IUG Journal of Natural and Engineering Studies **Vol 22, No 2, 2014, pp 45-60, ISSN 1726-6807**
Peer-reviewed Journal of Islamic University-Gaza **IUGNES**

Optimal Use of Nanofiltration for Nitrate Removal from Gaza Strip Municipal Wells

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Received on (22-10-2013) Accepted on (3-5-2014)

Abstract

Due to excessive usage of nitrate fertilizer in agriculture and discharging of wastewater from treatment plants, and leakage of wastewater form cesspools, nitrate level of water resources are increased. Increased nitrate in water resources could lead to serious problem including eutrophication, and potential hazards for human and animal health. The aim of this study is to optimize the use of Nanofltraiton for nitrate removal in Gaza Strip as case study. One commercial membrane (NF90) was used in this study. The stirred dead end flow model was used in addition, two types of water was used: Aqueous solution and real water. The performance of the tested membrane was measured in terms of flux rate and nitrate rejection under different operation conditions: nitrate concentration was varied between 50-400mg/L, applied pressure (6-12) bar and TDS concentration (500-3570) mg/l. The percentage of nitrate removal in real water was in the range of 0.52% and 55.63% and the flux rate range between 2.61 and 30.12 L/m2.hr. These values depend on operation conditions such as nitrate concentration, TDS composition and operation pressure. In real water, the percentage of nitrate removal was influenced by TDS value in general, but to be more specific, it was found that the concentration of sulphate has a great effect on nitrate removal, as the sulphate concentration increased the nitrate removal decreased. The optimum operating pressures are 8.6, 11.6 and 10.8 bar at H104, E142A and D75 well. Which achieve Palestine standard (70 mg/L) and high flux rate 7.46, 26.66 and 8.74 L/m2.hr. NF90 was observed to be an effective membrane for nitrate removal of Gaza Strip at higher permeate flux and lower applied pressure, especially in North Gaza Strip were low TDS and Sulphate concentration were observed.

Keywords NF90, Nitrate, Rejection, Well, Total dissolved solids and Pressure.

الاستخدام الأمثل لتقنية النانو في إزالة النترات من مياه أبار بلديات قطاع غزة

ملخص

نظراً للاستخدام المفرط للأسمدة النيتروجينية في الزراعة وحقن المياه العادمة من محطات المعالجة وتسرب المياه العادمة من الحفر الامتصاصية، زاد تركيز النترات في مصادر المياه. زيادة النترات في مصادر المياه قد تؤدي الى مشاكل صحية تتضمن زيادة المغذيات ومخاطر محتملة على صحة الانسان والحيوان. الهدف من هذه الدراسة هو تحديد الاستخدام الأمثل لغشاء النانو في

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إزالة النترات في قطاع غزة كدراسة حالة. تم استخدام (NF90) كغشاء نانو في هذه الدراسة. كما تم استخدام نموذج النهاية المغلقة بالإضافة الى استخدام نوعين من المياه محلول مائي وعينات مياه حقيقية. تم قياس كفاءة الغشاء بواسطة قياس معدل التدفق وإزالة النترات تحت ظروف تشغيلية مختلفة، الضغط التشغيلي (6–12) بار، مجموع الأملاح الذائبة (500–3570) ملجم/لتر. تراوح معدل إزالة النترات في العينات الحقيقية بين 0.52 و 55.63% و تراوح معدل التدفق بين 2.61 و 30.12 لتر/م2.ساعة. تعتمد هذه النتائج على الظروف التشغيلية كمعدل النترات، مجموع و تركيب الأملاح الذائبة و أيضا الضغط التشغيلي. يتأثر معدل إزالة النترات في عينات المياه الحقيقية بمجموع الأملاح الذائبة بشكل عام ولكي يكون البحث أكثر تخصصا فإن تركيز أملاح الكبريتات لها تأثير كبير عل معدل إزالة النترات ، كلما زاد تركيز الكبريتات قل معدل إزالة النترات. من خلال الدراسة تم استنتاج انه القيمة الأمثل للضغط التشغيلي كانت 8.6 ، 11.6 و 10.8 بار في الآبار(D75, E142A,H104) التي تحقق المعايير الفلسطينية لمياه الشرب والكائنة 70 ملجم/لتر و مع معدل تدفق عال 7.46 ، 26.66 و 8.74 لتر/م2.ساعة. تم التحقق من أن غشاء النانو (NF90) غشاء فعال لإزالة النترات في قطاع غزة مع معدل تدفق عال وضغط تشغيلي منخفض خصوصا في شمال قطاع غزة حيث توجد تراكيز منخفضة من الكبرتات ومجموع الأملاح الذائبة.

كلمات مفتاحية: غشاء النانو، الأملاح الذائبة، النترات، مياه الآبار، تحلية.

1. Introduction

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking water can result in tangible benefits to health .

The Gaza Strip is a highly populated, small area in which the groundwater is the main water source. During the last few decades, groundwater quality has been deteriorated to a limit that the municipal tap water became brackish and unsuitable for human drinking consumption in most parts of the Strip. The aquifer is intensively exploited through more than four thousands of pumping wells. As a result of its intensive exploitation, the aquifer has been experiencing seawater intrusion in many locations in the Gaza Strip; In addition high nitrate is measured in many places in Gaza strip aquifer[1]. Nitrate in the groundwater in the Gaza Strip has become a serious problem in the last decade. As a result of extensive use of fertilizers, discharging of wastewater from treatment plants, and leakage of wastewater form cesspools, increased levels of nitrate, up to 400 mg/L, have been detected in groundwater. Nitrate concentrations more than 50 mg/L are very harmful to infant, fetuses, and people with health problems.

To overcome this serious situation, the reverse osmosis (RO) technology is used to replace the tap water or to improve its quality. Several private Palestinian water investing companies established a small-scale reverse osmosis (RO) desalination plants to cover the shortage of good quality drinking water in the whole Gaza Strip.

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 [2].

Nanofiltration (NF) falls between ultrafiltration (UF) and RO, its separation characteristics are based on sieve effect, but also most of commercial NF membranes are charged. So the rejection of ions by NF membranes is the consequence of the combination of electrostatic and steric interaction association with charged shielding Donnan exclusion and ion hytration. These interactions depend on the treated and the membrane itself. The different properties make difficult the use of the existing predictive models. This makes necessary to obtained experimental data to know the performance of a particular NF membrane with specific water. Nanofiltration has many advantages: low operation pressure, easy operation, good quality product, and low investment [3-8].

Previous studies showed that the NF90 membrane (Dow-Filmtec) can be suitable for the removal of nitrates from groundwater. The NF90 membrane was designed to remove a high percentage of salts, nitrate, iron and organic compounds such as pesticides, herbicides and THM precursors. Its high rejection has been confirmed by several authors [9-12].

The interest of using nanofiltration for nitrate ions concentration reduction has been demonstrated. The performance of the process depends on the characteristics of nanofiltration membranes since the results differ from one membrane to the other. The best membrane has been also determined: the NF90 membrane allows strongly reducing nitrate ions concentration at high permeate fluxes. Only for NF90 membrane the product information indicates that it is designed to remove a high percentage of nitrates. It was shown that the NF90 membrane has a high rejection even to monovalent ions. This fact can be mainly explained by its tight pore structure and the negative charge of the membrane [5, 13].

The NF90 membrane presents, from a qualitative point of view, similar effects to those observed in a conventional NF membrane However, the extent of these effects is smaller, approaching the behavior of the NF90 to that of a reverse osmosis membrane. The relatively high nitrate rejection and its small dependence on feed conditions make this membrane suitable to treat types of water that slightly exceed the legal limit of nitrate concentration for drinking purposes [5].

New technologies including nanofiltration membrane (NF) application will be considered and experimentally investigated to measure the possibility of enhancing the performance of the desalination plants and increasing production in the near future. In addition, effluent brine treatment technology prior to disposal may be studied and recommended [14].

Understanding of the phenomena of retention on nanofiltration is complicated, thus experimentation still remains the best means of understanding the phenomena responsible for the retention [15].

In the Gaza Strip there is no desalination plant using nanotechnology, the aim of this research to test if Nanofiltration membrane is suitable for nitrate removal from groundwater.

2. Experiment conducting

i. Materials

NF90 (DOW Filmtec) nanofiltration element is a high area, high productivity element designed to remove a high percentage of salts, nitrate, iron and organic compounds such as pesticides, herbicides and THM precursors. The high active area membrane combined with low net driving pressure of the membrane allows the removal of these compounds at low operating pressure. Properties of NF90 are summarized in Table 1.

The system consists of HP4750 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 temperature and at pressure range of (6 – 12) bar; Figure 1 shows the system component.

Table 1 *Properties of NF90 indicate by manufacturer*

Membrane	NF90
Material	Polyamide
Operational pressure	5.4
Approximate rejection NaCl(%)	85-95
Water flux (L/m^2.hr)	43
pH range	4-11
Surface charge	Negative

Figure 1 *system component*

ii. Sampling

The filtration experiments were carried out on different samples:

1) Pure sample: deionized water with EC=7µS/cm

2) Aqueous standard solutions: (50-10-150-200-250-300-350-400) ppm of NO_3 asNO_3.

3) Real sample: Water samples were collected from different municipal wells distributed on all Gaza Strip governorates and divided based on the concentration of nitrates, the sample Nitrates concentrates are chosen every fifteen mg/L, the concentrations of Nitrates varied between (32-364) mg/L. The water samples were collected based on Palestine Water Authority (PWA) chemical tests results in 2011 Table 2. Figure 2 Shows wells sample location.

iii. Methods

After collecting the samples, major chemical analysis were performed for these samples such as (pH, TDS, and NO_3).

iv. Nitrate Measurement

4500-NO_3 nitrogen (nitrate) method was used in nitrate measurement. Nitrate concentration was determined by CT-2600 Spectrophotometer.

v. TDS Measurement

Concentration of TDS was determined by Conductivity meter (Microprocessor conductivity meter BODDS-307W, which measures the EC. To get the TDC value we multiply EC by (0.6).

vi. pH Measurement

pH is a logarithmic notation used to measure hydrogen activity (i.e., whether a solution is acid or basic).

$$pH = -\log [H^+]$$

As a simplification, it is assumed that pH is a function of the hydrogen ion concentration $\{[H^+]\}$ when in reality it is related to the hydrogen ion activity H+. Since pure water is slightly ionized, it is expressed as an equilibrium equation termed the ion product constant of water. The concentration of these two ions is relatively small and is expressed as a simple logarithmic notation. pH is the negative log of the hydrogen ion [16].

The pH was measured with (pH/ORP/ISE Graphic LCD pH Bench top Meter, HANNA instrument) pH meter.

3. Tested parameter

i. Flux Rate

Flux rate Represent the volume of liquid passing through specific area of membrane at certain operating pressure during a period of time.

The flux rate of a filter is important in determining how rapidly filtration can be completed. If there is nothing in the sample stream to clog the pores, the flux rate should remain constant.

$$\text{Flux rate} = V/A.t \ (l/m^2.hr)$$

Where;

V: volume of water permeated at the time (L/hr).

A: surface area of membrane (0.00146 m^2).

t: time of filtration (hr).

Note that these tests were carried out at different pressures (6, 8, 10, 12 bar), because this pressure ranges are lie in the operation pressure range of NF membrane (Filmtec membranes product information).

ii. Rejection

The same meaning of removal efficiency, represent the ability of membrane to reject salts and impurities from feed water. This is one of the most important characteristics of membrane; that's depended on the feed water characteristics, membrane characteristics and applied pressure.

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).

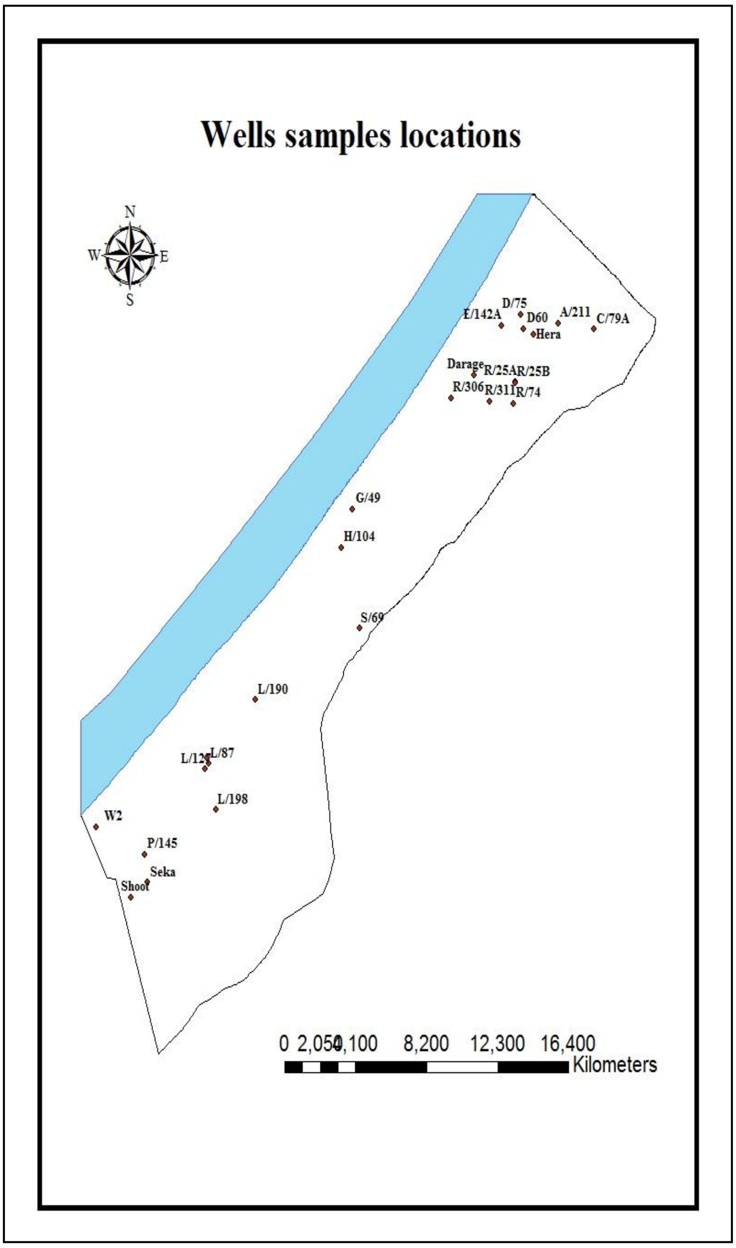

Figure 2 *Wells sample location*

Table 2 *Well sample chemical analysis*

Well No.	EC (μΩ/cm)	TDS (mg/L)	PH	Calcium Ca (mg/L)	Magnesium Mg (mg/L)	Sodium Na (mg/L)	Potassium K (mg/L)	Chloride Cl (mg/L)	Nitrate NO_3 (mg/L)	Sulphate SO_4 (mg/L)	Alkalinity (mg/l)	Hardness (mg/l)
S69	24260	1506	7.14	62	48	380	3.6	580	32	240	274	353
A211	755	500	7.48	48	32	54	3.2	97	45	22	212	251
W2	1564	970	7.62	71.44	59	167	5.9	217	71	108	167	421
H104	3900	2454	7.98	118	102	560	5.1	967	76	394	232	715
E124A	4810	3140	7.22	214	153	560	4	1442	80	149	181	1165
R74	3690	2200	7.37	46	76	680	3.2	824	120	219	429	427
D75	971	630	7.38	78	39	70	4.7	109	133	41	232	356
R306	2560	1587	7.89	87	49	400	3.4	566	136	155	371	418
G49	4810	3010	7.67	131	121	720	5.8	1196	138	550	247	827
Astath	4570	2900	8.02	65	64	840	10.8	1174	140	407	209	427
R25A	3010	1900	7.31	43	59	520	16	565	146	269	411	351
Darage	2100	1200	6.99	106	70	230	7.5	408	178	111	333	556
L198	3370	2100	7.35	33	37	640	3.2	695	185	375	284	235
C79A	2540	1600	7.14	95	89	300	3.3	509	190	105	361	605
L190	5620	3570	7.65	65	68	1050	5.9	1346	193	628	271	441
P145	2730	1650	7.47	105	77	380	4.8	662	206	213	162	580
D60	1534	950	7.22	107	60	135	7.5	225	211	90	252	516
R311	4290	2570	7.53	114	95	640	77.9	891	217	444	521	677
R25B	3250	2020	7.11	78	104	480	26	608	226	280	413	623
Seka	4240	2673	7.38	87	69	700	5.2	964	230	359	240	503
Hera	2050	1350	7.06	114	78	190	25	309	273	135	302	605
L87	3800	2450	7.89	94	93	580	6.4	848	304	271	292	619
Shoot	3710	2574	7.69	70	66	670	4	838	332	356	225	449
L127	3140	1950	7.17	117	97	430	3.8	687	364	157	228	690

4. Result and discussion

1) Flux rate

a) Aqueous solution

Many factor influence the flux rate such as operation pressure and ionic concentration Figure 3 illustrate the relation between flux rate and operation pressure for pure water sample. Flux rate dos not only depend on the operating pressure but also on the influent concentration. As ionic concentration increase the flux rate will be decrease as show in Figure 4 the effect of operating pressure and ionic concentration on flux rate in nitrate solution sample. For each pressure, a linear relation can be obtained for flux rate against the feed nitrate concentration with high correlation ranges between (0.94 to 0.97). This reduction in flux crossing is increased when the ions is added, probably due to increasing solution osmotic pressure [16].

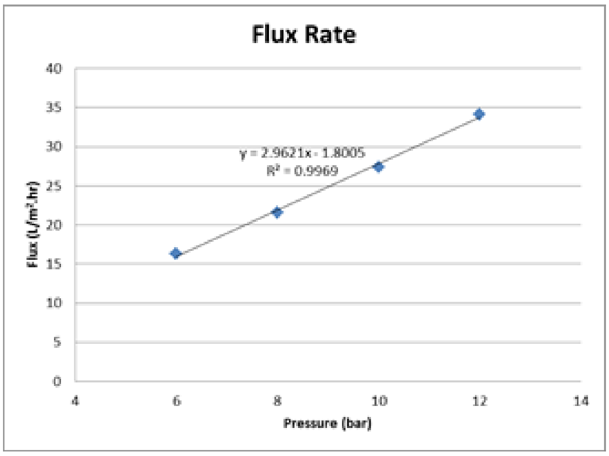

Figure 3 *pure water flux rate with different pressure*

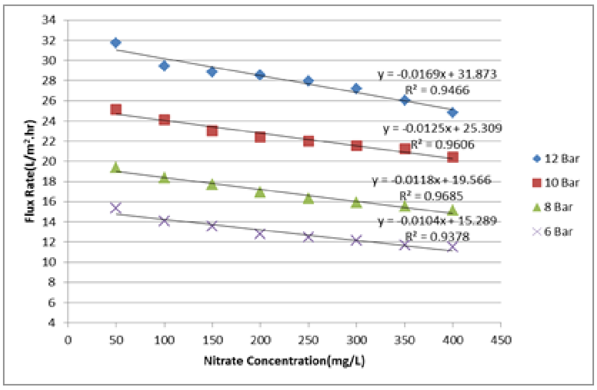

Figure 4 *Effect of feed nitrate concentration and operating pressure on flux rate(nitrate sample (50,100,150,200,250,300,350 and 400 mg/l as NO_3*

b) Real water sample.

As in case of a queues solution, the flux rate increases linearly with increase of feed TDS concentration for each pressure Figure 5 and Table 3 shows the effect of TDS concentration and operating pressure on flux rate, the general trend is as TDS concentration increases the flux rate decrease. Generally, when the ionic concentration increases the retention and thus flux, decrease due to Dannan exclusion effect [13].

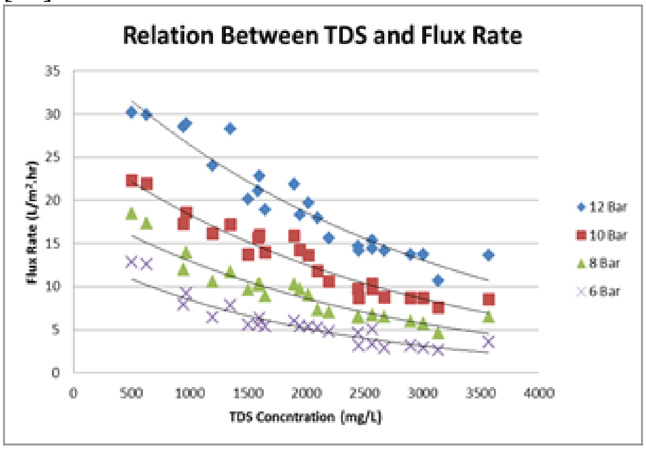

Figure 5 *Effect of feed TDS concentration and operating pressure on flux rate(nitrate sample (50,100,150,200,250,300,350 and 400 mg/l as NO_3)*

Table 3 *Flux rate and TDS concentration*

Well ID.	***TDS(mg/L)***	**Pressure (Bar)**			
		6 Bar	***8 Bar***	***10 Bar***	***12 Bar***
		Flux rate (L/m²^{2}.hr)			
A211	500	12.82	18.45	22.29	30.12
D75	630	12.57	17.37	21.95	29.87
D60	950	7.94	12.01	17.24	28.48
W2	970	9.22	13.93	18.54	28.86
Darage	1200	6.42	10.6	16.17	23.98
Hera	1350	7.79	11.69	17.13	28.24
S69	1506	5.57	9.6	13.72	20.16
R306	1587	5.55	10.18	15.64	21.1
C79A	1600	6.36	10.37	15.94	22.8
P145	1650	5.4	8.98	13.95	18.92
R25A	1900	6.04	10.28	15.85	21.82
L127	1950	5.35	9.69	14.19	18.26
R25B	2020	5.35	9.07	13.59	19.65
L198	2100	5.18	7.27	11.82	17.96
R74	2200	4.78	7.06	10.56	15.62
L87	2450	4.61	6.53	9.73	14.7
H104	2454	3.11	6.4	8.7	14.12
R311	2570	3.35	6.7	9.73	14.4
Shoot	2574	5.03	6.72	10.33	15.38
Seka	2673	2.92	6.53	8.81	14.12
Astath	2900	3.11	5.97	8.7	13.7
G49	3010	2.9	5.78	8.66	13.7
E124A	3140	2.61	4.65	7.55	10.71
L190	3570	3.61	6.49	8.53	13.61

2) Rejection of ionic component

a) A queues solution

The nitrate removal (rejection rate) of solution at different pressure were analyzed Figure 6 shows the effect of operation pressure and ionic concentration on nitrate rejection, as pressure increased nitrate rejection increased on the contrary as nitrate feed concentration increases nitrate rejection decreases. This can be explained by considering salt transport through the membrane as a result of diffusion and convection, which are respectively due to a concentration and a pressure gradient across the membrane. The increase of concentration involves the increasing formation, by the cations, of a screen which gradually neutralize the negative charges of the membrane. The forces of repulsion between the negative sites of the membrane and the anions NO3 are, therefore, decrease [13, 15].

The result in this study has been confirmed by [9, 13, 19, 20, and 21].

It can be shown that the nitrate retention rises with an increase in the pressure. This can be explained by the influence of the pressure on the permeate flux and also its effect on concentration polarization. The permeate volumetric flux increases linearly with the pressure, so the concentration polarization which leads to a resistance to the transfer through the membrane is not significant [13, 19].

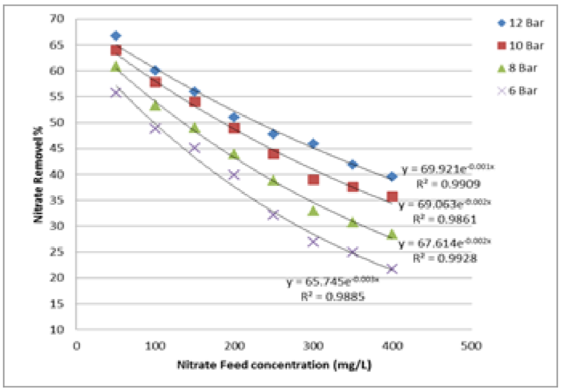

Figure 6 *Effect of feed nitrate concentration and operating pressure on nitrate removal percent(nitrate sample (50,100,150,200,250,300,350 and 400 mg/l as NO_3)*

At low transmembrane pressure (TMP), diffusion contributes substantially to the salt transport resulting in a lower retention. With increasing TMP, the salt transport by diffusion becomes relatively less important, so that salt retention is higher [22,23]

a) **Real water sample**.

As observed in aqueous solutions the effect of operating pressure was evaluated. In real water there were many factors that influenced the rejection percentage such as TDS concentration and other chemical concentration.

The result show that as operation pressure increases the removal of nitrate increases. However, for other wells, the operating pressure was not the main influencing factor. TDS concentration plays an important role.

Table 4 shows the results of nitrate removal and operating pressures, the maximum rejection percentage at 12 bar was 55.56% at well A211 and the minimum nitrate rejection was 0.56 at L190 wells when operating pressures was 6 bars depending to TDS concentration and composition and nitrate concentration in feed water

The result in Figure 7 showed that in general that relation between TDS concentration and nitrate rejection, when we fixed the nitrate concentration in feed water. As shown in Figure 7 there are drop in curve, but when the effect of nitrate concentration is fixed and plot the nitrate removal and sulphate concentration, a strong relation between sulphate concentration and nitrate rejection was found Figure 8.

Table 4 shows the nitrate rejection results against TDS and sulphat concentration. To show this relation, Nitrate concentration must be fixed. For example E124A well have 3140 mg/l as TDS concentration and S69 well has 1506 mg/l as TDS concentration, but nitrate rejection in E124A is higher than S69, although nitrate concentration in E124A is higher than in S68. This was due to that the sulphate concentration in E124A was 149 mg/L but in S69 was 240 mg/L. That means the sulphate concentration plays important role in NF90 nitrate rejection percentage. Because of high concentration of salphate ions, because of their high valance, nitrate is forced to pass through the membrane. The removal of monovalent ions such as nitrate was greatly decreased under the presence of sulfate ions. Retention of the negative sulphate ion in concentrate water disturbed the electrical equilibrium on both sides of the membrane that nitrate ions was forced through the membrane in permate water to maintain electric equilibrium the result have been matched with[5,18,21,24].

The sequence of rejection of monovalent anions can be written as R (F)> R (Cl)> R (NO_3), the observed retention of the three ions is similar to the ionic order and opposite to the hydration energy order for the monovalent ions, the F which has higher hydration energy is better retained than Cl and NO_3 [25,26].

Table 4 *Nitrate rejection percent at different applied pressure result with sulphate and TDS concentration*

Well No.	TDS	Nitrate NO_3 (mg/L)	Sulphate SO_4 (mg/L)	6 Bar	8 Bar	10 Bar	12 Bar
A211	500	45	22	33.33	42.22	48.89	55.56
W2	970	71	108	18.31	28.17	39.44	42.85
E124A	3140	80	149	75	21.25	27.5	35
S69	1506	32	240	8.23	15.63	22.32	28.13
H104	2454	76	394	5.35	10.6	15.15	18.5
D75	630	133	41	42.87	48.12	50.38	52.63
R306	1587	136	155	8.09	14.71	19.85	23.53
R74	2200	120	219	5	10.83	15	18.33
R25A	1900	146	269	4.79	10.27	14.38	17.81
Astath	2900	140	407	0.71	2.14	5.73	8.57
G49	3010	138	550	0.96	1.79	5.17	6.79
C79A	1600	190	105	16.84	19.47	24.21	36.63
Darage	1200	178	111	16.85	23.6	27.53	34.27
L198	2100	185	375	1.62	4.86	8.11	10.81
L190	3570	193	628	0.52	1.04	1.55	2.07
D60	950	211	90	36.49	39.81	41.71	43.6
P145	1650	206	213	6.31	13.59	23.3	30.1
R25B	2020	226	280	7.52	12.83	16.81	21.24
Seka	2673	230	359	2.17	10	12.61	15.22
R311	2570	217	444	1.38	3.23	8.76	12.44
Hera	1350	273	135	21.61	31.87	36.26	45.42
L127	1950	364	157	18.68	23.9	29.67	32.97
L87	2450	304	271	4.61	9.21	14.47	17.76
Shoot	2574	332	356	0.60	1.2	7.83	14.16

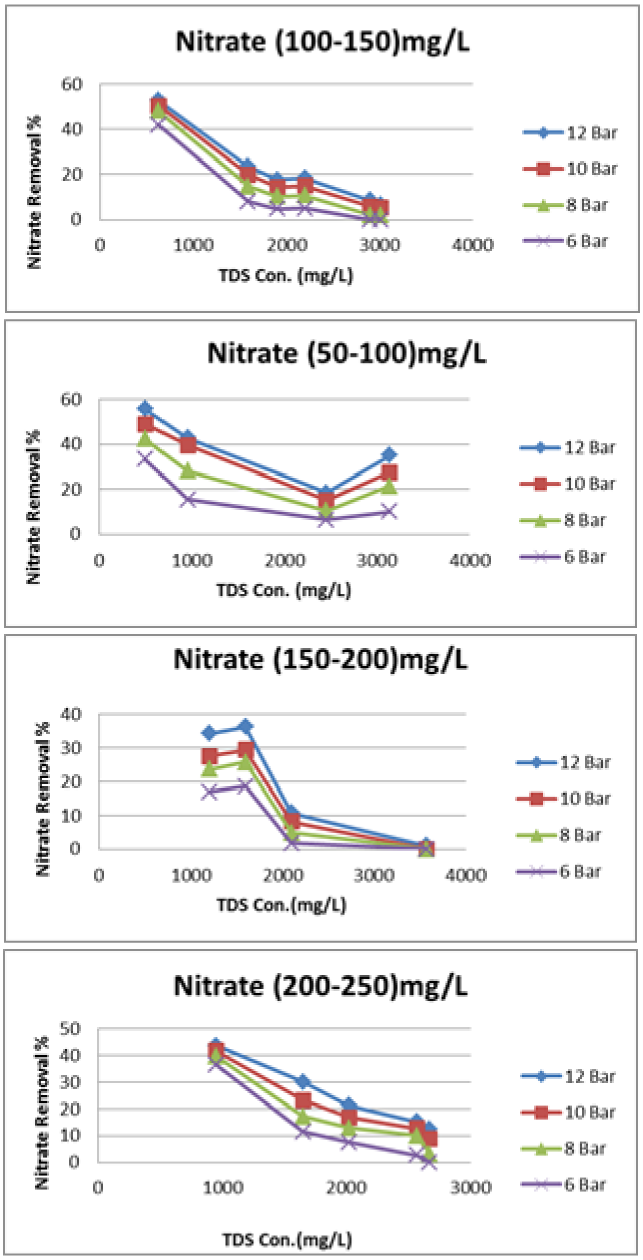

Figure 7 *Relation between TDS concentration and nitrate rejection*

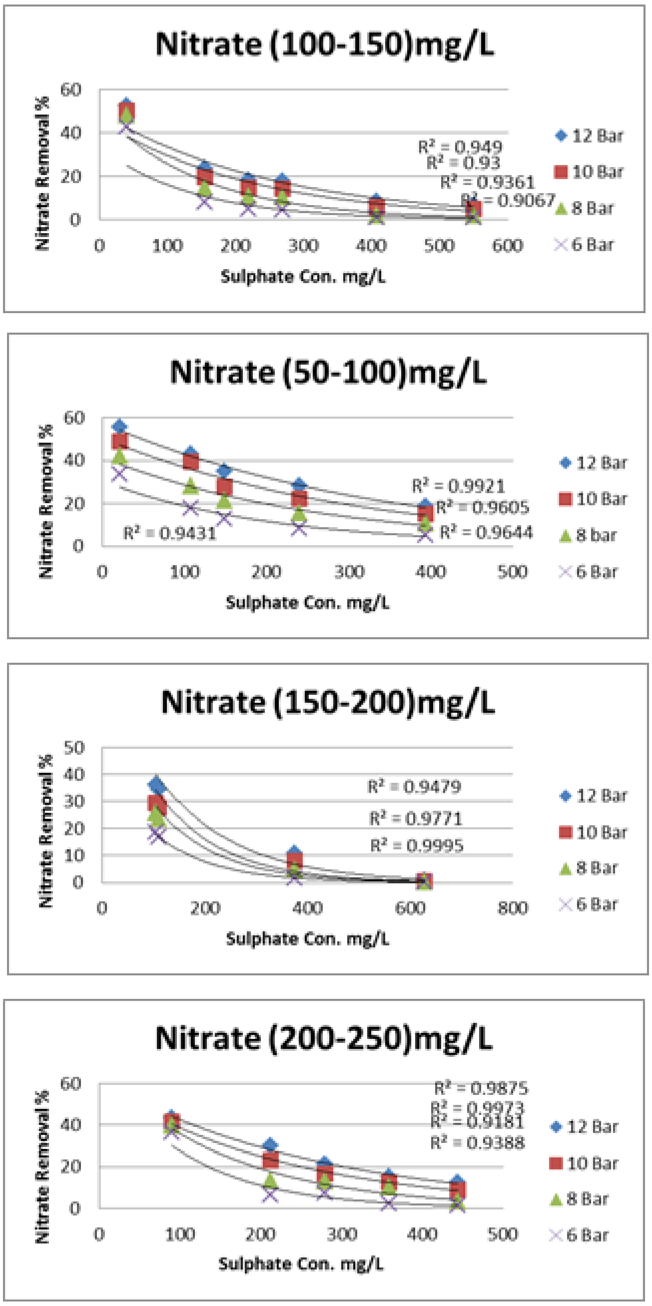

Figure 8 *Relation between nitrate rejection and sulphate concentration*

Comparison between Real water and Aqueous Solutions:

1) Flux Rate

The performance of NF90 membrane varied in terms of flux rate. Consequently, the pure water flux rate was higher than the real water flux rate.

As the water contains more salts or other substances, the flux rate decreases. At this pattern the membrane performance, so the pure flux rate was higher than of real water flux. Also complexity of water character play a good role in membrane behavior and that is why the queues solution flux rate is higher than real water flux rate.

The maximum flux rate for aqueous solution was obtained at 12 bar (34.13 L/m^2.hr) and minimum flux rate was obtained at 6 bar (16.31 L/m^2.hr).

The maximum flux rate for real water was obtained at 12 bar (30.12 L/m^2.hr) for A211 well and minimum flux rate was obtained at 6 bar (2.61 L/m^2.hr) for E142A well.

2) Nitrate Rejection

Generally, the overall rejection percentages of the NF90 membrane of aqueous solutions were found to be higher than the rejection of real water. For aqueous solution the maximum and minimum nitrate rejection of aqueous solution was 66.68% and 21.67% respectively, while for real water the maximum and minimum nitrate rejection of were 55.56% and 0.52 % respectively.

The characteristics of feed water significantly affect the membrane rejection such as the content of sulphate and hardness. This explains the difference of rejection between real water and aqueous solution. In addition, real water may contain some colloids and many other substances that can negatively affect the membrane rejection.

Optimization Process

Optimization is the process used to obtained the lowest operation pressure applied to produce water, the water must achieve the stander limit for slats concentration, the Palestinian standard state that maximum concentration of nitrate in drinking water 70 mg/L and maximum concentration of TDS 1500 mg/L.

As dead end system was used, a disadvantage of the stirred cells that it doesn’t simulated large scale modules, particularly in terms of the boundary layer mass transfer coefficient. The stirred cell would tend to achieve lower retention and experience more fouling than large scale Spiral Wound Modules [16].

So to develop optimization process cross flow system is needed which represent the actual case in desalination plant. In this research guide value to optimization process was developed.

To obtain the optimum point which achieve quality at lowest pressure, the permeate nitrate concentration was plotted with pressure, also permeate flux was plotted in the same graph; the crossing point between two line is the best operation point. This method, as mention before, provide approximate results, to develop actual result pilot scale should be done.

Three wells were used to illustrate the optimizing procedure: H104, E142A, D75. In this sulphate concentration and TDS are low which enhance the selection of the best operating pressure.

Figure 9 shows that the best operating point for well H104 is at 8.6 bar (operating bar) with flux rate 7.46 L/m^2.hr. The nitrate concentration in permeate water will be 70 mg/l, when the influence water concentration is 76mg/l.

Figure 10 illustrates the operation diagram for well D15, the feed water nitrate concentration is 133 mg/l, the best operating point is at 11.5 bar with flux rate 26.66 L/m^2.hr and nitrate concentration in the permeate water is 62 mg/l.

Figure 11 illustrate the operation diagram for well E142A, the feed water nitrate concentration is 80 mg/l, the best operating point is at 10.8 bar with flux rate 8.74 L/m^2.hr and nitrate concentration in the permeate water is 55 mg/l.

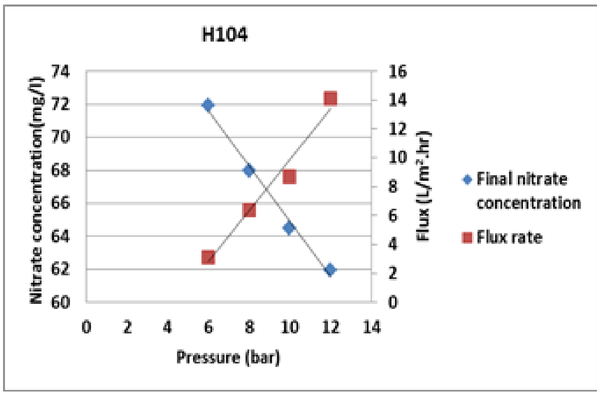

Figure 9 *H104 opreation diagram (Intial nitrate concentration 76mg/l)*

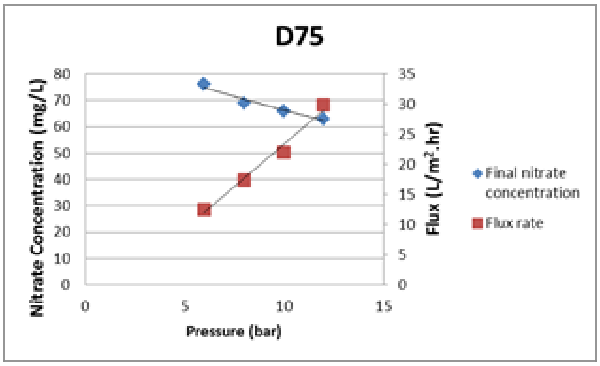

Figure 10 *D75 opration diagram (Intial nitrate concentration 133mg/l)*

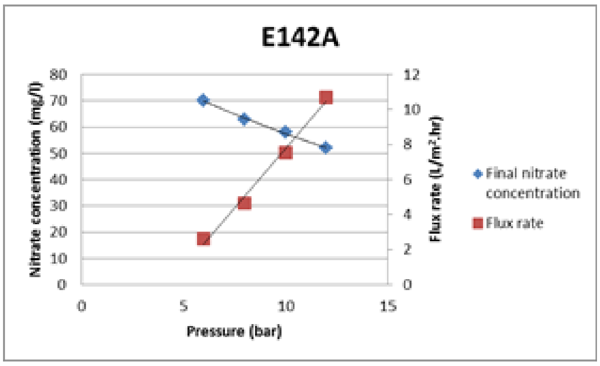

Figure 11 *E142A opration diagram (Intial nitrate concentration 80mg/l)*

5. Conclusion

NF90 membrane showed good result for nitrate removal in real water, which varied between 0.52% and 56.56%, and flux rate between 2.61 and 30.12 L/m^2.hr, when the operating pressure varied between 6 and 12 bar.

It can be concluded that the sulphate has negative effect on chloride rejection and on nitrate rejection. As the real water contains more salts or other substance, the flux rate decrease. At this pattern the membrane performance, so the pure flux rate was higher than of real water flux. Also complexity of water character play a good role in membrane behavior and that is why the nitrate solutions flux rate are higher than real water flux rate.

NF90 was observed to be an effective method to nitrate removal of Gaza Strip at higher permeate flux and lower applied pressure, especially in North Gaza Strip were low TDS and Sulphat concentration were observed. In other Gaza Strip places TDS and sulphat should be removed before using nanofiltration to nitrate removal.

The characteristics of feed water significantly affect the membrane rejection such as the content of sulphate and hardness. This explains the difference of rejection between real water and aqueous solution.

Sensitivity of the system to the circumstances like temperature, quality of deionized water used in system flushing, regular insurance of zero leakage of pressure , the period of using membrane, using tools washed by deionized water , all these restriction make the test harder.

The importance of testing Nanofiltration membranes as new emerging technology in Gaza strip is to improve the overall desalination quality with acceptable cost; carrying out tests helps to understand the behavior of NF90 for nitrate removal.

Desalination of brackish water using Nanofiltration technique is seen as one of the promising solution that can assist Gaza in filling the gap between the growing needs for water, limited water recourses, limited energy resource, the standard of domestic water and unacceptable water quality.

References

1. Aish, A.,*Water Quality Evaluation Of Small Scale Desalination Plants In The Gaza Strip Palestine*. Department of Geology, Faculty of Science, Al Azhar University, P.O. Box 1277 Gaza, Palestine (2010).

2. Mogheir, Y., Abuhabib, A., Hasouna, A., Shehab, F., Shaat, S., *Comparative Approach for Desalination of Brackish water using low pressure Nanofiltration membranes*, Global Advanced Research Journales, (2013).

3. Wang, M., Su, Z., Ando, M., Shintani, T., *Separation performance of a nanofiltration membrane influenced by species and concentration of ions*, Desalination 175, 219(2005).

4. Paugam, L., Taha, S., Dorange, G., Quemeneur, F., *Mechanism of nitrate ions transfer in nanoflitration depending on pressure, pH, concentration and medium composition*. J. Membr. Sci. 231:34-46(2004).

5. Santate-Morose, A., Gazalvez-Zafrilla, J., Lora-Garcia, J., *Nitrate removal from ternary ionic solution by a tight nanofiltration membrane*. Desalination, 204, 63-71(2005).

6. Wang, X., Shange, W., Wang, D., Wu, L., *Characterization and application of nanofiltration membranes: state of the art*, Cong- Hui TU (2009).

7. Amouha, M., Bidhendi, G., Hooshyari, B., *Nanofiltration efficiency in nitrate removal from groundwater: A semi-industrial case sta*dy(2011).

8. Galanakis, C., Fountoulis, G., Gekas, V., *Nanofiltration of brackich groundwater by using a polypiperazine membrane*, (2012).

9. Santafé, A., Gozálvez, J., Lora, J., *Performance of nanofiltration membranes in the removal of nitrate ions*. Desalination, 185 - 1707–1713(2005).

10. Krieg, H., Modise, S., Keizei, K., Neomagus, H., Salt *rejection in nanofiltration for single and binary salt mixtures in view of sulphate removal*. Desalination, 171, 205–215(2004).

11. Drewes, J., Reinhard, M., P. Fox, P., *Comparing microfiltration-reverse osmosis and soil-aquifer treatment for indirect potable reuse of water*. Water Res., 37(15) ,3612–3621(2003).

12. Visser, T., Modise, S., Krieg, H., Keizer, K., *The removal of acid sulphate pollution by nanofiltration*. Desalination, 140, 79–86(2001).

13. Garcia, F., Ciceron, D., Saboni, A., Alexandrova, S., *Nitrate ions elimination from drinking waterby nanofiltration*, Membrane choice. Separ. Purif. Technol., 52,197-200(2006).

14. Mogheir, Y., A, Foul., A, Abuhabib., A, Mohamad., *Assessment of large scale brackish water desalination plants in the Gaza strip*.,(2013).

15. Paugam, L., Taha, S., Dorange, G., Quemeneur, F., *Influence of ionic composition on nitrate retention by nanofiltration,* Institute of chemical engineers, Trams IchemE, Vol 81, Part A, (2003).

16. Bailar, John, C. Jr., Chemistry, Academy Press, New York, New York (1978).

17. Schafer, Al., Fone, A., Waitem, T., *Nanofiltration Principles and Application*, (2008).

18. Paugam, L., Taha, S., Cabon, J., Gondrexon, N., Dorange, G., *Nanofiltration of ammonium nitrate soluation. Study of influent parameters*, Rev Sct Eau-J Wat Sci, 14(4):511-523(2001).

19. Paugam, L., Taha, S., Dorange, G., Quemeneur, F., *Mechanism of nitrate ions transfer in nanoflitration depending on pressure, pH,concentration and medium composition*. J. Membr. Sci. (2004), 231:34-46.

20. Kang, M., Jeong, T., Hwang, I., *Nitrate by nanofiltration in very small drinking water systems*. World Appl. Sci. J., 5(2009).

21. Amouha, M., Bidhendi, G., Hooshyari, B., Nanofiltration efficiency in nitrate removal from groundwater: A semi-industrial case stady(2011).

22. Schaep, J., Van der Brugen,B., Uyetherhoven, S., Croux, R., Vandecasteele, C., Wilms, D., Van Houtte, E. and Vanlerberghe, F., *Removal of hardness from* *groundwater by nanofiltration*, Desalination, 119,295-301.,(1998).

23. Van Gestel, T., Vandecasteele, C., Buekenhoudt, A.,.Dotremont, C., Luyten, J., Leysen, R., Van der Bruggen, B. and Maes, G., *Salt retention in nanofiltration with multilayer ceramic TiO2 membranes, Journal of Membrane Science*, 209, 379-389(2002).

24. Choi, S., Yun, Z., Hong, S., Ahn, K., *The effect of co-exisiting ions and surface characteristic of nanomembrane on the removal nitrate and fluoride*. Desalenation, 133,53-64(2001).

25. Diawara, C. K., Sidy Lô, M., Rumeau, M., Pontie, M. and Sarr, O., *A phenomenological mass transfer approach in nanofiltration of halide ions for a selective defluorination of brackish drinking water*, Journal of Membrane Science, 219, 103-112(2003).

26. Wang, M. Su, Z.Y. Yu, X.L. Wang, M. Ando and T. Shintani.,*Separation performance of a nanofiltration membrane influenced by species and concentration of ions*, Desalination 175, 219(2005).