Ain Shams University
Faculty of Science

Synthesis of Nano Enhanced Reverse Osmosis Membrane for Desalination of Saline Groundwater in Sharm El Sheikh, South Sinia, Egypt

A Thesis Submitted by

Heba Ibrahim Mohamed Ragab Isawi

(M.Sc., organic Chemistry 2008)

For the Degree of
Doctor of Philosophy in Science
(Chemistry)

Department of Chemistry
Faculty of Science
Ain Shams University

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DATE OF EXAMINATION: / /2016

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ABSTRACT

The Sharm El-Sheikh area is one of the most attractive touristic resorts in Egypt and in the world in general. The Sharm El-Shiekh area is located at the arid region of the South Sinai Peninsula, Egypt. Water desalination is considered the main freshwater supply for hotels and resorts. Scarcity of rainfall during the last decades, high pumping rates, disposal of reject brine water back into the aquifer, and seawater intrusion have resulted in the degradation of groundwater quality in the main aquifer. Water chemistry, stable isotopes, Seawater Mixing Index (SWMI), and factorial analyses were utilized to determine the main recharge and salinization sources as well as to estimate the mixing ratios between different end members affecting groundwater salinity in the aquifer. The groundwater of the Miocene aquifer is classified into two groups: group I represents 10 % of the total samples, has a moderately high saline groundwater, and is mostly affected by seawater intrusion. Group II represents 90 % of the total samples and has a high groundwater salinity due to the anthropological impact of the reject brine saline water deeper into the Miocene aquifer. The main groundwater recharge comes from the western watershed mountain and the elevated plateau while the seawater and reject brine are considering the main sources for groundwater salinization. The mixing ratios between groundwater recharge, seawater, and reject brine water were calculated using water chemistry and isotopes. The calculated mixing ratios of group I range between 25 and 84 % recharge groundwater to 75 and 16 % seawater, respectively, in groundwater located close to the western watershed mountain indicating further extension of seawater intrusion. However, the mixing percentages of group II range between 21 and 88 % reject brine water to 79 and 12 % seawater, respectively, in groundwater located close to the desalination plants. The outcomes and conclusion of this study highlight the importance of groundwater management to limit further groundwater deterioration of the Miocene groundwater aquifer and limit seawater intrusion along the coast.

Water desalination using reverse osmosis membrane is crucial and could be considered as the only source for sustainable fresh and potable water in the area. Therefore, a new approach for modification of polyamid thin film composite membrane PA(TFC) using synthesized ZnO nanoparticles (ZnO NPs) was shown to enhance the membrane performances for reverse osmosis water desalination. First, active layer of synthesis PA(TFC) membrane was activated with an aqueous solution of free radical graft polymerization of hydrophilic methacrylic acid (MAA) monomer onto the surface of the PA(TFC) membrane resulting PMAA-g-PA(TFC). Second, the PA(TFC) membrane has been developed by incorporation of ZnO NPs into the MAA grafting solution resulting the ZnO NPs modified PMAA-g-PA(TFC) membrane. The surface properties of the synthesized nanoparticles and prepared membranes were investigated using the FTIR, XRD and SEM. Morphology studies demonstrated that ZnO NPs have been successfully incorporated into the active grafting layer over PA(TFC) composite membranes. The zinc leaching from the ZnO NPs modified PMAA-g-PA(TFC) was minimal, as shown by batch tests that indicated stabilization of the ZnO NPs on the membrane surfaces. Compared with the a pure PA(TFC)and PMAA-g-PA(TFC) membranes, the ZnO NPs modified PMAA-g-PA(TFC) was more hydrophilic, with an improved water contact angle ($50 \pm 3^{\circ}$) over the PMAA-g-PA(TFC) ($63 \pm 2.5^{\circ}$). The ZnO NPs modified PMAA-g-PA(TFC) membrane showed salt rejection of 97% (of the total groundwater salinity), 99% of dissolved bivalent ions (Ca^{2+}, $SO_4^{2-}$and Mg^{2+}), and 98% of mono valent ions constituents ($Cl^{-}$and Na^{+}). In addition, antifouling performance of the membranes was determined using E. coli as a potential foulant. This demonstrates that the ZnO NPs modified PMAA-g-PA(TFC) membrane can significantly improve the membrane performances and was favorable to enhance the selectivity, permeability, water flux, mechanical properties and the bio-antifouling properties of the membranes for water desalination.

Keywords: Hydrogeochemistry, Isotopes, Seawater intrusion, Reject brine water, Seawater Mixing Index, Factorial analysis, Sharm El-Shiekh, ZnO nanoparticles, Desalination, Grafting, Antifouling, Morphology, Reverse Osmosis.

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Heba Isawi

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