A novel combination of a membrane and a photocatalytic reactor for water reclamation

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ABSTRACT

Membrane Bioreactors (MBR) in wastewater treatment has gained significant popularity the last fifteen years, especially due to reclamation need. Membrane bioreactors (MBRs) have been used increasingly in municipal and industrial wastewater treatment. Although MBRs are ideal for water reclamation projects, the high-quality effluent and additional pathogen removal make MBRs a promising technology for discharging high-quality, partially disinfected wastewater into streams and water bodies while using little or no chemical addition for disinfection. The purpose of this study was to compare and (test) evaluate the performance, in terms of microbial removal, in effluents of five different commercially available membrane modules working under the same operating conditions in a pilot scale unit, and then treated in a photocatalytic reactor subsequently for disinfection. Also it was examined the difference in microbial removal between a gravity sedimentation system in a conventional activated sludge process (CAS) and an SMBR separation process. The SMBR process uses separation on membrane elements, to improve the biological process and produce an effluent that exceeds the effluent quality produced in CAS, due to the pore size of membrane and the even more extra sludge film that is formed on them. In this study it is verified that organic matters larger than the membrane pores are being retained in the reactor, and organics even smaller than the membrane pores are being retained due to additional filtration provided by the cake layer that develops in these high solids environments.

Table 1. *Bacterial indicators removal by associated pilot membrane and photocatalytic treatment*

Indicator	Total Coliforms cfu/100 ml	Removal %	E. coli cfu/100 ml	Removal %	Streptococci cfu/100 ml	Removal %	Enterococci cfu/100 ml	Removal %
Raw Sewage	35×10^6		$9{,}5 \times 10^6$		5×10^6		39×10^4	
Secondary sedimentation (1/2h)	6×10^6	83	-	-	10^5	98	-	-
Secondary sedimentation (1h)	$2{,}5 \times 10^6$	93	-	-	-	-	-	-
Secondary sedimentation (2h)	$7{,}5 \times 10^5$	98	5×10^5	95	2×10^4	99,6	19×10^3	95
MBR A Type	6×10^3	99,98	<10	100	<10	100	<40	99,99
MBR B Type	1×10^4	99,97	<10	100	<10	100	<40	99,99
MBR C Type	0	100	<10	100	<10	100	<40	99,99
MBR D Type	$1{,}5 \times 10^4$	99,96	<10	100	<10	100	50	99,99
MBR E Type	0	100	<10	100	<10	100	<10	99,99
Photocatalysis (1/2h) A Type	0	-	<10	100	<10	100	<40	99,99
Photocatalysis (1/2h) B Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1/2h) C Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1/2h) D Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1/2h) E Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1h) A Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1h) B Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1h) C Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1h) D Type	0	-	<10	100	<10	100	<10	100
Photocatalysis (1h) E Type	0	-	<10	100	<10	100	<10	100

Test results showed that MBR systems were capable of operating on advanced primary effluent, despite variable conditions and membrane fouling. As shown in Table 1, no bacterial contamination indicators and bacterial pathogens were detected in the permeate and probably the same happens with the parasites that have bigger sizes. This is attributed to the microfiltration or ultrafiltration membranes which have a pore diameter smaller than the size of bacteria and parasitic microorganisms, so that the membrane is an effective barrier. However, Table 1 shows the effectiveness of the photocatalytic process in removal of bacterial indicators. The results indicate a great degree of removal >99.96% for Coliforms and >99.99% for the other bacteria.

Permeate microbial results concerning the usually encountered bacteria proved that MBR systems combined with a Photocatalytic method are able to produce permeate of high quality to be used in several applications such as land irrigation, agricultural activities etc., in accordance with local standards.

MBRs have been proven as efficient and versatile systems for wastewater treatment over a wide spectrum of operating conditions. The treatment performance of the MBR is better than in conventional activated sludge process. A high conversion of ammonium to nitrate (>95%) and high COD removal efficiency (90-98%) was achieved in the pilot unit, regardless of the influent and HRT fluctuations. Microbial analysis of permeates showed almost the absence of bacterial indicators of contamination. At the same time, the photocatalytic method presented 100% efficiency in the elimination of viral indicators although effluent figures are not so high.

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