Journal of Young Scientist, Volume III, 2015
ISSN 2344 - 1283; ISSN CD-ROM 2344 - 1291; ISSN Online 2344 - 1305; ISSN-L 2344 – 1283

THE USE OF ULTRAFILTRATION MEMBRANE SYSTEMS TO TREAT WASTE WATERS GENERATED FROM HARD COAL MINING

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Abstract

The recent studies regarding the membrane technologies indicate that the membrane process applications involve for providing the high quality drinking water and increasing the use of industrial water consumption. The membrane process has been used in applications such as wastewater treatment, industrial water production, water softening, and in the separation of compounds having different molecular weights. Of using in many membrane process Microfiltration (MF) and Ultra filtration (UF) are low pressure filtration processes that are used for pathogen and suspended solids removal as seen in many studies (Guo et al., 2010; Yang et al., 2014). In this study, we investigated the possibility of using microfiltration (MF) and ultrafiltration (UF) membrane systems for treatment of wastewater generated from underground hard coal mining of Kozlu Basin. In first stage of this study, the wastewater was treated using MF membrane filtration system. The MF membrane filtration system was composed of the flat sheet MF membrane module equipped with Polivinilflorid (PVDF) membranes purchased from MICRODYN-NADIR membranes, Germany. The MF membrane has a filter area of 140 cm2 and average pore diameter of 0.2 µm as given by supplier. In second stage of study, the effluents of MF were treated using UF membrane filtration. The UF membrane filtration system was composed of the flat sheet UF membrane module equipped with Polyethersulfone (PESH) membranes purchased from MICRODYN-NADIR membranes, Germany. The UF membrane has a filter area of 140 cm2 and molecular weight cut-offs (MWCOs) of 50 KDa as given by supplier. In the experimental study, the raw water was provided from discharge point of underground hard coal mining of Kozlu Basin. In order to determine the total treatment performance of the MF/UF system, water samples were taken from inlets and outlets of the MF and UF membrane systems, respectively. The pressures were fixed at 1 and 2.5 bars for MF and UF, respectively during the experimental study. In test of wastewater, total coliform, turbidity, conductivity, pH, nitrite, nitrate, phosphate, sulphate, sodium, potassium, chemical oxygen demand (COD), total suspended solids (TSS), calcium, magnesium and total hardness as parameters were analysed in raw and treated water. The results were compared with Turkish Standards (TS 266) and European Union (EC).

Key words: *membrane, wastewater treatment, hard coal mining, water reuse*

INTRODUCTION

Membrane filtration is basically based on placing a selective barrier between two phases. As a result of exerting a driving force to one side of the membrane, components are transported towards the membrane surface. Therefore, some components pass through the membrane (permeate) and others are retained according to their size (retentate). In industrial application, different membrane systems and configurations might be arranged, including pretreatments and other treatment stages based upon different technologies, in order to meet those target water quality standards (Ordonez et al., 2014).

The membrane is the key of the membrane separation technology, and it directly affects process efficiency and practical application value. At present, almost all membranes for industrial processes are made from inorganic materials or organic polymers. The organic polymers include organic polymer membranes are made of organic polymers such as polysulfone (PSF), poly(ethersulfone) (PES), poly-acrylonitrile (PAN), polyamide, polyimide, poly(vinylidene fluoride) (PVDF) and polytetrafluoroethylene (PTFE). Therein, PVDF is one of the most used membrane materials and has been paid much attention by researchers and manufacturers in recent years (Liu et al., 2011; Kang and Cao., 2014). It exhibits high mechanical strength, good chemical resistance and thermal stability as well as excellent aging resistance, which are very important for the actual application of separation membranes. Moreover, PVDF shows good process ability to prepare flat sheet, hollow fiber or tubular membranes (Liu et al., 2011). Owing to the features, in first stage of this study, we assume it would appropriate to use PVDF membrane for MF so as to treat raw wastewater. Besides, of another membrane material, PES is one of the most important polymeric materials and is widely used in separation fields. PES and PES-based membranes show outstanding oxidative, thermal and hydrolytic stability as well as good mechanical property. The membranes has always asymmetric structure (Barth et all., 2000; Zhao et all., 2013). Though PES and PES-based membranes have been widely used, they have disadvantages. The main disadvantage of the membrane is related to its relatively hydrophobic character (Zhao et all., 2013). Therefore, in second stage of this study, PESH membrane having hydrophilic character was employed for wastewater treatment.

In the present study, the raw water was provided from underground hard coal mining and the total treatment performance of the MF/UF system was determined. In the total treatment performance of wastewater, total coliform, turbidity, conductivity, pH, nitrite, nitrate, phosphate, sulphate, sodium, potassium, chemical oxygen demand (COD), total suspended solids (TSS), calcium, magnesium and total hardness as parameters were analysed in raw and treated water and permeate water quality of UF membrane system was compared with Turkish Standards (TS 266) and European Union (EC) in order to assess its usability as a drinking water service or the other processes.

MATERIALS AND METHODS

Before MF/UF experiments, raw wastewater were analysed. MF and UF experiments were performed by using a cross-flow flat-sheet membrane for the filtration of the wastewater generated from underground hard coal mining. The flow sheet of the membrane filtration system was shown in figure 1 and cross flow flat sheet test unit in lab scale was shown in figure 2.

The membranes used in this work were:

1) Polivinilflorid (PVDF), hydrophobic, average pore diameter of 0.2 µm

2) Polyethersulfone (PESH), hydrophilic, MWCO 50 kDa

In the first stage of experimental studies, the wastewater generated from the underground coal mining works was treated using MF membrane filtration system. During the membrane filtration process, MF membrane system was constantly run at trans-membrane pressure (TMP) of 1 bar. In the second stage of experimental studies, the effluents of MF were treated using UF membrane filtration system. During the membrane filtration process, UF membrane system was constantly run at TMP of 2.5 bars.

In following, according to the procedure outlined in standard methods, quality parameters, which are total coliform, turbidity, conductivity, pH, nitrite, nitrate, phosphate, sulphate, sodium, potassium, COD, TSS, calcium, magnesium and total hardness, were analysed in permeates of MF and UF.

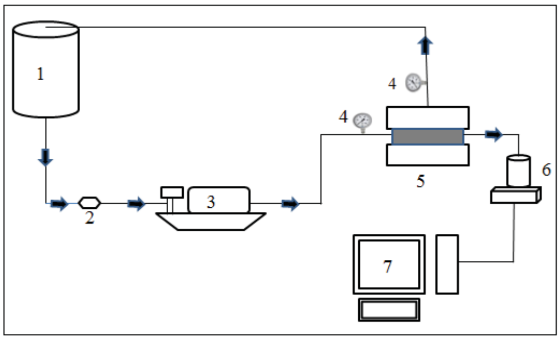

Figure 1. Laboratory scale membrane flow diagram (1. Waste water tank 2. Flow meter 3. High pressure pump 4. Manometer 6. Electric balance 7. Computer)

Figure 2. Cross flow flat sheet test unit in the lab scale

In the study, the wastewater from underground mining was operated in cross-flow batch mode. In this manner, the feed crosses the cell adjacent to the membrane surface and the permeate passes through the cell vertical to the membrane surface. In other words, the feed was pumped to the cross-flow cell from the tank and the permeate was taken out of the loop and collected in an Erlenmeyer flask and measured using an electric balance, and the retentate was completely returned to the tank. This cycle was repeated continuously. By the time the pump heated, it was needed to cool, so the feed tank was equipped with cooling water coil and heat exchanger. The cell consisted of two rectangle parts and was made of stainless steel. During the experiments, flow rate, trans membrane pressure (TMP), and temperature were carefully controlled.

RESULTS AND DISCUSSIONS

Table I shows the test results and removal efficiencies of raw and the treated water. As seen in Table I, total the removal efficiency of turbidity, TSS, phosphate, sulphate and COD were found as 99%, 65%, 80% 98% and 72%, respectively. In other words removal efficiencies of turbidity, TSS, phosphate, sulphate and COD for MF/UF system were relatively high. In the meantime, total coliform as a bacteriological parameter were not detected at the all water samples. In conclusion; according to Table I, the effluent of UF is roughly suitable for the TS 266 and (EC). However, for drinking water suitability, the other parameters such as cadmium, lead, iron, chromium, cobalt, nickel and copper must also be examined. As conclusion, this study shows that polluted water from underground hard coal mining were treated by MF/UF membrane system and may be used as drinking water.

Table 1. The test results and removal efficiencies of raw and the treated water.

Water quality parameters	Waste water from underground mining	Permeate of MF membrane system	Permeate of UF membrane system	Total removal Efficiency (%)	Turkish Standards Institute (TS 266)	European Union (EC)
T. coliform (number/100 ml)	0	0	0	0	0	0
Turbidity(NTU)	100,5	3,6	0,82	99	5	4
Conductivity (µs/cm)	1257	907	886	30	2500	2500
pH	8,06	8,54	8,68	-	6,5-9,5	6,5-9,5
Nitrite (NO2-) mg/L	0,008	0,005	0,0044	45	0,5	0,5
Nitrate (NO3-) mg/L	0,99	0,684	0,644	35	50	50
Phosphate (PO42-) mg/L	0,0038	0,0022	0,00076	80	-	-
Sulphate (SO42-) mg/L	51	1,03	0,94	98	250	250
Sodium (Na+) mg/L	173,43	176,8	184,6	-	200	200
Potassium (K+) mg/L	2,6	2,3	2,3	12	-	-
COD mg/L	56	16	16	72	-	-
TSS mg/L	17	12	6	65	-	-
TDS mg/L	624	567	511	18	-	-
Calcium (Ca2+) mg/L CaCO3	60	50	45	25	-	-
Magnesium (Mg+) mg/LCaCO3	68	62	64	6	-	-
Hardness mg/L CaCO3	128	112	109	15	500	500

CONCLUSIONS

In conclusion, the effluent of UF is suitable for the TS 266 as well as (EC). However, for drinking water suitability, the other parameters such as cadmium, lead, iron, chromium, cobalt, nickel and copper must also be examined. As conclusion, this study shows that polluted water from underground hard coal mining were treated and may be to serve as drinking water. Also, this study shows that the wastewater can be recyclable and reusable.

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