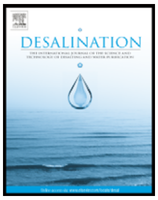
Desalination 259 (2010) 65–70

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal



Treatment of olive mill wastewaters by nanofiltration and reverse osmosis membranes

Tamer Coskun *, Eyup Debik, Neslihan Manav Demir

Yildiz Technical University Faculty of Civil Engineering, Environmental Engineering Department Esenler_Istanbul, Turkey

ARTICLE INFO

Article history:
Received 3 March 2010
Received in revised form 14 April 2010
Accepted 14 April 2010
Available online 14 May 2010

Keywords:
Centrifuging
Nanofiltration
Olive mill wastewater (OMW)
Reverse osmosis
Ultrafiltration

ABSTRACT

Treatment of olive mill wastewaters (OMW) by membrane techniques were investigated in this study. For this purpose, OMW was centrifuged, and filtered via UC010 ultrafiltration membrane followed by filtration through NP010, NP030, and NF270 nanofiltration membranes, and XLE and BW30 reverse osmosis membranes. Besides, skipping the ultrafiltration step, the centrifuged OMW was filtered through NP010 and NP030 membranes in order to evaluate the performance of the centrifuging process as a pretreatment option. For the OMW percolated through ultrafiltration membranes, the membrane fluxes reached values of up to 21.2, 5.2, 28.3, 15.5, and 12.6 L m^{-2} h^{-1} for NP010, NP030, NF270, XLE, and BW30 membranes, respectively. The maximum COD removal efficiencies obtained at 10 bars were 60.1%, 59.4% and 79.2% for NP010, NP030, and NF270 nanofiltration membranes, respectively, while they were 96.3% and 96.2% for XLE and BW30 reverse osmosis membranes, respectively. Besides, conductivity removal efficiencies obtained at 25 bars were 93.2% and 94.8% for XLE and BW30 membranes, respectively. Obtained efficiencies are higher than those obtained in the treatment of OMWs with other treatment methods. Thus, it was concluded that membrane processes are a good alternative for the treatment of OMWs. Additionally, the centrifuging process was found to be a promising pretreatment method.

1. Introduction

Olive and olive oil production is an important means of livelihood especially in the Mediterranean coasts. Global olive oil production is 2.88×10^6 tons per year in 2009 [1]. Turkey has one of the most important positions in global olive and olive oil production industry, and has the second and fourth biggest shares in global markets of olive and olive oil production, respectively [2]. Turkey produces olive on an area of 800,000 ha of olive grove with 95 million olive trees.

Olive mill wastewaters (OMWs) are generated in two-phase olive oil production processes along with olive pomace or in three-phase olive oil production processes alone. OMW generation in Mediterranean countries is over 3.0×10^7 m^3 annually [3].

Treatment of OMWs is of great importance and very difficult due to the high organic, phenol, fatty acids, and suspended solids content. It was stated, in previous studies, that biochemical oxygen demand (BOD) of OMWs range from 15,000 to 135,000 mg L^{-1}, while chemical oxygen demand (COD), suspended solids (SS), and pH are between 37,000 and 318,000, 6000 and 69,000 mg L^{-1}, and 4.6 and 5.8, respectively [4–7]. The production process, being batch or continuous, has a great effect on the characteristics of OMWs. Stronger wastewaters are generated in batch processes than in continuous ones due to the lower water consumption.

Due to the above-mentioned properties, OMWs possess great environmental impacts. Besides, olive and olive oil producers suffer from inefficient treatment techniques for OMWs. Anaerobic treatment [8–10], fenton and electrofenton processes [9,11,12], chemical precipitation [12–14], and electrocoagulation process [15–18] were used in previous studies. However, previous research has shown that none of these treatment processes alone offer sufficient treatment efficiencies. Besides, there are no processes for the treatment of OMWs that are accepted and used widely.

Membrane processes have recently become a great topic of research due to their applicability in wastewater treatment. Decreasing costs of installation and operation of membranes favored the use of membrane processes. Of the membrane processes, microfiltration and ultrafiltration are used mainly for primary treatment purposes while nanofiltration and reverse osmosis are used for final treatment. Specifically, reverse osmosis membranes offer so high treatment efficiencies that they are used in a wide range of applications including recovery of materials from industrial wastewaters and treatment of sea water for drinking purposes.

Final treatment of OMWs by membrane processes has not been widely accepted, yet; and limited number of research papers has been published up to date. This study focuses on the investigation of the performance of nanofiltration and reverse osmosis processes in the treatment of OMWs pretreated by centrifuging and ultrafiltration

---

* Corresponding author. Tel.: +90 212 383 5379; fax: +90 212 383 5358.
E-mail addresses: tcoskun@yildiz.edu.tr (T. Coskun), debik@yildiz.edu.tr (E. Debik), nmanav@yildiz.edu.tr (N.M. Demir).

0011-9164/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.desal.2010.04.034

Table 1
OMW characteristics.

Parameter	Value
pH	4.6 ± 0.2
Conductivity (mScm^{-1})	5.3 ± 0.2
Turbidity (FAU)	5,111 ± 468
TS (g L^{-1})	24.8 ± 0.5
VS (g L^{-1})	20.2 ± 0.4
TSS (g L^{-1})	6.8 ± 0.7
VSS (g L^{-1})	6.6 ± 0.6
COD (g L^{-1})	40.3 ± 1.0
Soluble COD (g L^{-1})	30.0 ± 0.9
TOC (g L^{-1})	12.9 ± 0.5
TN (g L^{-1})	0.24 ± 0.05
Oil and grease (g L^{-1})	4.2 ± 1.0

processes. Since available literature does not cover the use centrifuging as a primary treatment option, the results from the current study were used to evaluate its performance as a primary treatment step in OMW purification.

2. Materials and methods

2.1. Characterization of the OMW

The wastewater was obtained from a continuous olive-oil producing process (Milas area of Turkey). The characteristics of the raw wastewater are given in Table 1.

Total solids (TS), volatile solids (VS), total suspended solids (TSS), volatile suspended solids (VSS), chemical oxygen demand (COD), soluble COD, oil and grease were determined according to the Standard Methods [19]. Total organic carbon (TOC) and total nitrogen (TN) analyses were performed by the Hach Lange IL 550 TOC-TN analyzer.

2.2. Centrifuging process

Centrifuging process was used for primary treatment of the OMW. Beckman Coulter Allegra X-12 centrifuge was used for centrifuging the wastewater for 30 min. at 3750 rpm. COD, TSS, and conductivity of the centrifuged wastewater were measured.

2.3. Membrane processes

The membrane system was supplied from Osmonics® Inc, which was GE SepaTM CF2 membrane cell. The concentrate stream was flowed back to feed vessel while permeate stream was being collected separately as shown in Fig 1. A cartridge filter (10 µm pore size) was used as a prefilter to remove coarse particulates from wastewaters before membrane cell. All membrane experiments were performed at 25 °C with a heat exchanger which is in the feed vessel.

An ultrafiltration membrane (UC010), three distinct types of nanofiltration membranes (NP010, NP030, and NF270), and two distinct types of reverse osmosis membranes (BW30 and XLE) were used in this study. Properties of these membranes are shown in Table 2. The operating pressures were 2 bars for ultrafiltration, 4, 6, 8, and 10 for nanofiltration, and 10, 15, 20, and 25 bars for reverse osmosis.

Prior to application to nanofiltration and reverse osmosis membranes, the OMW was centrifuged and filtered by ultrafiltration membrane. In addition, NP010 and NP030 membranes were used to filter centrifuged wastewater in order to investigate the performance of the centrifuging process alone as a primary treatment option.

After nanofiltration and reverse osmosis processes, COD and conductivity are measured in the treated wastewater. Besides, membrane fluxes in each process were calculated by monitoring permeate flowrates once in a minute.

3. Results and discussion

3.1. Centrifuging and ultrafiltration processes

The change in COD and conductivity of the OMW after centrifuging and ultrafiltration processes is summarized in Table 3.

It is obvious in Table 3 that the primary treatment processes do not affect conductivity values of the wastewater since both of these processes are incapable of removing dissolved solids. However, as a result of particulate separation, COD removal efficiencies of 30.5% and 36.8% were achieved by centrifuging and ultrafiltration processes, respectively. The combined COD removal efficiency of these two

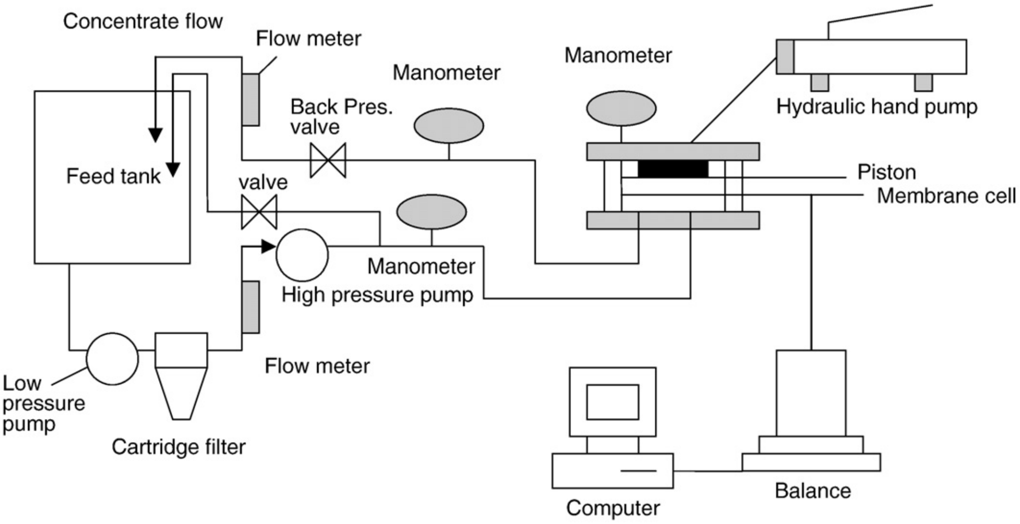


Fig. 1. Schematic diagram of membrane process (adapted from [20]).