

Development and Evaluation of woven fabric microfiltration immersed membrane bioreactors on waste water treatment for reuse

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Abstract

This paper reports the main results of a pilot scale WFM-IMBR operated for more than 30 days without sludge withdrawal and fed on real municipal wastewater. The experiments were oriented towards three main objectives; the performance of the system and the long term stability operation of the system. The experimentation was conducted at Durban Metro Southern Waste Water Works, Veolia plant at Merewent. WFM-IMBR was designed based on Wiese pilots scale system (see figure 1). The sludge and hydraulic retention time was 30 days and 24 hour respectively. DO inside WFM-IMBR was kept above 2mg/L at all given time (see figure 7). The result showed that with the increase in MLSS concentration, critical flux decreases and it can be improved by the increasing the aeration (see figure 2). It was also observed that critical flux can negatively affected by the membrane history. The trial demonstrated that WFM-IMBR can be operated for extended periods at sub-critical flux without hydraulic loss and no need of cleaning (see figure 3). In terms of the performance of the system, COD and MLSS removal was found to be above 95% and 100% respectively (see figure 4). Turbidity was found to be less than 1NTU at any given time (see figure 5). The bacterial growth was observed to vary on COD loading rate.

There is further need to carry out the same investigation with all elements of conventional WWT method with WFM-IMBR and the link between COD loading rate and sludge growth rate and its effect on fouling of WFM-IMBR.

Introduction

Membrane bioreactors (MBR) represent an existing alternative to conventional wastewater treatment process (1). However, problems related to operation high costs, mainly due to membrane fouling, still needs to be addressed. The deposition of biomass and suspended solids on the membrane surfaces and within the membrane pore leads to an increase of the hydraulic resistance and permeate flux decline(2). Physical or chemical cleaning of the membrane is required to remove foulant and maintain optimum membrane performance in long term operation (3). Fouling can be limited, consequently reduced by using air scouring as commonly practised, by maintaining the permeate flux below critical flux (J_c) (4). This flux is related to flux and Trans membrane pressure (TMP). Above critical flux fouling takes place and cleaning practise are necessary to restore membrane flux (5). This paper reports the trials that were conducted on a pilot scale WFM-IMBR for 30 days at subcritical flux operation using a real activated sludge.

Materials and Methods

A pilot scale WF-IMBR set up with 20 modules and area 0.2904 m^2 was constructed based on Wiese pilot scale version (see figure 1). The system was fed with real wastewater from aerobic reactors. Permeate was withdrawn using a peristaltic pump. The permeate flow rate and Trans membrane pressure were continuously recorded. The system was fed with a real activated sludge from aerobic reactors. The hydraulic and sludge retention time was 24 hours and 30 days respectively.

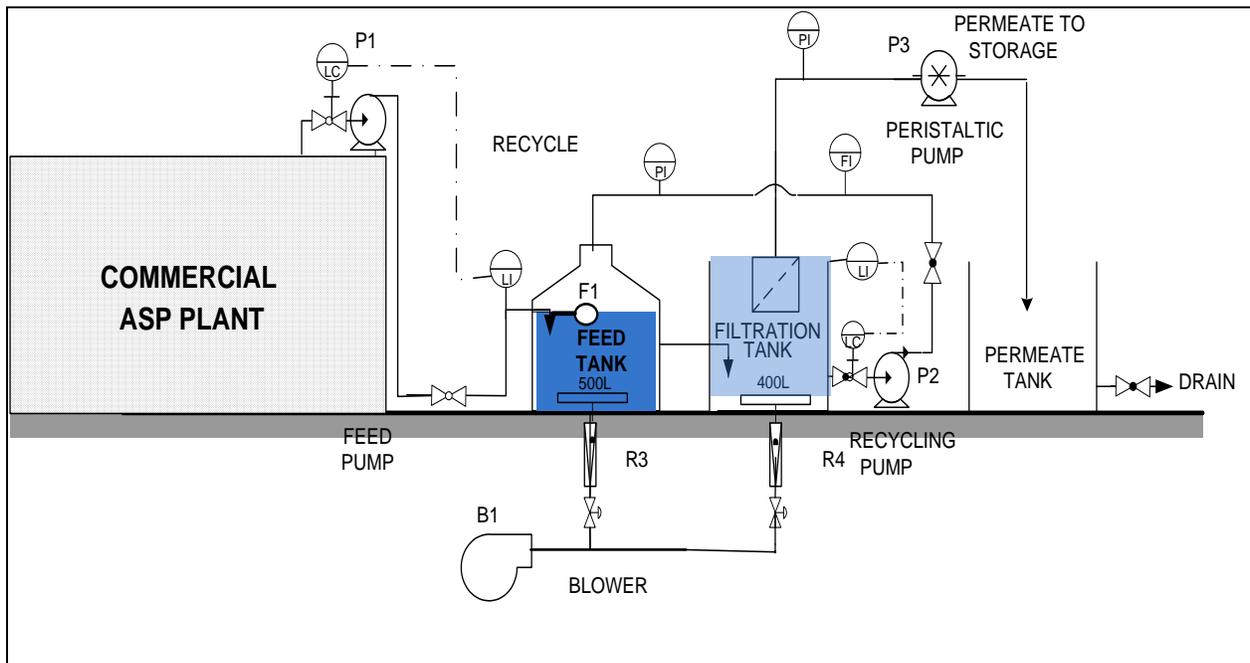


Figure1. The P and I diagram of immersed woven fibre microfiltration membrane bioreactor

Results

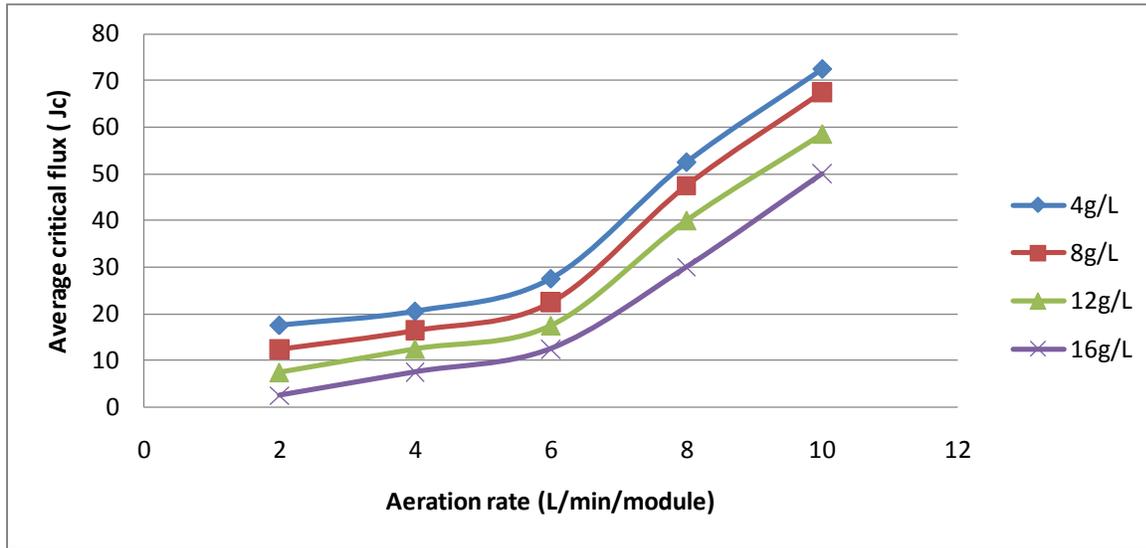


Figure 2: the relationship between average critical flux and aeration rates at different concentration of activated sludge.

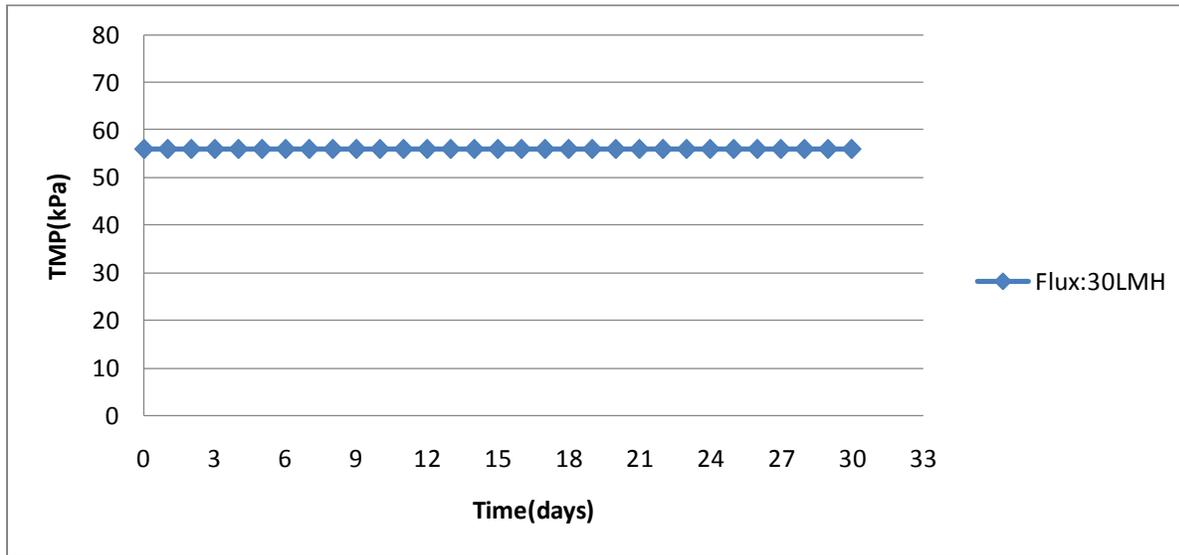


Figure 3: the relationship between Trans-Membrane Pressure and Time at fixed subcritical operation of 30LMH.

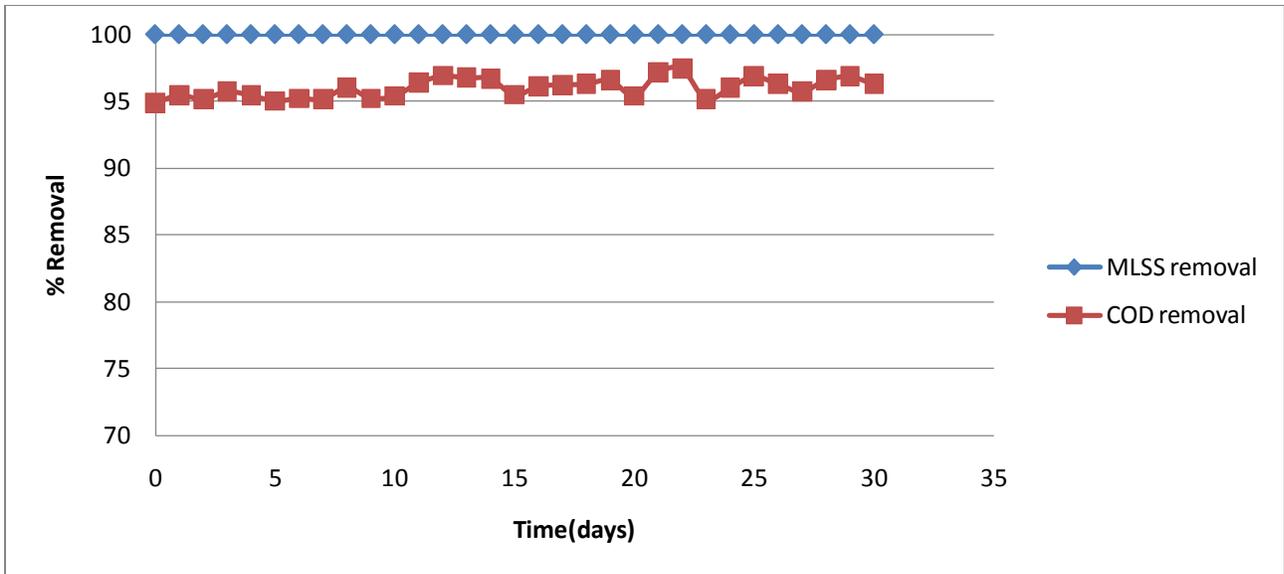


Figure 4: the relationship between COD/MLSS removal and Time at varying sludge concentration.

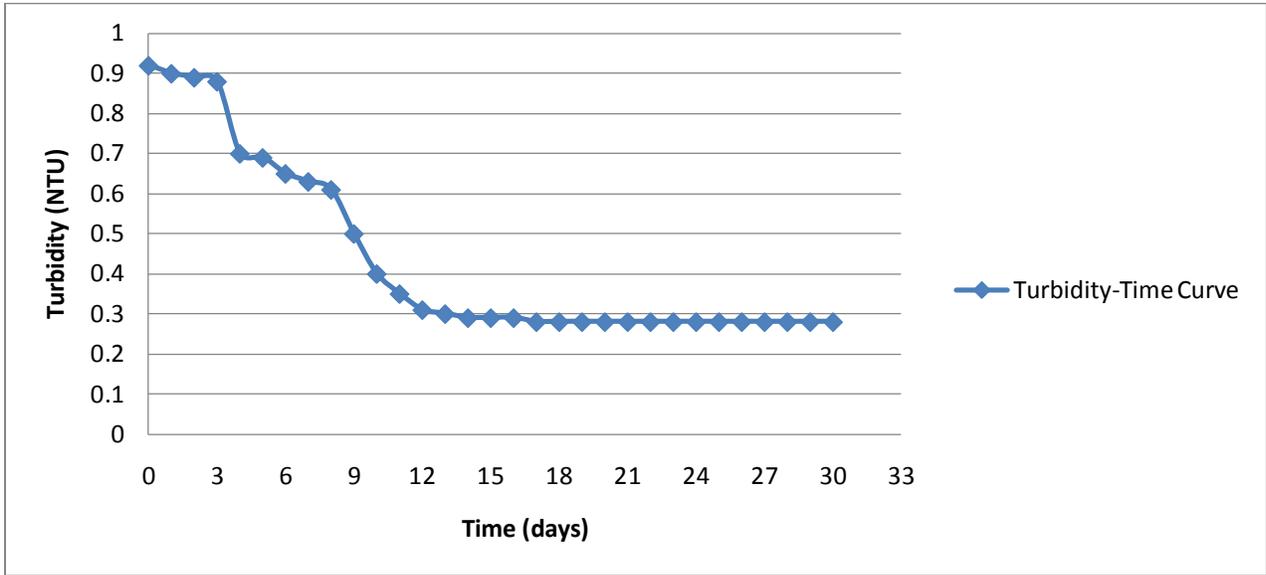


Figure 5: the relationship between permeate Turbidity (NTU) and Time at varying sludge concentration.

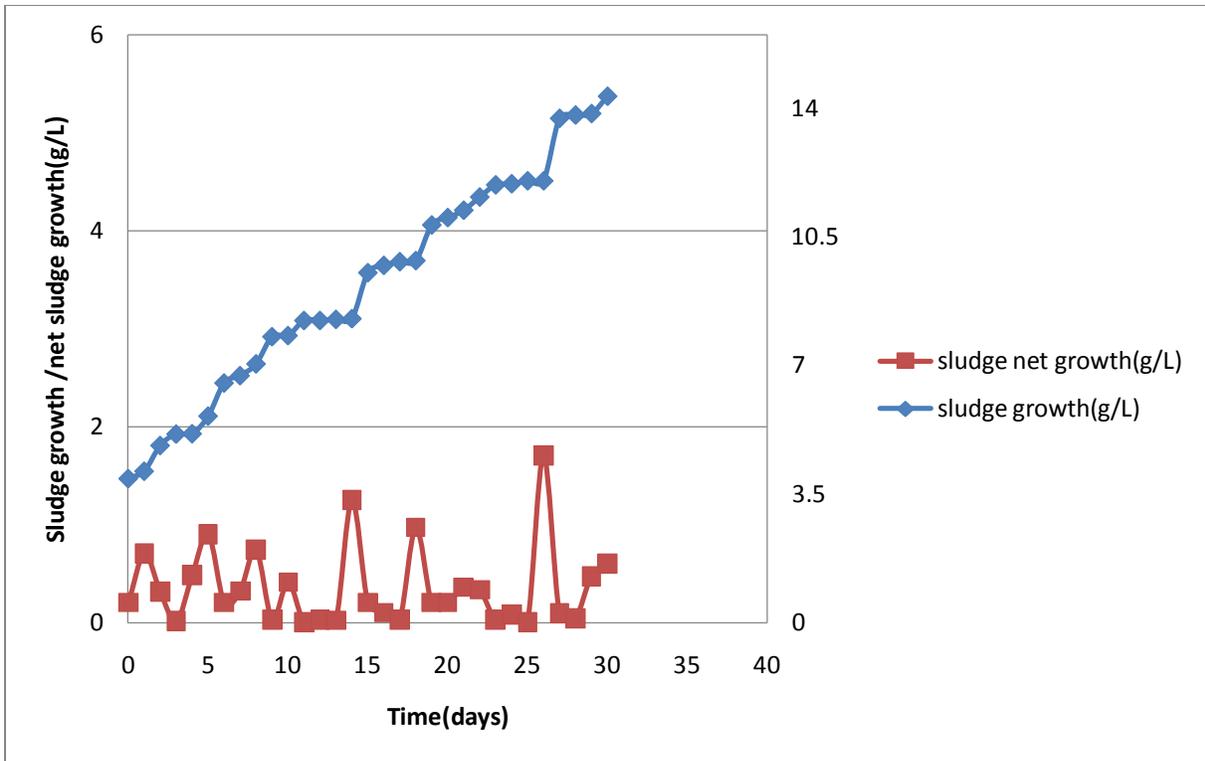


Figure 6: the relationship between sludge growth/net sludge growth and Time at varying COD loading rates.

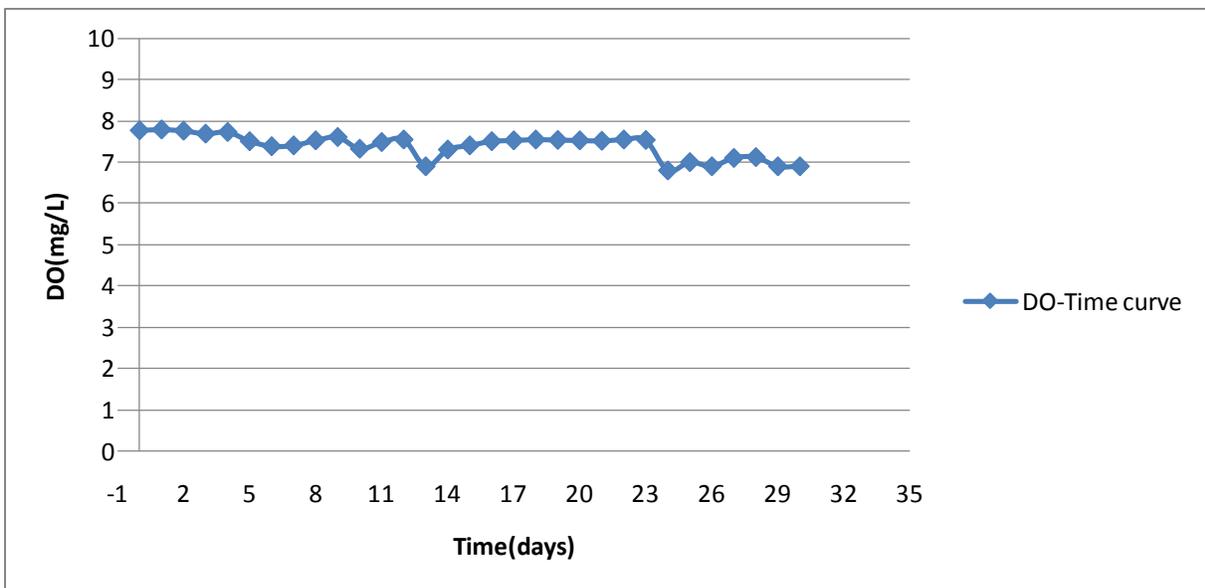


Figure 7: the relationship between Dissolved Oxygen (mg/L) and Time at fixed aeration of 10L/min./module

Discussion of results

The effects of various parameters on critical flux were examined in this study. It was observed that the critical flux decreased with the increase of sludge concentration (see figure 2) and it could be enhanced by improving the aeration intensity. It was also observed that the critical flux increases with the increase of aeration rate intensity.

Membrane history was found to have negative effects on membrane critical flux, i.e. the critical flux decreased as the membrane operation prolonged. It could be concluded that critical flux is dependent on many factors including membrane material, biomass in a MBR and measurement parameters, rather than a simple function of just a parameter. Other parameters should be maintained almost the same when the effect of a specific parameter on critical flux is determined.

The sub-critical flux operation trials demonstrated that WFM-IMBR can be operated for prolonged time with neither no hydraulic loss nor need of membrane cleaning (see figure 3). The performance of WFM-IMBR pilots scale fifty people equivalence system was found to exceed the design expectation; COD and MLSS removal was found to be 95% and 100% respectively (see figure 4). The permeate turbidity was found to be less than 1 NTU and it was decreasing with the increase in time and eventually stabilizes after prolonged time (see figure).

Conclusion

Data generated from the WFM-IMBR pilot scale set up was found to be equivalence to that of established IMBR pilot scale set up in terms of performance, long-term stability operation and ease of membrane cleaning.

The assessment of parameters affecting the sustainable operation of WFM-IMBR long term operation, in terms of operational values, the following was observed:

The increases MLSS concentration, decreases critical flux and the increases in aeration increases (improved) the critical flux. The TMP was found to be stable for 30 days and there was no variation observed in hydraulic performance. This was the evidence that MBR can be operated for extended period at subcritical flux operation. The performance of the WFM-IMBR, in terms of quality was found to be exceeding the expectation with more than 95% COD removal, 100% MLSS removal and permeate turbidity less than 1NTU at all given time.

Thus far woven fibre membranes has evaluated for shorter and long term periods in wastewater application, in laboratory scale and pilot scale set up however it has proved a great potential in membrane technology; excellent COD and MLSS removal, excellent permeate turbidity , long term stability operation and ease of membrane cleaning.

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