Economic study of the treatment of surface water by small ultrafiltration units

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Abstract

The purpose of this work is to evaluate the possibility of utilising an ultrafiltration process for the treatment of water from the dam in the Kabylia region of Algeria and, in particular, for the provision of drinking water to people living in dispersed small villages. The water quality was determined by measuring turbidity, and natural organic matter concentration. The results obtained with an ultrafiltration process indicate that this technique can considerably reduce suspended and organic matter. It also improves the bacteriological quality of the treated water. An economic evaluation for ultrafiltration of surface water is presented. The economic study was performed for a drinking water unit of 20 m^3/h . It was found that the cost per m^3 of treated water ($ 0.235/m^3) obtained would not be excessively high for the states of the North African region.

Notation

J_v	Permeate flux ($\ell/h \cdot m^2$)
OD_c	Optic density of the concentrate solution
OD_p	Optic density of the permeate solution
P_o	Oulet membrane pressure (Pa)
P_1	Inlet membrane pressure (Pa)
R_{OD}	Experimental apparent rejection coefficient based on optic density (%)
R_{Tur}	Experimental apparent rejection coefficient based on turbidity (%)
T	Temperature (°C)
Tur_c	Turbidity of the concentrate solution (NTU)
Tur_p	Turbidity of the permeate solution (NTU)
U	Tangential velocity (m/s)
UF	Ultrafiltration process
DP	Average transmembrane pressure (Pa)

Introduction

Access to water as a natural resource is a serious problem in the North African region. The treatment of water before distribution to people is essential in order to maintain quality of life. The North African population is increasing and the greatest rate of future growth will be in cities. Governments in this region use the full extent of economic capacity and current knowledge to develop acceptable urban environments and an efficient water supply. Lower priority is given to supplying water to small villages dispersed in the North African region. The long distances between the water reservoirs and these villages, as well as the tropical temperature of this region, necessitate a chlorine disinfection process which, as result of the presence of natural organic matter (NOM) in the raw water, may lead to the formation of carcinogenic by-products. Furthermore, the digestible organic carbon present in NOM leads to a potential for bacterial regrowth in distribution systems (Lin et al., 2000).

The required conformity to microbiological standards for drinking water cannot be guaranteed cost-effectively by conventional technologies (Brugger, 2000). Membrane technology has been utilised to solve this problem, and the efficiency of this process has made it possible to increase the quantity and the quality of drinking water distributed to the rural population (Lin et al., 2000; Jolis et al., 1999 and Yuasa, 1998, Magara et al., 1998; Brahiti et al., 1994, Anselme et al., 1992, Tazi-Pain et al., 1992; Bersillon et al., 1989).

The main purpose of this work was to investigate the operation and efficiency of ultrafiltration in the treatment of surface water to drinking water standards for supply to small villages of the Kabylia region, with populations not exceeding 3 000. In the present study, an organic ultrafiltration membrane was used to treat surface water collected from the Keddara Dam under various experimental conditions. The effect of average transmembrane pressure (*P*) and tangential flow rate (*U*) on the performance of ultrafiltration membranes was measured. Raw water was treated by ultrafiltration under optimal conditions (tangential velocity and average transmembrane pressure), and an economic study of the membrane process was conducted.

Materials and methods

The main physico-chemical characteristics of Keddara Dam water are presented in Table 1. The water quality was determined by measuring the following parameters (Lefebvre, 1995): pH (WTW, model 1223), conductivity (TOA model CM-8ET), turbidity (HACH, model 2100A) and optic density at 254 nm and 270 nm (MILTON ROY UV/Vis spectrophotometer, model Spectronic 1201). The latter two determinants express values for suspended matter and dissolved organic matter in the raw water. The bacteriological quality of the water is evaluated by determining biological cell counts by the spread-plate method (ASM, 1987).

Ultrafiltration experiments were performed using the Microlab 130 S pilot unit made by Gamma Filtration, France. It was equipped with an organic Patterson Candy International (PCI-BX6) membrane with a molecular mass cut-off of 20 kDa. The PCI module was composed of 18 tubular polysulfone membranes with a length of

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