Available online at www.sciencedirect.com
ScienceDirect
Desalination 220 (2008) 123–131
DESALINATION
www.elsevier.com/locate/desal

Cost analysis of seawater desalination with reverse osmosis in Turkey

Demet Akgul[a], Mehmet Çakmakcı[b], Necati Kayaalp[c], Ismail Koyuncu[c]*

[a]GE Infrastructure Water and Process Technologies, Istanbul, Turkey
[b]Zonguldak Karaelmas University, Environmental Engineering Department, 67100 Zonguldak, Turkey
[c]Istanbul Technical University, Environmental Engineering Department, 34469 Istanbul, Turkey
Tel. +90 212 285 3789; Fax +90 212 285 3781; email: koyuncu@itu.edu.tr

Received 24 December 2006; accepted 3 January 2007

Abstract

Economically usable water resources per capita are decreasing due to excessive population increase each year in Turkey. For this reason, new water resources should be found in the near future. The potential water resources are seawater or well water both of which need removal of salinity. The most promising treatment method for salinity is reverse osmosis. While reverse osmosis becomes widespread, the cost of the process will decrease. There is no detailed information about cost of seawater desalination in Turkey. In this study, a cost analysis of seawater desalination in Turkey was performed for reverse osmosis systems. The basic parameters of cost analysis such as capacity, recovery, membrane life, energy, chemical costs and flux were evaluated based on the effects on capital, operating and total production costs.

Keywords: Desalination; Reverse osmosis; Operating parameters; Unit costs

1. Introduction

Usable water potential of Turkey is $205 \cdot 10^9$ m^3 and $110 \cdot 10^9$ m^3 of this water is economically utilizable. This means that 3150 m^3 of water is available per capita per year in Turkey which has a population of 65 million currently. When economically utilizable part of the potential water is considered, this becomes 1735 m^3 per capita per year [1]. It is assumed that a state which is wealthy regarding its water resources have to possess a water potential of 10,000 m^3 per capita per year. States having 1000–2000 m^3 of water potential per capita per year is considered in water stress, and those having below 1000 m^3 of water potential per capita per year is considered at water scarcity.

According to this categorization, Turkey which has 1735 m^3 of water per capita per year can be considered as a state in water stress. Moreover

*Corresponding author.

Presented at the conference on Desalination and the Environment. Sponsored by the European Desalination Society and Center for Research and Technology Hellas (CERTH), Sani Resort, Halkidiki, Greece, April 22–25, 2007.

0011-9164/08/$– See front matter
doi:10.1016/j.desal.2007.01.027

according to population projection made for 2025, population is expected to become 79 million. When future population of Turkey is taken into consideration, utilizable water potential per capita per year decreases below 1300 m^3. This value is valid in case of no decrease in utilizable water potential in the future [1].

For this reason, alternative solutions for water supply should be found for these regions. The most permanent and reliable solution between alternatives for drinking water production is to treat ground water or seawater if the area is close to the sea. Best preferable method in consumption of chemical and energy, and salt removing range is membrane processes.

Wide spreading of membrane processes in Turkey as drinking water production has been after year 2000, mainly with the start of local system productions. However, no serious cost analysis has been done until today. It is thought that seawater desalination is very expensive technique. With a detailed cost analysis, useful datas for economical point of view will be met in the conception and selection of these systems that are being produced and used more and more each day [2].

The purpose of this study is to make a cost analysis of seawater desalination in Turkey for reverse osmosis systems. Three seawater qualities were used for the conception of the systems whose cost analysis was performed. For each water quality, too many calculations were performed with 5 different capacities, 3 recovery rates, 3 membrane life's, 4 different energy costs, 3 different chemical costs and 3 different fluxes. Investment costs, operating costs and total production costs of the systems were analyzed and evaluated for three different sea water compositions. Investment, operating and total production costs of the systems were calculated. Besides, the effects of different priced consumption materials on operating and total production costs were determined. The effect of standard pre-treatment group on unit production costs were also researched during the study.

2. Methods

In this study, different designs were made using seawater reverse osmosis membranes. The effect of capacity, flux, feed water quality, recovery, pre-treatment, energy and chemicals usage were analyzed in these designs. Designed systems were evaluated regarding both capital and operating costs. The water sample analyses were taken from General Electric W&PT Haasrode-Belgium laboratory, Kimser Analysis laboratory and water treatment companies [2].

Seawater reverse osmosis membrane (SWHR-380, Filmtec Corporation) and reverse osmosis system analysis programme ROSA 6.0 were used in the designs made in this study.

Three seawater having different qualities were used. These seawaters were taken from the Mediterranean Sea, the Marmara Sea and the Black Sea. Geographic location of these seas can be seen from Fig. 1 and the water quality parameters of these seawaters are given in Table 1.

Different membrane process designs were performed for each water quality using five capacities (250, 1000, 2000, 5000, 10,000 m^3/day), three recovery rates (30%, 35%, 40%) and three fluxes (19.8 L/m^2 h, 14.2 L/m^2 h, 11.3 L/m^2 h). Recovery rates are selected according to the interval where system performance of seawater is maximum. Since the generally recovery interval used for seawater is 30–40%, it is also used in this study. Likewise fluxes used in design are also those providing maximum performances practically.

Due to deterioration in their performance, reverse osmosis membranes are replaced over 3 to 5 years. For this reason, three different membrane lifes changing as 3, 4 and 5 years were used. Energy prices can be various at different places. General energy price is 6 cent/kWh for house usage. The price in industry is 8–9 cent/kWh. The energy prices ranging between 6–9 cent/kWh were used in cost calculations. Six cent/kWh was used as a general value where a specific price does not mentioned.