diagram of the MBR, (1) Anoxic Tank(10,8 L); (2) Blower; (3) Air diffuser; (4) Aerobic Tank (31,5 L); (5) Ultrafiltration membrane; (6) Pipe recycle; (7) and (8) Spending channel Sludge; (9) Pumps; (10) Backwash Tank.

In this research, two stages, namely preliminary stage and the main stage of the experiment. In the preliminary stage of the analysis consists of COD of industrial wastewater and synthetic wastewater, seeding, and acclimatization. While the main experiment stage is the stage of waste processing operations with the variables specified in the MBR.

Acclimatization is done to adjust the life of the activated sludge microorganisms with new wastewater. At this stage of acclimatization is done by separating solids activated sludge with water, then add into the synthetic wastewater to activated sludge that has been separated, and then aerated. Acclimatization process is done in batch in the aeration tank. Glucose from wastewater is useful for supplying carbon and energy in the process of metabolism and proliferation of microorganisms contained in the activated sludge. In addition to the glucose contained nutrients nitrogen and phosphorus. Added nitrogen derived from urea, $(NH_2)_2CO$, whereas for the needs of the element phosphorus derived from potassium phosphate, KH_2PO_4 (Thamer et al., 2008). Glucose and nutrient needs for growth of microorganisms in the activated sludge was approached by comparing Biological Oxygen Demand (BOD) : N : P at 100 : 5 : 1 (Wesley, 1989). In addition, the operating conditions of the process of acclimatization is set at room temperature, neutral pH and Dissolved Oxygen (DO) is quite > 2 mg / L .

In outline, the research procedure on the main stage of the experiment is as follows, enter the feed in the form of industrial wastewater into the aeration tank, wastewater will be degraded by microbes under aerobic conditions. Wastewater discharged from the aeration tank to the anoxic tank, wastewater under anaerobic conditions, then the effluent flowed back to the aeration tank. Wastewater will overflow into the space containing the membrane module. The results will be processed into the membrane module, and the effluent will come out in the form of the permeate, while the retentate consisting of a mass of microbes and waste that has not been degraded compounds will be returned to the solution in the aeration tank, and so on.

In this study, the concentration of COD used 1800, 2800 and 3600 mg/L with concentration of MLSS ranged from 2000 to 5000 mg/L. SRT 5, 10 and 20 days at 1800 mg/L. For observation of DO in the aerobic tank ranged from 4.75 to 5.14 mg/L

On the main stage, synthetic wastewater flowed into the aeration tank capacity of 31.5 liters at a rate of 31.5 L/day. Wastewater will be degraded by microbes in aerobic conditions. Most of the liquid from the aerobic tank in the recycle to the anoxic tank with a capacity of 10.8 liters with a recycle rate of 50.4 L/day. Wastewater will overflow into the room containing the membrane module which previously had the settling process in the area of sedimentation. Then the filtration process using ultrafiltration membranes where the effluent that comes out in the form of permeate. Then analyze MLSS, DO in the aerobic tank and analyze total N and turbidity in the permeate water. And analyze COD before and after the membrane.

3. RESULTS AND DISCUSSION

Effect of MLSS and COD on MBR performance

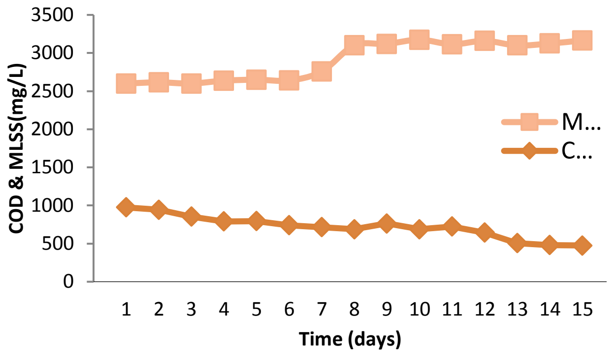

Figure 2. Relations COD and MLSS (mg/L) versus time (days) to COD 3600 mg/L

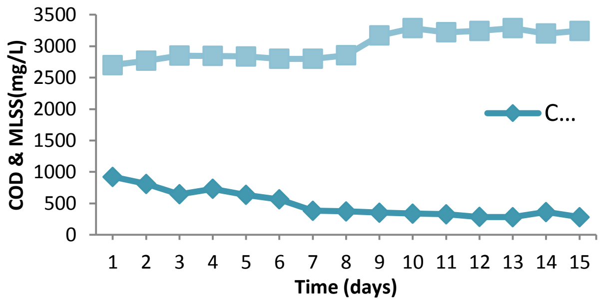

Figure 3. Relations COD and MLSS (mg/L) versus time (days) to COD 2800 mg/L

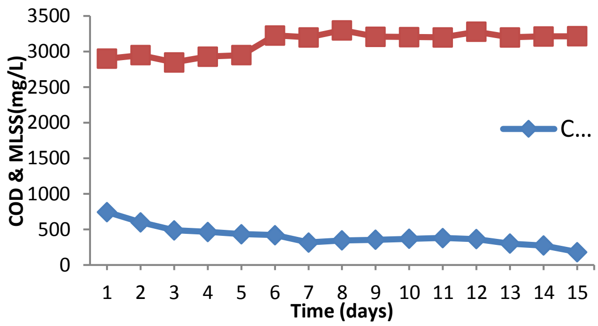

Figure 4. Relations COD and MLSS (mg/L) versus time (days) to COD 1800 mg/L

Figure 2, 3 and 4 shows the different MLSS concentrations in the feed COD concentration of 1800 mg/L, COD 2800 mg/L, COD 3600 mg/L. In COD 1800 mg/L can be shown day-1 MLSS 2900 mg/L and the 15th day of MLSS 3216 mg/L, has the F/M ratio of 0.22. In COD 2800 mg/L can be shown day-1 MLSS 2700 mg/L and the 15th day of MLSS 3245 mg/L, has the F/M ratio of 0.36. In COD 3600 mg/L can be shown day-1 MLSS 2600 mg/L and the 15th day of MLSS 3166 mg/L, has the F/M ratio of 0.42. Different MLSS concentration can affect the metabolism of microorganisms that multiply in the aerobic tank. The metabolism of microorganisms is affected by the F/M ratio, where the F/M ratio is the ratio between the substrate carbon as an energy source is also required by the growth of microorganisms by the number of microorganisms.

Effect of Variation of SRT on the Removal of COD

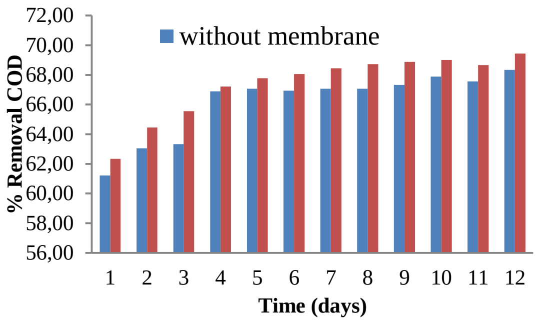

Figure 5. Percentage removal COD versus time (days) at 5 days SRT

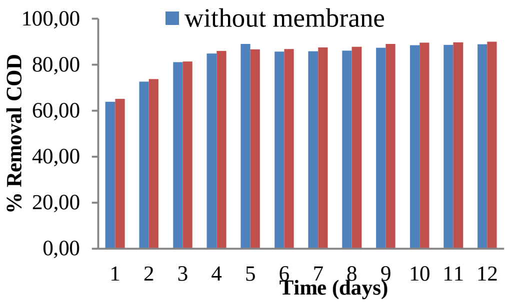

Figure 6. Percentage removal COD versus time (days) at 10 days SRT

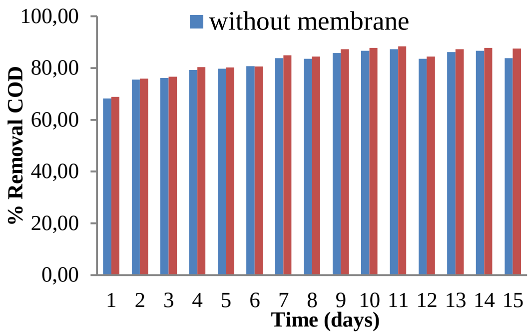

Figure 7. Percentage removal COD versus time (days) at 20 days SRT

Figure 5, 6 and 7 shows a decrease in COD removal versus time for each SRT. And note that the highest COD concentration reduction occurred in both the SRT 10 days without using a membrane or membranes.

The longer SRT, the residence time of microorganisms in a bioreactor tank is getting longer, consequently in the degradation of organic compounds is getting better, but is usually between 3-14 days to produce a biological floc which can be handled with ease. If SRT < 3 days, the biomass has not been enough to precipitate easily resulting in bulking. And if SRT > 3 days, floc particles are very small to be able to precipitate quickly and the fraction of living cells in very low biomass (Sundstrom and Klei, 1979).

Wastewater treatment with activated sludge in aerobic process is influenced by the F/M ratio can affect the COD removal. If the F/M ratio is too large, there will be bulking sludge. Because it is not a proper balance between the concentration of activated sludge biomass with nutrition or substrate so as to allow the needs of DO is increasing. And if the process in the aerobic tank is not good because of imbalance F/M ratio, so the filtration process serves to enhance aerobic process in removing COD.

From these data it is also known that there is no significant difference between the effluent using a membrane and no membrane. The membranes used were ultrafiltration membrane that has limitations in the separation of COD. Ultrafiltration membrane capable of separating colloidal and solid particles such as protein, starch, antibiotics, viruses, colloidal silica, gelatin, organic matter, bacteria, fat and solids.

Total N Removal

If the total amount of N that came out less than 0.5 N the total number of incoming or % removal of > 50 %, then the denitrification process was successful. But if the total amount of N that comes out is greater than the total amount of N entering the denitrification process is not going well in the anoxic tank. As shown in Table 2, 3 and 4 where N total entry of 242.518 mg/L.

Table 2 shows the total N out at 5 days SRT variables, from 197.89 to 71.52 mg/L, so the removal percentage reaches 70.51 % at day 12.

Table 2. Percentage removal of total N in the SRT 5 days

Days	N total exit (mg/L)	N removal (mg/L)	Percentage Removal
1	197.89	44.631	18.40
2	159.72	82.802	34.14
3	117.76	124.758	51.44
4	98.94	143.578	59.20
5	82.82	159.702	65.85
6	81.74	160.780	66.30
7	76.36	166.159	68.51
8	77.44	165.078	68.07
9	75.28	167.237	68.96
10	71.52	170.997	70.51
11	70.98	171.536	70.73
12	71.52	170.999	70.51

Table 3 shows the total N in 10 days SRT variables, from 66.67 to 22.58 mg/L, so the removal percentage reaches 90.69 % at day 12.

Table 3. Percentage removal of total N in the SRT 10 days

Days	N total exit (mg/L)	N removal (mg/L)	Percentage Removal
1	66.67	175.846	72.51
2	52.69	189.826	78.27
3	44.09	198.426	81.82
4	34.95	207.567	85.59
5	30.11	212.404	87.58
6	29.04	213.480	88.03
7	27.96	214.554	88.47
8	30.11	212.405	87.58
9	27.96	214.557	88.47
10	22.58	219.933	90.69
11	22.58	219.933	90.69
12	22.58	219.933	90.69

Table 4 shows the total N in 20 days SRT variables, from 67.22 to 56.46 mg/L, so the removal percentage reaches 76.72 % at day 17.

Table 4. Percentage removal of total N in the SRT 20 days

Days	N total exit (mg/L)	N removal (mg/L)	Percentage Removal
1	67.22	175.296	72.28
2	70.98	171.536	70.73
3	70.44	172.077	70.95
4	65.07	177.451	73.17
5	62.38	180.141	74.28
6	67.22	175.298	72.28
7	67.76	174.762	72.06
8	68.83	173.689	71.62
9	62.92	179.599	74.06
10	62.38	180.139	74.28
11	61.30	181.216	74.72
12	60.23	182.290	75.17
13	62.38	180.136	74.28
14	61.30	181.216	74.72
15	60.22	182.294	75.17
15	59.69	182.833	75.39
17	56.46	186.059	76.72

Controlling of Fouling on Membrane

Events of membrane fouling on the membrane surface fouling is an event that may affect the performance of the membrane. The fouling due to the continuous operation of the bioreactor so that the particles of activated sludge accumulates on the surface layer of the membrane which causes a decrease in flux.

In the SMBR system, the membrane is placed on the aerobic tank, which is intended to replace the secondary sedimentation basin role in separating the slurry with supernatant. The separation process SMBR system will aggravate the performance of the membrane. While the MBR system, the membrane is separated from the aerobic tank and placed after the sedimentation tank. This effort is done to reduce the performance of membrane filtration to extend the operating time, because the quality of the wastewater after precipitation can reduce the load of filtration. The results of flux measurements for each system is illustrated in Figure 8, 9 and 10.

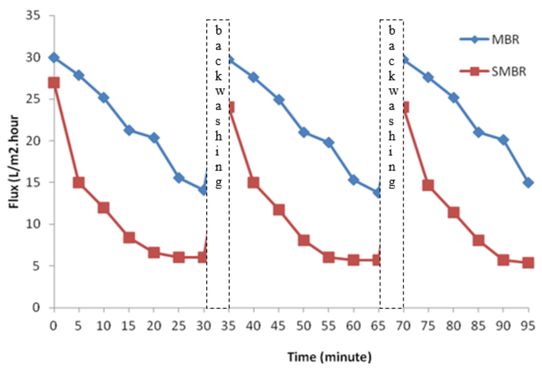

Figure 8. Comparison of Flux (L/m^2.h) MBR and SMBR versus Time (minutes) on the COD 1800 mg/L

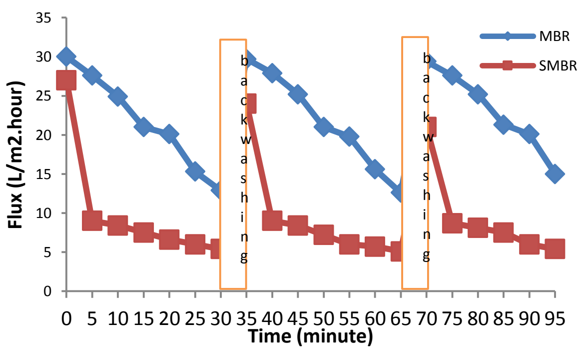

Figure 9. Comparison of Flux (L/m^2.h) MBR and SMBR versus Time (minutes) on the COD 2800 mg/L

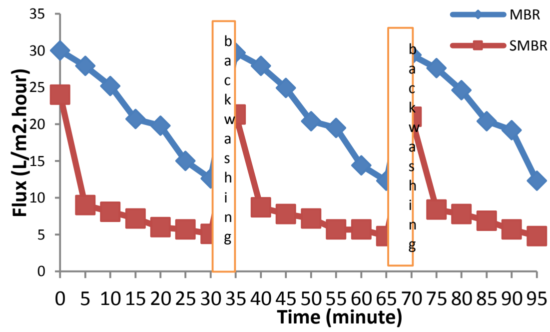

Figure 10. Comparison of Flux (L/m^2.h) MBR and SMBR versus tTme (minutes) on the COD 3600 mg/L

From Figure 8 note that the flux of SMBR system for COD 1800 mg/L is 27 to 5.4 L/m^2.h, smaller than MBR system having 30 to 15 L/m^2.h flux, meaning that within 1 hour membrane in the MBR system can produce permeate much as 15 to 30 L. In Figure 9 SMBR system for COD concentration of 2800 mg/L, which is a significant decrease from 27 to 5.4 L/m^2.h whereas the MBR system and the gradual decline occurred relatively small distance from the flux that is 30 to 12.9 L/m^2.h. After backwashing every 30 minutes once the flux can return 27 L/m^2.h the SMBR system and 30 L/m^2.h the MBR system. The same is shown in the COD concentration of 3600 mg/L which is in Figure 10.

Flux is getting dropped caused by fouling due to particles that accumulate on the surface layer of the membrane. It can be seen that the presence of backwashing the membrane flux can increase although not to the initial conditions. The increase in flux can not be returned as the initial condition because there is still fouling that can not be lost by backwashing.

Figure 11. Fouling in SMBR

In Figure 11 shows presence of membrane fouling in SMBR system. This event aggravate the performance of membrane fouling which will affect the life of the membrane and the membrane maintenance and power requirements for process separation.

Therefore, SMBR system development into the MBR system. MBR system develops conventional system, with the addition of the sedimentation space is relatively smaller than the space of sedimentation on the conventional system. Sedimentation space on the MBR system is also able to overcome the problem of bulking sludge in the aerobic tank, where the membrane is still running well to enhance an error control in aerobic process. If using SMBR and the error occurs, it will often do backwashing or should provide the membrane in significant amounts.

Membrane fouling is a process where solute or particles deposit onto a membrane surface or into membrane pores in a way that degrades the membrane's performance. The fouling due to the continuous operation of the bioreactor so that the particles of activated sludge accumulates and results of the surface layer of the membrane which causes a decrease in flux. Membrane fouling increased with increasing F/M (Thamer and Ahmed, 2008).

One of the factors that affect the performance of the membrane is Soluble Microbial Products (SMP). The decrease in membrane performance can be caused by SMP which will affect the permeate flux related with the occurrence of membrane fouling. SMP can be proteins, fats and carbohydrates are formed from a biological process as a byproduct of the process in the aeration tank. It is known that the longer SRT, the more SMP which formed that will clog pores and lead to decreased permeate flux versus time operation. The occurrence of fouling for each sewage treatment is different depending on the biological processes and the use of membrane systems that use submerged membranes (SMBR) or system development than the conventional activated sludge treatment that is equipped with a Membrane Bioreactor (MBR). It is known by observing flux every minute so that decrease of flux can be observed continuously.

The existence of microorganisms in bioreactors is vital to the formation of SMP, which directly influence the permeate flux in membrane filtration processes related with the occurrence of fouling (Widjaja and Yustia, 2007).

Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (total suspended or dissolved solids). Turbidity in NTU units (Nephelometric Turbidity Units) showed turbidity of a water sample, which in this study in the wastewater in the aerobic tank and permeate were analyzed turbidity with a turbidity meters.

It is affecting the clarity of effluent include dispersed growth of filamentous bulking and bacteria that cause bacterial difficult to settle due to the very small size so just floating in the water. This is resulting effluent or water becomes turbid.

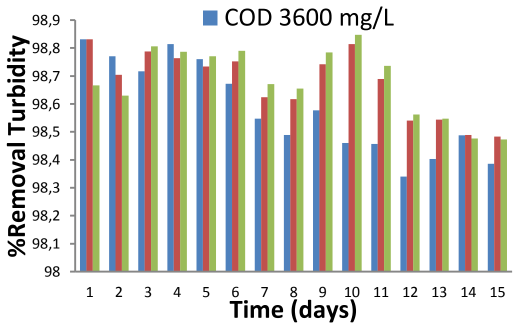

Figure 12. Percentage removal turbidity (NTU) versus time (days) to COD 3600, 2800 and 1800 mg/L

Figure 12 shows that the wastewater treatment using activated sludge and membrane ultrafiltration can reduce the turbidity of the wastewater that is 98.47% to 98.85%. Where are shown in Figure 13 results before filtering and after filtering with a membrane.

Figure 13. Effluent Before and After Screening with Membrane in COD 1800 mg/L and SRT 10 days

CONCLUSSIONS

COD removal is influenced by the concentration of MLSS and DO concentration, whereas total N removal while affected by anoxic conditions. The best conditions obtained at SRT 10 days, which is in the process of aerobic and membrane filtration process. Total N permeate smaller than the total number N of 0.5 % removal of influent or > 50 % of the denitrification process was successful. In order to achieve turbidity removal 98.47 to 98.85%. In the MBR of flux 30 L/m^2.h dropped to 15.6 within 25 minutes, compared to SMBR of flux 27 to 5 L/m^2.h within 5 minutes.

The results showed that the aerobic wastewater treatment with MBR and anoxic as a whole is relatively stable and well despite operating at high feed COD.

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