The application of membrane bioreactors for domestic wastewater treatment in Palestine

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Introduction

The east coast of the Mediterranean is considered a semi arid region where water availability is far less than demand. As a consequence of the lower water use for domestic purposes, the discharged wastewater effluents are highly concentrated which poses a challenge for the selection of appropriate technologies used for wastewater treatment since conventional processes are not capable of treating such concentrated effluents.

The application of membranes in wastewater treatment is an evolving technology and membrane bio reactors (MBRs) are getting more attention worldwide. The MBR is a combination of suspended growth reactor and membrane filtration device set into a single unit process. This combination has various advantages such as the smaller footprint, absence of bulking problems, and the ability to withstand variable influent conditions (Bernal et al, 2002) and high feed concentrations (Watanabe and Kimura, 2006). These advantages promote the use of MBRs where conditions similar to that existing in Palestine exist. In addition to that, MBRs have the ability to produce effluent complying with standards set for wastewater reuse options (Melin, 2006).

Membrane fouling increases the investment cost and power consumption per unit of treated wastewater which are the main constraints that limit the use of MBR technology (Judd, 2004). However, the expansion of the technology worldwide and the more understanding of fouling mechanisms are reducing the operation costs continuously.

This research aimed at experimenting the MBR for the treatment of domestic wastewater effluent for the purpose of studying the system performance and efficiency under existing wastewater characteristics.

Material and methods

A lab scale MBR unit is in place at BERC labs since August 2007. The unit was used to test the treatment efficiency of domestic wastewater of rural origin. The MBR unit is a *ZEEWEED®-10 ZENOGEM®* membrane bioreactor system equipped with hollow-fiber submersible ultrafiltration membrane. A detached pretreatment unit for biological nutrient removal and suspended media carriers were also used to evaluate their comparative effect on the treatment efficiency and on the membrane fouling potential. The treated wastewater passed through a settling tank for primary treatment before entering the MBR unit. Wastewater source was of domestic origin from households near BERC lab in Til, Nablus.

Relevant parameters of the influent wastewater, treated permeate, and the mixed liquor suspended solids (MLSS) were measured to monitor the performance of the system over time and determine the optimum conditions under which the system could be operated. A Hach DR2800 spectrophotometer was used to measure the concentrations of the chemical oxygen demand (COD), total organic carbon (TOC), total nitrogen (TN), ammonium (NH_4-N), nitrate (NO_3-N) and phosphate (PO_4) ion concentrations. Other tests including the total suspended and volatile solids (TSS, VSS) were measured according to the standard methods for the examination of water and wastewater (APHA, 1998). Turbidity was measured using a Hach 2100P turbidimeter, dissolved oxygen (DO) was measured using a hach HQ40D meter.

The MBR was operated for a period of 85 days as submerged bioreactor without the use of the nitrification-denitrification pretreatment unit to serve as reference for comparison. The pretreatment was put in operation for another 90 days to observe the effect of nitrogen removal from wastewater prior entering the MBR on its performance. The carrier media were introduced after 175 days of continuous operation for a period of 55 days.

Results

The turbidity of the influent wastewater and the MBR permeate was plotted over time. Although the turbidity of the influent expressed in number of turbidity units (NTU) remained stable, a notable decrease in the turbidity of permeate was noticed after the installation of the pretreatment. In most of the samples, the turbidity of permeate was less than that of tap water.

The performance of the MBR against fouling was assessed mainly by measuring the permeability of the membrane. Normalized permeability values were used to neutralize the effect of the viscosity of the liquid under different operation temperatures on the flux across the membrane. The permeability during the initial stage before the operation of the pretreatment ranged between 120-180 (l/m^2.hr.bar) and was about 150 on the average. After the operation of the pretreatment unit, permeability values as high as 255 were recorded with average values around 200. This continued about 35 days before starting to drop down to about 30 after 75 days of operation. This emphasized the hypothesis that the major component for membrane fouling was the bio-fouling due to the accumulation of organic matter o the surface and within the pores of the membrane. The rapid decrease in permeability is justified by the buildup of foulants on the surface of the membrane (Woo-Nyoung Lee et al, 2006). It is assumed that the level of permeability decline before the operation of the pretreatment was due to the low flux through the membrane at that stage.

The analysis of solids contents in the MBR throughout the experiment demonstrated that the MBR maintained a TSS level of about 10 g/l which is 3-4 times higher than that existing in conventional activated sludge process. A drop in the level of TSS was noticed during the period after the installation of the pretreatment unit. This was due to the dilution of the suspension since the volume of the reactor was doubled after operating the pretreatment unit. The values of TSS maintained its previous range once the system stabilized.

The removal efficiency of the MBR was tested for various parameters including COD, ammonium, phosphate, and nitrate. In most of the cases, an increased removal rate was noticed when the pretreatment was in operation.

The concentrations of nutrients were measured in influent wastewater and in treated permeate and the removal efficiency was calculated for each. In the case of total and ammonium nitrogen it was noticed that the operation of the pretreatment caused an increase in the removal efficiency although the total content of nitrogen remained high due to the initially high concentration in the influent wastewater. The effect of MBR and the pretreatment on the removal of phosphate did not indicate any clear trend. The addition of carrier media into the MBR had minimal effects on the quality of effluent although stabilized the permeability rate of liquid across the membrane.

The results obtained from the MBR system operated at BERC during the experiment period indicated that the use of MBR for the treatment of highly concentrated wastewater is applicable and feasible. The removal efficiencies of the MBR system were within average limits although the quality of permeate was above standards in terms of suspended solids and turbidity. The inclusion of a nitrogen pretreatment removal process proved to be of a notable effect both on the permeability through the MBR membrane and on the quality parameters in general.

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