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Characterization of ZW-1 ultrafiltration membrane and its application for direct municipal wastewater treatment

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Introduction

In recent times when the population faces severe water shortages, any available wastewater source should be treated with adequate technology for reuse and ultimately to protect the aquatic environment. In this sense, an enormous amount of municipal wastewater, which is most often biologically processed, should also be membrane processed. The aim of this work was to examine the efficiency of low pressure membrane process of ultrafiltration (UF) for the purification of characterized municipal wastewater. ZeeWeed-1 (ZW-1) hollow fiber ultrafiltration membrane was characterized with polyethylene glycol and polyethylene oxide at different permeate fluxes and afterword it was used to treat municipal wastewater.

Material and Methods

ZW-1 (GE Water & Process Technologies, Hungary) hollow fiber ultrafiltration membrane with a surface of 0.046 m^2 was characterized with 250 mg L^{-1} solutions of polyethylene glycol, PEG, (35 kDa) and polyethylene oxide, PEO, (100, 300, and 600 kDa) at different permeate fluxes (10, 20, and 40 L m^{-2} h^{-1} (LMH)) and pH 7. The raw municipal wastewater was characterized before and after UF treatment by the following parameters: turbidity, pH, conductivity, chemical oxidation demand (COD), total carbon (TC), inorganic carbon (IC), dissolved organic carbon (DOC), and content of cations (NH_4^+, Na^+, K^+, Ca^{2+}, and Mg^{2+}) and anions (SO_4^{2-}, Cl^-, NO_2^- and NO_3^-).

Results and Discussion

The molecular weight cut-off (MWCO) of ZW-1 membrane, presented in Fig. 1, decreases with the increase of permeate flux. At 10 and 20 L m^{-2} h^{-1} MWCO was 300 and 600 kDa, respectively. For the highest tested permeate flux (40 L m^{-2} h^{-1}) rejection did not achieve 90% so it can be concluded that the MWCO was higher than 600 kDa.

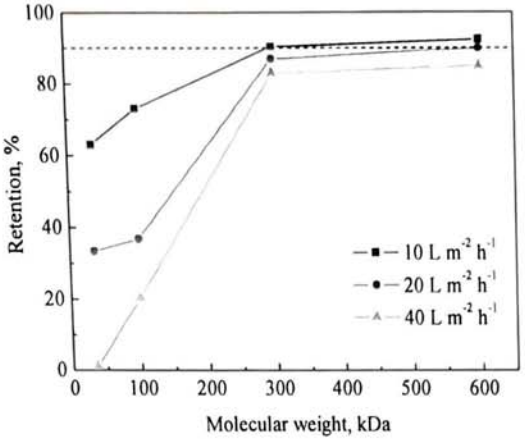

Figure 1. The retention of ZW-1 for PEG (35 kDa) and PEO (100, 300, and 600 kDa)

The raw municipal wastewater and permeate parameters obtained at 10, 20 and 40 LMH are presented in Table 1.

Table 1. The characteristics of raw municipal wastewater and permeates after investigated permeate fluxes (10, 20 and 40 LMH).

Parameter	Units	Feed	Permeate (10 LMH)	Permeate (20 LMH)	Permeate (40 LMH)
pH	-	7.46	7.85	7,56	7,68
Conductivity	$\mu S\ cm^{-1}$	879	830	845	845
Turbidity	NTU	33.10	0.18	0,05	0,07
COD	$mg\ O_2\ L^{-1}$	130.0	32.4	33,2	30,0
TC	$mg\ L^{-1}$	113.0	100.8	106,5	108,9
IC	$mg\ L^{-1}$	81.86	73.84	81,40	81,42
DOC	$mg\ L^{-1}$	31.14	26.96	25,10	27,48
NH_4^+	$mg\ L^{-1}$	15.40	14.32	15.76	15.66
Na^+	$mg\ L^{-1}$	32.05	33.53	31.53	31.44
K^+	$mg\ L^{-1}$	10.23	33.53	31.53	31.44
Mg^{2+}	$mg\ L^{-1}$	19.74	17.81	9.54	8.90
Ca^{2+}	$mg\ L^{-1}$	88.05	90.72	86.62	86.38
Cl^-	$mg\ L^{-1}$	28.98	34.74	28.29	28.54
SO_4^{2-}	$mg\ L^{-1}$	3.12	2.88	3.14	3.20
NO_3^-	$mg\ L^{-1}$	<1	<1	<1	<1
NO_2^-	$mg\ L^{-1}$	<1	<1	<1	<1

ZW-1 membrane efficiently reduced turbidity (99%) and COD (~70%), while, as expected the inorganic carbon, conductivity, and content of cations and anions remained similar to the levels of untreated wastewater. The DOC was not retained by this type of membrane due to its higher MWCO. The permeate flux did not significantly influence the treatment efficiency. This indicates that the molecular weight of the organic components contained in municipal wastewater is mostly lowered than 300 kDa.

Conclusions

The retention of ZW-1 was strongly influenced by the permeate flux with the MWCO of 300 kDa at 10 L m^{-2} h^{-1} and MWCO >600 kDa at 40 L m^{-2} h^{-1}. This influence is more pronounced at lover molecular weights. When municipal wastewater was treated, ZW-1 showed high efficiency for the removal of turbidity and COD.