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Treatment of model textile dye wastewater (MTDW) towards developing novel submerged membrane bioreactor process

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This paper deals with the treatment of model textile dye wastewater (MTDW) by a submerged membrane bioreactor (MBR) with commercial membrane. For this work, MTDW was developed investigating different literatures and a pilot-scale automised MBR unit was applied to carry out the tests with this model wastewater. The system will be upgraded later to attain novel MBR process replacing the applied commercial membrane by novel membrane materials which will be developed by European Commission funded project “BioNexGen” [1].

The hydraulic volume of the MBR reactor employed was 57 L with submerged flat sheet commercial membranes (3 sheets, with 25 cm × 25 cm dimensions of each sheet, total active membrane area of 0.33 m^2). To reach the target, different MBR process parameters like COD, BOD, TOC, pH, conductivity, flux, TMP, MLSS, colour contents, air supply, O_2 consumption, HRT, SRT, drying residue, nutrients etc. have been investigated. As one of the delegating results, it can be reported that under the operating conditions of permeate flux of 4 L/m^2h, around 50 mbar of TMP, 12 g/L of MLSS, 35 h of HRT, 1.0 m^3/h of air supply to MBR reactor, 7.5-8.0 of pH and temperature of 18±2 °C, the COD removal efficiency was around 88% for 2400 mg/L inlet COD fed to the membrane bioreactor.

1. Defining Model Textile Dye Wastewater (MTDW)

In order to verify the testing results towards developing novel MBR process, the chemical compositions of the feed needs to be constant. To collect benchmarking data with constant chemical compositions of feed, a model textile reactive dye wastewater (MTDW) has been defined (Table1) based on different literature studies.

Table1: Composition of model textile dye wastewater (MTDW)

No.	Dyestuffs & chemicals	Concentration (mg/L)	Reference
1	Remazol Brilliant Blue R	50	
2	Acid Red 4	50	
3	NaCl	2500	[2]
4	$NaHCO_3$	1000	[3]
5	Glucose	2000	Adapted from [3]
6	Albatex DBC (Detergent)	50	[4]

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2. Experimental set up

The schematic diagram of the MBR testing unit is shown in Fig.1. It's a sensor controlled automised submerged MBR unit with a membrane module (membrane: UF, material: PES, pore size: 0.04 µm, dimensions: 25 cm × 25 cm, total active membrane area: 0.33 m^2) from Microdyn-Nadir GmbH, Germany.

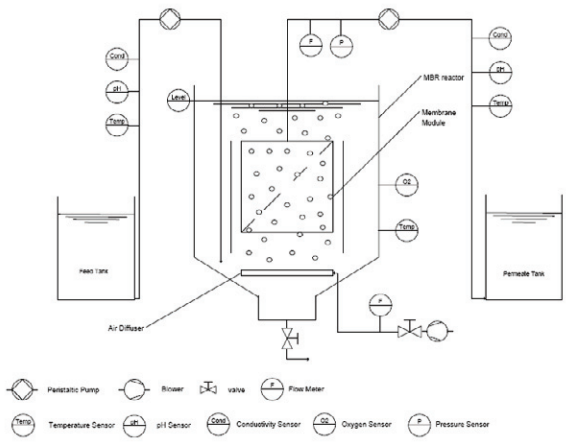

Fig.1: Schematic diagram of MBR unit

3. Results and discussion

The MBR trial has been running for 4 months continuously. The start up trial was done with only one dye (Remazol Brilliant Blue R) with reduced concentration (25 mg/L) to acclimate the micro-organisms with the process. After having the micro-organisms acclimated with the feed conditions, the tests were performed continuously with MTDW (see Table 1) and the results on COD, BOD, TOC, pH, conductivity, flux, TMP, MLSS, permeate colour contents, air supply, O_2 consumption, HRT, SRT, drying residue, nutrients etc. were obtained. The COD removal efficiency and correlation between COD & colours and colour removal efficiencies are shown in Fig.2 and Fig.3 respectively. Under the operating conditions of around 50 mbar TMP, 12 g/L of MLSS, 35 h of HRT, 1.0 m^3/h of air supply, pH of 7.5-8.0 and temperature of 18±2 °C, the COD removal efficiency was around 88% (Fig.2) for 2400 mg/L inlet COD fed to the membrane bioreactor. From Fig.3 it is noticed that the concentration of dyes (red and blue) in the permeate are not highly correlated to that of permeate COD values. The permeate COD in red is around 25 mg/L while it is 30 mg/L in blue representing 50% and 40% colour removal efficiency of red and blue colour respectively. Since the molecular weight of the dyes are much smaller than the pore size of the applied membrane, the dyes are supposed to be passed through the membrane. This quantity of dye removal efficiency might have happened due to adsorption or degradation in the reactor which will be verified later.

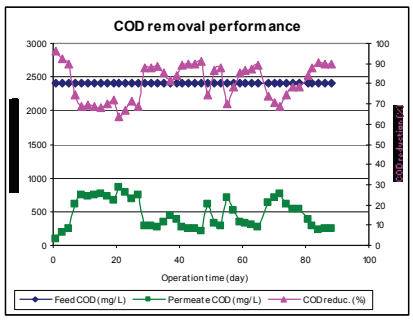

Fig. 2 : COD removal efficiency

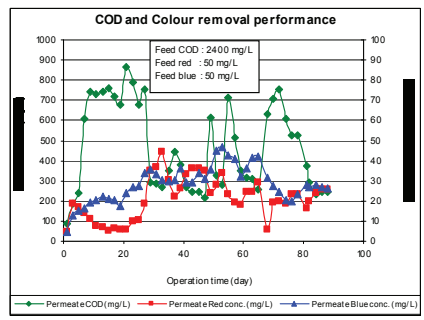

Fig. 3 : COD & colour removal efficiencies

4. Conclusion and future work

Among the results obtained so far it is observed that around 88% COD removal efficiency and 40-50% dye removal efficiency have been obtained. The tests will be continued at HRT of 25 h, 15 h, 10 h, aeration of 1.5 m^3/h and pH value of 10.0 and the critical flux of the applied membrane module will be defined. In the later phase, the commercial membrane module used in the MBR reactor will be replaced by novel membrane and the similar test will be carried out to compare the results. The critical flux of the novel membrane will be also determined and it will be compared with the existing one. The rejection of low molecular weight compounds like dyestuffs will be studied as well. Additionally, optimum operating conditions will be adapted to develop the novel submerged MBR process.

Acknowledgement

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