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Performance evaluation of BWRO desalination plant — A case study

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Abstract

Fouling and scaling are the most serious problems in membrane processes. In sea/brackish water applications, pretreatment of RO feed water is the key step in designing the plants to avoid membrane fouling and scaling. Recent developments in pretreatment processes are more adapted to raw water quality. But, in some cases, raw water quantity/quality varies during seasons and is also influenced by the environment. Thus, pretreatment design becomes complicated and should cope with the raw water quality changes. The success of such operation requires qualified operators who will be able to adapt with different situations. Surface and brackish water sources are mostly facing these problems. In this paper, performance evaluation carried out for a brackish water reverse osmosis (BWRO) plant located in the west of Algeria is presented. This plant showed poor performance after a few months of operation. The operating pressure and pressure drop increased significantly without an increase in the production capacity and the permeate conductivity decreased surprisingly. Frequent shutdowns of the plant were observed due to severe membrane fouling. To identify the causes for the poor performance, different investigations were carried out. Membrane autopsy was performed and chemical analyses of foulants on the membrane surface by scanning electron microscopy were carried out to identify the matters responsible for fouling. The results showed that the quality of raw water changed widely due to drying of some wells and decrease of the water level in other wells. RO membranes were fouled by inorganic matters mainly colloidal/particulate silica and fine particles of clay present in raw water. Thus, the pretreatment scheme was thoroughly reviewed to find out why suspended solids were not removed by the sand and cartridge filters even though SDI was always less than 1. The problem was resolved by injecting a coagulant before the sand filters.

Keywords: BWRO; Pretreatment; Fouling; Membrane autopsy; Performance improvement

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1. Introduction

Algeria has for decades relied on rainfall for the water policy and strategy, but that proved to be not an adequate solution considering the actual water deficit. The water need for different sectors is increasing and this will worsen since it is projected that population will double in the next 20 years. The use of non conventional solutions, mainly seawater and brackish water desalination, becomes an imperative and inevitable solution to supply fresh water. Many important desalination projects are launched with a target to produce about 2 million m^3/d by 2009.

Due to recent developments in membrane technology, the trend in the desalination industry is to use reverse osmosis (RO) for desalting seawater. Brackish water desalination using membrane technology is also expanding as the salinity of groundwater is increasing. Selecting an appropriate process to meet specific needs at specific locations is essential though the biggest challenge remains in the capability to successfully operate these plants once installed due to peculiarities of sea and brackish waters in the region.

Due to the worsened situation in the last few years to supply potable water in some areas where the dams were almost dry, the Algerian government took an urgent decision to build quickly several small-scale SWRO and BWRO plants with a total capacity of about 70,000 m^3/d to cater the water needs in these regions. One of these plants is investigated in this study. It is a BWRO desalination plant located in the west of Algeria built in the last quarter of 2004 with a designed capacity of 24,400 m^3/d. The objective of this paper is to study the performance of the plant and identify the causes of severe membrane fouling.

The most serious problem in BWRO plants operation is the complexity to control membrane fouling and scaling mainly due to frequent variation of quantity/quality of raw water. As a consequence, the plant's efficiency will decrease due to the increase of pressure drop thus decrease of the flux, increase of operational cost by increasing the energy consumption, additional chemical use and reduce the membranes lifetime. Therefore, pretreatment steps should be adapted to avoid membrane fouling and scaling due to feed water quality changes. In this study, the first step was to investigate the type of fouling and then the foulants responsible for membrane clogging.

2. Plant description

2.1. Raw water characteristics

The raw water coming from five wells contains ca. 7 g/l total dissolved solids, predominantly chloride and sodium ions. The feed salinity varies during the seasons but never exceeds 10 g/l. The increase in the salinity represents only dissolved salts. Iron and manganese concentrations remain constant. The feed water temperature is almost constant in all seasons — 25ºC. Raw water analysis is presented in Table 1.

Table 1
Raw water composition

Ca^{++}, mg/l	432
Mg^{++}, mg/l	243
Na^{+} (calculated), mg/l	1616.11
K^{+}, mg/l	24
Mn^{++}, mg/l	0.51
Fe^{++}, mg/l	0.05
SiO_2, mg/l	25.33
HCO_3, mg/l	597
Cl^{-}, mg/l	2811.60
SO_4^{2-}, mg/l	1110
NO_3^{-}, mg/l	22.9
F^{-}, mg/l	0.13
SDI	5.83
pH	6.51
Turbidity, NTU	1.48
Temperature, ºC	25
Conductivity, μS/cm	9990
TDS, mg/l	6882.63