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Full Length Research Paper

Comparative Approach for Desalination of Brackish Water Using low pressure Nanofiltration membranes

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Nanofiltration membranes were tested using a widely common lab scale dead-end filtration system. Two commercial NF membranes, denoted as NF1 and NF2 were tested on pressure range (6-12) bars. The water samples used were real samples collected from BaniSuhaila well in Khan Yuonis as a representative ground water sample in Gaza strip, Palestine. The tested parameters were: Salt rejection (TDS), Nitrate removal(NO_3), Flux rate (L/m^2.hr), permeability (L/m^2.hr.bar) and Flux recovery rate. Following our lab work results, we may conclud that Nanofiltration membranes for desalting water are potentially suitable for brackish desalination in Gaza Strip due to: reasonable salt rejection, (up to 51%) for NF1 membrane at relatively low operating pressure of 12 bar attributing to energy consumption reduction as well as cost effective compared to the current used technology of RO membranes. Therefore, NF technology can be considered as standalone technology for brackish desalination in Gaza. Such advantage may also attribute to desalination trends developing in Gaza Strip. Reasonable flux rate with lower salt rejection were obtained for NF2. This may allow this membrane to be applied as pre-treatment process for RO membranes used in desalination plants in Gaza Strip attributing to scaling reduction and increasing of desalination efficiency. A relationship were build according to result between pressure and flux rate indicating that 2 bar increasing of pressure led to increase the flux by (25-39) percent on NF2 membrane and (21-39) percent on NF1 membrane using real samples, that will help the operator to efficiently operate desalination system using this technique.

Keywords: Desalination, Brackish Water, Low pressure Nanofiltration membranes.

INTRODUCTION

Water scarcity continues to challenge population around the world, especially those living in areas that considered as arid or semi-arid regions like Middle East. As part of this region, Gaza Strip suffers from water scarcity, as the reliable water source in Gaza Strip for domestic, agricultural and industrial supply is the ground water presented in coastal aquifer. This aquifer, however,

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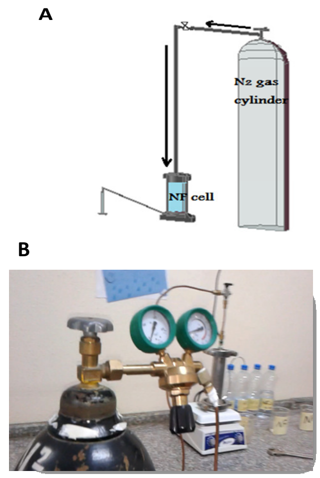


Fig. 1.A)Schematic diagram B)Experimental set-up

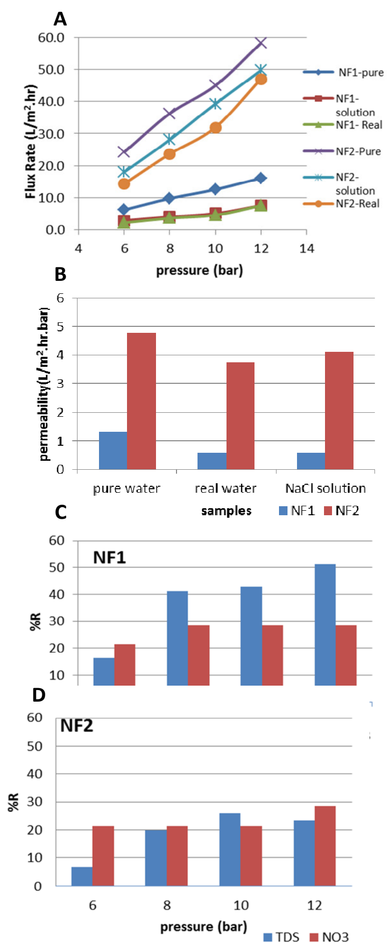


Figure 3.3. A) flux rate of NF1 & NF2 for all samples B) permeability of NF1 & NF2 for all samples C) TDS & NO3 rejection of NF1 for real sample D) TDS & NO3 rejection of NF2 for real sample E) TDS rejection ofNF1 & NF2 for 2000 ppm solution.

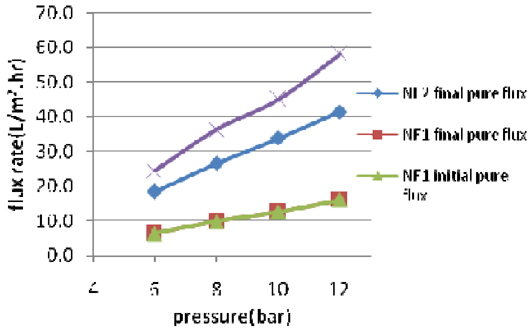
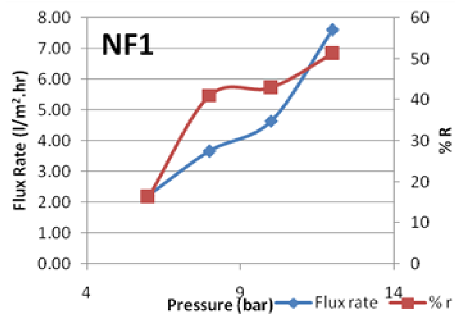


Figure 3.4. change in Flux rate of NF1 and NF2.

A



B

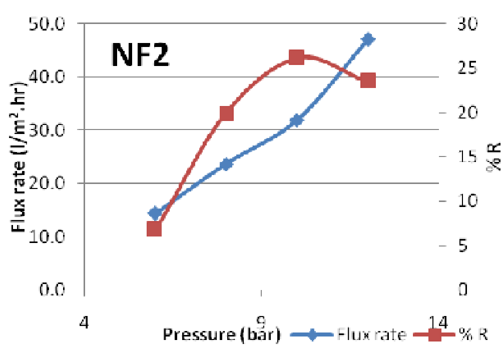


Figure 4. A) Operation diagram for NF1 B) Operation diagram for NF2.

Figure 3.5. A) Operation diagram for NFI B Operation Diagram for NF2

suffers from rapid deterioration due over pumping that leads mostly to aquifer exhausting and sea intrusion. In such situation, salinity is rapidly increasing as well as Nitrate concentrations increasing due to excessive use of fertilizers, mainly in agricultural activities, and lack of sewage collection and treatment.

Desalination is a considerable alternative for water supply in order to alleviate the stress on the aquifer and to improve the quality of water in the area. So, desalination plants began to be established in Gaza strip using RO technique. The shortage of energy source become a big constrain facing desalination plants of which these plants are operating at limited operational hours.

The need to find more choices to develop water sector in Gaza Strip become an essential priority. Thinking of innovative actions for desalination sector needs balance and acceptable decisions. The study aims to find the best available choices which suit Gaza groundwater characteristics and conditions of the country. Within this framework, set of tests were carried out to examine NF membrane performance with Gaza water characteristics in order to know the possibility of applying this technology in Gaza Strip.

Experiments conducting

Material

Two commercial Membrane denoted as NF1 and NF2 purchased from Amfor Inc., China,were tested in a dead-end lab scale filtration system. The system consists ofHP4750 stainless cylindrical cell purchased from Steirlitech - UK with volume of 300mL. The cell is pressurized via Nitrogen Gas supplied by Gas cylinder with a manual pressure regulator. The experiments are conducted at room temperatureand at pressure range of (6 – 12) bars.

Sampling

The filtration experiments were carried out on different samples:
1)Pure sample: deionized water with EC=7µS/cm 2)Synthesis standard solution: 2000 ppm as NaCl solution 3)Real sample: the real sample was taken from Banisuhila well as a presentative sample of Gaza's water characteristic after pretreatment units; with 2360 ppm TDS & 61.6 ppm NO_3.

Tested parameter

The tested parameter were:
1)Flux rate: represents the volume of liquid passing through specific area of the membrane at certain operating pressure during a period of time, using the following formula:
Flux rate = V/A.t (l/m^2.hr)
Where; V: volume of water(L)permeated at the time (t)
A: surface area of membrane (0.00146 m^2),t: time of filtration(hr).
2) Permeability: is defined as the slope of flux rate versus pressure.
Permeability= V/A.t.ρ (l/m^2.hr.bar)
Where; ρ: pressure(bar).
3) Rejection: represent the ability of membrane to reject salts and impurities from feed water. The ability of membrane to reject TDS & NO_3 was measured using the following equation:
$\%R= (1-C_p/C_f)*100$
Where;C_p: salt concentration in permeate(mg/l).
C_f: salt concentration in feed water(mg/l).
4)Flux recovery rate: measures the ratio of treated water to feed water and used to describe the membrane performance. as there is no out for concentrate in our lab-scale system, the flux recovery rate will be measured as indication of recovery rate.The following equations were used in calculating the flux recovery rate.
$\%R(recovery)=(J_0-J)/J_0*100$
Where;J_0: initial pure water flux(l/m^2.hr).J: pure water flux after real sample filtration(l/m^2.hr).

RESULTS AND DISCUSSION

These results illustrate the desalination performance of the two Nanofiltration membranes used (NF1 and NF2).

Flux Rate Results

The difference of flux Rate between samples on NF1 &NF2 membrane tends the same trend (pure>solution>real) on flux Rate but on different ranges summarized by flux Rate of NF2> NF1membrane.
As the water contains more salts or other substances the flux rate decreases, at this pattern the membrane performance, so the pure flux was higher than real flux. Also complexity of water character play a good role in membrane behavior and that is why the NaCl solution flux rate is higher than real water flux rate as illustrated in the Figure2. A.

Permeability

The membranes behave with the same pattern of flux rate. As illustrate in Figure2. B, NF2 has higher permeability than NF1, As the feed water characterized by complex characteristics, the membrane permeability may negatively be affected.

Rejection

TDS removal was varied as pressure changed whereas NO3 slightly affected with pressure change. For NF1 membrane, TDS rejection increased with pressure while Nitrate rejection seemed to be consistently the same as shown in Figure 2.C. For NF2 membrane, TDS rejection increased between 6 and 10 bar before slightly decreased at 12 bar. In addition, Nitrate removal by NF2 was slightly the same except for 12 bar pressure which witnessed the highest Nitrate rejection as shown in Figure 2. D. Generally, NF1 membrane reported higher TDS and Nitrate over NF2 membrane. Figure 3.3. E. shown the performance of NF1 & NF2 in term of TDS rejection for 2000 ppm solution.

Flux recovery rate

Flux recovery rate was measured at pressure 12bar for NF1 and NF2. The Figure 3.4. illustrates the change of flux rate after operating for 8-9hrs.

Operational diagram

An operation diagram was concluded as shown in Figure 3.5. A and Bto determine the best use of the two type of NF membrane as it shows the performance with different operating pressure, also it can help the operator to easily know the related flux and rejection of the system by only choosing pressure value.

CONCLUSION

The importance of testing Nanofiltration technology in Gaza strip is to improve the overall desalination quality with acceptable cost; Carrying out tests helps to understand the behavior of NF1 & NF2 membrane The tests were carried out using different samples: pure, real and synthetic solution in order to understand the membrane behavior, the focus was on the real sample because it's the goal on the desalination plant. And at low presser Rang [6, 12] Bar; to find the optimal presser that will achieve our aim to save energy and minimize operational cost . The difference of flux Rate between samples on NF1 &NF2 membrane tends the same trend (pure>solution>real) on flux Rate but on different ranges summarized by flux Rate of NF2> NF1membrane About NF1 membrane the tests on Real samples shows good result of removing TDS which was 51.2% at operation pressure 12 bar , under this pressure the flux Rate was 7.6 L/m^2.sec; which is not encouraging; so this pressure is the optimum for NF1 membrane NF2 membrane tests using the same real sample shows 23.4% removal efficiency of TDS at 12 Bar and 20% removal at 10 Bar, and relatively high flux rate 47 L/m^2.sec at 12 Bar and 31.9 L/m^2.sec at 10 bar which considered as unreasonable difference, so the optimal presser of NF2 is 10 Bar which will save power and minimize cost . According to the result; 2 Bar increasing of pressure led to [1.3- 1.7] increase on flux of real sample.

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REFERENCES

Abuhabib AA, Mohammad AW, Rakmi Abd. Rahman (2011).. Potential of Nanofiltration for Brackish Water Desalination in Gaza Strip, journal of advanced research materials, 2011.

Schäfer AI, Fane AG, Thomas D. Waite (2005). Nanofiltration principle and applications, Elsevier Advanced Technology, 2005.

Ahmed A, Robert W. Lovitt (2007). Fouling strategies and the cleaning system of NF membranes and factors affecting cleaning efficiency, Journal of Membrane Science 303 (2007) 4–28.

Andrea I, Nikolaos A, Anastasios JK, Eric MVH, Rene S, Marianne N (2004). Fouling in Nanofiltration(chapter 8), Elsevier(2004).

Van der Bruggen B, M. M¨anttari, Nystr¨om M (2008). Drawbacks of applying nanofiltration and how to avoid them: A review, Separation and Purification Technology 63 (2008) 251–263.

Cleaning and Disinfection Procedures for FILMTEC™ NF200 and NF270 Elements, DOW,http://www.filmtec.com, April, 2012.

EPA, membrane filtration guidance manual, 2005.

Executive Summary Of the strategy for water sector in Palestine, PWA, 2013 -2011.

Gaza water status and strategic future plan, CMWU, 2009.

Hanane DACH, comparison of nanofiltration (NF) and reverse osmosis (RO) processes for the treatment of brackish water feeds, the university of Angers, 2008.

Husam B (2009). Desalination status in the Gaza Strip and its environmental impact, Desalination, 196 (2006) 1–12.

Jørgen W (2001). B. Sc. Chem. Eng, Membrane Filtration Handbook Practical Tips and Hints, Osmonics, Inc(2001).

Khaled W, Raja BA, Loubna F, Francis Q, Pascal J (2007). Brackish groundwater treatment by nanofiltration, reverse osmosis and electrodialysis in Tunisia: performance and cost comparison, Desalination 207 (2007) 95–106.

Laukokkeong (2007). feed spacer of spiral wound membrane module for anofiltration and reverse osmosis: modeling, simulation and design, 2007.

Pontié M, Dach H, Leparc J, Hafsi M, Lhassani A (2008). Novel approach combining physico-chemical characterizations and mass transfer modelling of nanofiltration and low pressure reverse osmosis membranes for brackish water desalination intensification, Desalination 221 (2008) 174–191.

Maryam AA, Gholam Reza NB, Behnam H (2011). Nanofiltration Efficiency in Nitrate Removal from Groundwater: A Semi-Industrial Case Study, TarbiatMoallem University, 2011.

Ranjan Sharma (2012). Membrane Filtration, , http://www.OzScientific.com, April, 2012.

Menachem E (2006). Mechanisms of Organic Fouling and Chemical Cleaning of RO/NF Membranes, Department of Chemical Engineering Environmental Engineering Program, Yale University, 2006.

Monthly informative report about the situation of Humanitarian in Gaza Strip, Organization of the Islamic Conference ,April 2011.

Mousa SM, Salem G (2010). Performance evaluation of reverse osmosis desalination plant: A case study of WadiMa'in, Zara and Mujib Plant, Desalination 14 (2010) 265–272.

Peter S. Cartwright, P.E., (2003). CWS-VI, Nanofiltration when it works for the whole house, Water Conditioning & Purification (2003).

Report on the planned sectorial, Water and sanitation sector, Ministry of Planning, 2010-2020.

Riina Liikanen, Jukka Yli-Kuivila, Risto Laukkanen (2002). Efficiency of various chemical cleanings for nanofiltration membrane fouled by conventionally-treated surface water, Journal of Membrane Science 195 (2002) 265–276.

RiinaLiikanen (2006). Nanofiltration as a refining phase in surface water treatment, Helsinki University of Technology Laboratory of Water and Wastewater Engineering Espoo 2006.

Sara Z, Mojtaba F, Abdollah RM (2009). The Potential Use of Nanofilters to Supply Potable Water in Persian Gulf and Oman Sea

Watershed Basin, World Academy of Science, Engineering and Technology 49 2009.