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Assessment of the Quality of Freshwater Based on the Use/Non Reverse Osmosis Water Treatment Technology in Commercial Plants in Egypt

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Abstract

Reverse Osmosis (RO) water treatment as commercial plants has become increasingly prevalent in the Egyptian market, offering a wide variety of origins and technologies. Most of these are usable on taps and others are used on a larger scale at commercial stations in villages all over Egypt. These plants are usually known as filters, however, they usually differ greatly according to both the capacity and the technology by which they function. Some use without RO membrane and others have. The purpose of this manuscript is to test as many of these plants as possible and carry out a full study of water quality before and after using the proper device. The obtained results showed that the RO process is well adapted for this treatment; the rejection rate efficiency is up to 97.94% for the totality of solutes (the electrical conductivity decreased from 836 µs/cm to 17.2 µs/cm). The plants (P3, P7, and P8) are perfect to use where maximum removal efficiency, salt rejection, salt passage, recovery %, and concentration factor values were recorded (85.9, 81.93, 18.07, 78.00%, and 4.50), (97.27, 97.94, 2.06, 80.00%, and 5.00) and (92.44, 93.28, 6.72, 79.00%, and 4.70). Through the previous values for all plants under study, we are recommended to change the RO membrane for plants (P1, P2, and P4) and modify P5 to the RO system. The experienced service support, good maintenance program, and correct system design led to the RO system providing many years of high-purity water. Such a study should evaluate its function as well as the water quality itself. A detailed study will be offered and the results will be assessed according to both international as well as Egyptian environmental laws.

Keywords: Contaminates, Environment, Large scale, Membrane, Reverse osmosis, Water treatment

1. Introduction

In a purification technology, Reverse Osmosis (RO) uses a semi-permeable membrane. This membrane technology is not exactly a filtration method because in RO, an applied pressure is used to overcome osmotic pressure, the colligative property, that is driven by chemical potential, a thermodynamic parameter [1]. Environmental protection laws enacted by many countries that include water conservation are often poorly enforced, which has negative consequences for the future, as clean water is a right and a basic necessity for a disease-free life [2]. According to [3], different treatment technologies are available for the removal of toxic heavy metals. The adsorption [4], chemical precipitation [5], ion exchange [6], coagulation [7], RO [8], electrolysis, and membrane process are widely used [9]. However, RO technology is an important solution for generating safe potable water. RO technology removes microbial and biological contaminants and salinity. The removal of components that are not hazardous to health, such as hardness, color, odor, taste, and smell, is optional but usually incorporated as a part of the RO process. In the past few decades, different water treatment technologies have emerged that cater to specific purposes, such as activated carbon and bio-filters, which are frequently fitted to water taps. However, such filters remove only components that are adsorbed by carbon and are unable to remove heavy metals and fluoride effectively [10].

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Specifically, RO membranes, demonstrate the best overall removal of total dissolved solids (TDS) and organic compounds by using low-energy, high-performance RO membrane elements are not the only contributors to reducing energy consumption in RO plants. Currently, most commercial RO plants use power-recovery devices to reduce energy consumption, notably, the Pressure Exchanger by Energy Recovery [11]. The RO method, which is used in 69% of seawater desalination plants, consumes 3–4 kWh of energy for every m3 of fresh water produced. The RO method is considered to consume less energy for water production because it does not involve phase changes, as compared to other technologies [12]. Despite the use of ultrafilters, inorganic compounds, heavy metals and microbes pass through them due to their large diameter pores. Since RO relies on a diffusion mechanism, the separation efficiency varies based on the solute concentration (TDS), applied water temperature, and pressure [2,13]. High-pressure pumps in RO systems force water through the pores of the membranes (permeate) and the remaining water with higher concentrations of solutes is pushed out as wastewater [14].

Many harmful effects occur when the membrane is fouling and thus a reduction in the water production flow rate as pressure increases, a gradual membrane degradation which results in a shorter membrane life and a decrease in the permeate quality [15]. Fouling refers to pore plugging and external pore blocking, resulting from the deposition of particles and colloids on the membrane surface and precipitation of smaller dissolved materials within the membrane pores and on the membrane surface, the performance of Filmtec company membrane has higher quality and quantity than LG company. At a flow rate of 45 gpm and a constant feed pressure of 900 psi, the two membranes have the same performance [16]. There is a trade-off between an increased water permeability and a decreased solute rejection rate. However, during the manufacturing process of the RO membrane, the amount of pores in the membrane, which represent the spaces within the polymers, is controlled and the size is changed according to the required dimensions. Pore blocking is important in the fouling mechanisms of ultrafiltration and microfiltration (MF) membranes by colloids and macromolecules, but its role is insignificant in RO and also nanofiltration (NF) membranes. Due to the formation of bacterial and biological growth or sediment on the RO membrane, fouling occurs [17]. Recently, several RO desalination plant projects have been implemented in Egypt on the Mediterranean and Red Sea coasts with the control of brine wastewater as a by-product of seawater desalination [18]. This study is achieved with the use of RO technology. Properly designed RO methods remove more than 97% of all potential toxic contaminants in a one-step process. For that, the water quality was evaluated in terms of TDS and electrical conductivity. This study explains the performance RO method for six plants in simple terms using the inferential statistics method and summarizes the usefulness of this technology in specific situations in maintaining human health.

2. Materials and methods

2.1. Sampling

Eight raw water samples were pretreated before being fed P5 without treatment (Fig. 5), P6 has normal filtration only (Fig. 6) and P1, P2, P3, P4, P7, and P8 have RO treatment plants (Figs. 1–4, 7, 8) and pure water which outlet after plants. All information about the eight plants were described in Table 1. Samples were collected from two governorates, 1) Gesr El-suze and Nasr cities in Cairo governorate and 2) Tala, Al Shohadaa, and Shepen Elkom cities in Al Menofieya governorate. The analytical characteristics of the samples collected during the investigation period, which spans from February 2023 to January 2024, reflect the average samples of that day's activity.

2.2. Field measurements

Water temperature, electrical conductivity, dissolved oxygen, and pH value were measured in situ, using Hydro lab, Model (Multi Set 430i WTW).

Fig. 1. Pure system Co. (RO/N-4 plus) for household.

Fig. 2. Pure system Co. (RO/N-5 plus) for household.

Fig. 3. Pure system Co. (RO/N-6 plus) for household.

Fig. 4. Chieh Sheng Co. (RO/N–6 plus) for household.

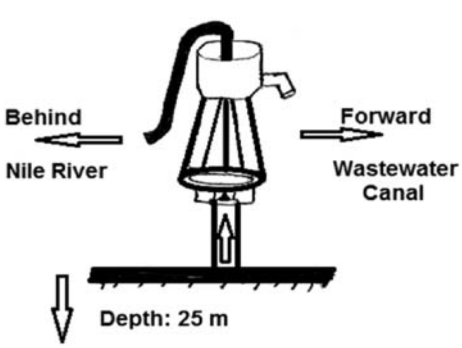

Fig. 5. Drinking pump for underground water.

Fig. 6. Aqua-Sana co. for water distillation (Commercial plant).

Fig. 7. Abo salah co. for water treatment and distilled water (Commercial plant—Large scale).

Fig. 8. Pure water co. for water treatment Household.

2.3. Laboratory analysis

Raw and pure water samples were kept in 2 L polyethylene bottles in ice box and analyzed in the laboratory. The methods of analyses are discussed in the American Public Health Association [19], except where noted. TDS were determined by filtering a known volume of the sample through a GF/C filter and then evaporating it at 180 °C. The Winkler method measures the concentration of dissolved oxygen in samples. Chloride concentration was determined using Mohr's method, and

Table 1. Details of eight water plants in the area under investigation.

Al Menofieya governorate, Egypt				Cairo governorate, Egypt			
Treatment methods	Conditions of raw water samples	Name and address of treatment plant	No	Treatment methods	Conditions of raw water samples	Name and address of treatment plant	No
Without treatment	Underground water temp.: 20 °C depth: 25 m	Drinking pump (underground water) commercial address: Toukh Dlaka, Tala, Al Menofieya-Egypt (Fig. 5)	5	Reverse osmosis (RO) technology production capacity: 48 gal/day made in U.S.A	Supply water (Nile River) temp.: 21 °C	Pure system co. (RO/N-4 plus) for household address: Gamal Abd El-Naser street, Gesr El -Suze, Cairo Egypt. (Fig. 1)	1
Filtration by sand filter granular carbon filter activated carbon filter production capacity: 10 m^3/day made in Italy	Underground water treated with chlorine gas temp.: 19 °C depth: 90—95 m	Aqua-sana co. for water distillation commercial address: Elmahade Eldiny, Tala, Al Menofieya-Egypt (Fig. 6)	6	Reverse osmosis (RO) technology production capacity: 48 gal/day made in U.S.A	Supply water (Nile River) temp.: 20 °C	Pure system co. (RO/N-5 plus) for household address: 6-Dr/Mahmod Hobe Allah street, Nasr city, Cairo—Egypt (Fig. 2)	2
Reverse osmosis (RO) technology production capacity: 50 m^3/day made in U.S.A	Underground water treated with chlorine gas temp.: 21 °C depth: 90—95 m	Abo salah co. for water treatment and distilled water commercial address: Before Denshiway bridge, Al shohadaa, Al Menofieya, Egypt (Fig. 7)	7	Reverse osmosis (RO) technology production capacity: 48 gal/day made in U.S.A	Supply water (Nile River) temp.: 21 °C	Pure system co. (RO/N-6 plus) for household address: 2- Maktapat Samyer and Ali street, Nasr city, Cairo—Egypt. (Fig. 3)	3
Reverse osmosis (RO) technology production capacity: 50 gal/day made in U.S.A	Underground and supply water (Nile River) temp.: 19.9 °C depth: 80—90 m	Pure water co. for water treatment household address: El-Zeraain bilding, East side, Shepen Elkom, Al Menofieya-Egypt (Fig. 8)	8	Reverse osmosis (RO) technology production capacity: 50 gal/day made in Taiwan Globe well filter	Supply water (Nile River) temp.: 22 °C	Chieh Sheng co. (RO/N — 6 plus) for household address: 5-Dr/Aze Aldine Taha, Nasr city, Egypt. (Fig. 4)	4

sulfate concentration was measured using turbidimetric methods. Calcium and magnesium were determined by direct titration using EDTA solution, a flame photometer Model 'Jenway PFP, U.K.' was used to measured Na^+ and K^+. Concentrations of NO_2—N, NO_3—N, NH_4—N, and SO_{4-} were determined using colorimetric techniques with the formation of reddish purple azo-dye, Copper-Hydrazine sulfate reduction, and phenate methods, respectively. Total Fe^{+2}, Mn^{+2}, Cu^{+2}, Zn^{+2}, Cr^{+3}, Pb^{+2}, and Cd^{+2} were measured after digestion by conc. HNO_3 using an atomic absorption reader (Savant AA AAS with GF 5000 Graphite Furnace). The solutions and chemicals used in this study are of the highest purity available, complying with Sigma—Aldrich analytical standards.

2.4. RO membrane materials

In sixth's plants the most common RO membrane materials are polyamide thin film composites and cellulosic types (cellulose acetate [CA], cellulose triacetate [CTA], and blends). These synthetic fibers are used to create extremely thin membranes. Membrane material can be spiral wound around a tube, or hollow fibers can be bundled together, providing a tremendous surface area for water treatment inside a compact cylindrical element. Hollow fiber membranes have greater surface area (and therefore greater capacity) but are more easily clogged than the spiral-wound membranes commonly used in household RO systems [20].

2.5. Operational performance of RO

2.5.1. Membrane efficiency %

The efficiency of membrane is calculated by dividing drop of Contaminated concentration (ΔC) between feed water (mg/l) and pure water (mg/l) by Contaminated Conc. of feed water (mg/l) into the system Eq. (1) [21]:

$$\text{Membrane Efficiency \%} = \frac{\left[\text{Contaminated Conc. of feed water}\left(\frac{mg}{L}\right) - \text{Contaminated Conc. of pure water}\left(\frac{mg}{L}\right)\right] \mathbf{x\,100}}{\text{Contaminated Conc. of feed water}\left(\frac{mg}{L}\right)} \quad (1)$$

2.5.2. Salt rejection %

To determine effective the RO membranes are removing contaminants by using Eq. (2):

$$\text{Salt Rejection \%} = \frac{\left[\text{Conductivity}\left(\mu\frac{S}{cm}\right)\text{of Feed Water} - \text{Conductivity}\left(\mu\frac{S}{cm}\right)\text{of Permeate Water}\right]\mathbf{x\,100}}{\text{Conductivity}\left(\mu\frac{S}{cm}\right)\text{of Feed Water}} \quad (2)$$

System performance improves as salt rejection increases. A low salt rejection can mean that the membranes require cleaning or replacement [21].

2.5.3. Salt passage %

This is the amount of salts expressed as a percentage that are passing through the RO system Eq. (3) [22], It is the inverse of Eq. (2).

$$\text{Salt Passage \%} = (\mathbf{1} - \text{Salt Rejection})\% \quad (3)$$

2.5.4. Recovery %

The recovery rate, also known as the system's efficiency, is determined by dividing the volume of treated water produced by the volume of feed water introduced into the system Eq. (4) [22]:

$$\text{Recovery \%} = \frac{\left[\text{Volume of Treated Water Produced}\left(\frac{L}{m}\right)\mathbf{x\,100}\right]}{\text{Volume of Feed Water Used}\left(\frac{L}{m}\right)} \quad (4)$$

2.5.5. Concentration factor

The recovery rate, or efficiency, of the system is calculated by dividing the volume of treated water produced by the volume of water feed into the system Eq. (5):

$$\text{Concentration Factor \%} = \frac{\mathbf{1}}{(\mathbf{1} - \text{Recovery \%})} \quad (5)$$

When designing a RO unit, the concentration factor equation is very important because it relates to the recovery of the system. The more water you recover as permeate (the higher the % recovery), the more concentrated salts and contaminants you collect in the concentrate stream [22].

3. Results and discussion

3.1. The performance of the eight plants under investigations

The results of the physico-chemical analysis are presented in Table 2 for raw water delivered by the groundwater, Supply water (Nile River) as feed water into the plants (P1, P2, P3, and P4), and pure water as product its. The data showed a descending order of the ability of these plants to removal of contaminates among study period that can be arranged as follows: P3>P1>P4>P2. The quality of water produced from the pretreatment demonstrates that turbidity underwent the strongest reduction up to 100%; it was reduced from 2.9 NTU to ND in P3.

The ability of membrane to removal the contaminates and the maximum removal efficiency are shown in Fig. 9, in P3 were EC recorded 81.9%, TDS recorded 82.6%, TH recorded 69.2%, Mg recorded 80%, Ca–H recorded 62.5%, $SO4^{-}$ recorded 94.3%, Cl^{-} recorded 65.5% and NO_3–N, recorded 75%, NH_4–N recorded 98.3%, Na^{+} recorded 88.9%, K^{+} recorded 91%, Fe^{+2} recorded 99.3%, Mn^{+2} recorded 95.2%, Cu^{+2} recorded 95.7%, Cr^{+3} recorded 87.5%, Zn^{+2} recorded 98.4%, Pb^{+2} recorded 98.2% and Cd^{+2} recorded 97.8%. Then the average of treatment efficiency for P3 equal 85.9% and the data showed a descending order of the efficiency of these plants (P1, P2, P3 and P4 were 60.9, 51.8, 85.9 and 60.2, respectively.) to removal of contaminates among study period that can be arranged as follows: P3>P1>P4>P2.

The results of the physico-chemical analysis are presented in Table 3 for raw water delivered by the groundwater and supply water (Nile River) as feed water into the plants (P5, P6, P7, and P8) and pure water as product its. The data showed a descending order of the ability of these plants to removal of contaminates among study period that can be

Table 2. *Physico-chemical analysis of water before and after reverse osmosis treatment plants (P1, P2, P3, and P4).*

Area Under Investigation at Gesr El-Suze and Nasr city in Cairo governorate, Egypt

Parameters	Allowable range [26]	Plant 1 (P1)		Plant 2 (P2)		Plant 3 (P3)		Plant 4 (P4)	
		Before	After	Before	After	Before	After	Before	After
Color	Color less	Color less	Color less	Color less	Color less	Yellowish	Color less	Color less	Color less
Tasty	Acceptable	Unaccep	Accep	Unaccep	Accep	Unaccep	Accep	Unaccep	Accep
Smell	Non existent	Existent	Non	Existent	Non	Existent	Non	Existent	Non
Turbidity NTU	1	1.3	ND	1.55	ND	2.9	ND	1.23	ND
EC μS/cm	1680	543	254	382	197	383	69.2	380	170.5
TDS mg/L	1000	325.8	269.4	229.2	176.2	229.8	40.1	228	100.3
pH	6.5–8.5	7.27	7.1	8.13	7.6	7.8	7.2	7.42	7.16
T.H mg/L	500	160	90	190	85	130	40	142	134
Ca–H mg/L	350	100	50	100	55	80	30	97	87
Mg–H mg/L	150	60	40	90	30	50	10	45	47
Mg mg/L	150	14.58	9.72	21.87	7.29	12.15	2.43	11.42	11.42
Ca mg/L	350	40	20	40	22	32	12	38.8	34.8
DO mg/L	>5.0	5.3	6.73	5.14	7.14	6.74	7.09	5.55	7.1
SO_4^- mg/L	250	94.97	6.86	30.66	8.24	85.51	4.86	52.1	22.11
Cl^- mg/L	250	22.47	10.37	20.93	12.92	23.51	8.12	35.24	11.90
NO_2 mg/L	0.2	1.43	0.85	ND	ND	ND	ND	ND	ND
NO_3 mg/L	45	0.64	0.17	0.14	0.13	0.08	0.02	0.43	0.15
NH_4 mg/L	0.5	0.4	0.22	0.34	0.15	0.6	0.01	0.7	0.08
Na^+ mg/L	200	72	15	65	28	81	9	78	6
K^+ mg/L	1.0	0.92	0.5	1.21	0.7	1.11	0.1	0.98	0.07
Fe^{+2} mg/L	0.3	1.1	0.06	0.5	0.02	1.21	0.008	0.42	0.19
Mn^{+2} mg/L	0.4	0.09	0.02	0.03	0.02	0.189	0.009	0.02	0.01
Cu^{+2} mg/L	2.0	2.4	0.7	2.9	1.5	3.24	0.14	2.2	0.22
Cr^{+3} mg/L	0.05	0.07	0.04	0.04	0.02	0.08	0.01	0.055	0.01
Zn^{+2} mg/L	3.0	1	0.07	0.04	0.02	1.02	0.016	0.81	0.05
Pb^{+2} mg/L	0.01	0.05	0.01	0.04	0.03	0.056	0.001	0.054	0.01
Cd^{+2} mg/L	0.003	0.078	0.011	0.08	0.01	0.045	0.001	0.094	0.001

arranged as follows: P7>P8>P6>P5. The quality of water produced from the pretreatment demonstrates that turbidity underwent the strongest reduction up to 100%; it was reduced from 3.4 NTU to ND in P3.

The ability of membrane to removal the contaminates and the maximum removal efficiency are shown in Fig. 10, in P7 were EC recorded 98%, TDS recorded 97%, TH recorded 98%, Mg recorded 97%, Ca–H recorded 98%, SO4⁻ recorded 92%, Cl⁻ recorded

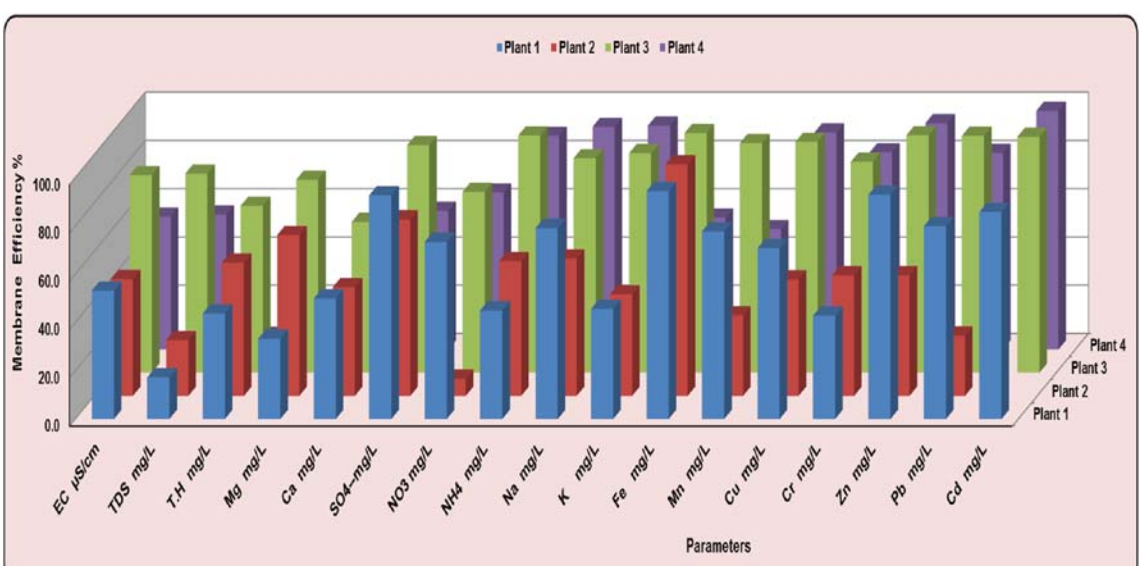

Fig. 9. Membrane efficiency % in reverse osmosis treatment plants (P1, P2, P3, and P4) against contaminates under study.

Table 3. Physico-chemical analysis of water before and after the treatment plants (P5, P6, P7, and P8).

Area Under Investigation at Tala, Al shohadaa and Shepen Elkom cities in Al Menofieya governorate									
Parameters	Allowable range [23]	Plant 5 (P5)		Plant 6 (P6)		Plant 7 (P7)		Plant 8 (P8)	
		Before	After	Before	After	Before	After	Before	After
Color	Color less	Color less	Color less	Color less	Color less	Yellowish	Color less	Color less	Color less
Tasty	Acceptable	Unaccep	Unaccep	Unaccep	Accep	Unaccep	Accep	Unaccep	Accep
Smell	Nonexistent	Existent	Existent	Existent	Non	Existent	Non	Existent	Non
Turbidity NTU	1	1.1	1.1	2.1	ND	3.4	ND	2.3	ND
EC μS/cm	1680	1464	1464	1105	301	836	17.2	521	35
TDS mg/L	1000	891.4	891.4	677	177.6	515	13	314	19
pH	6.5–8.5	7.7	7.7	7.91	7.83	7.84	7.5	8.77	7.69
T.H mg/L	500	400	400	430	110	360	9	200	20
Ca–H mg/L	350	200	200	250	60	220	5	150	12
Mg–H mg/L	150	200	200	180	50	140	4	50	8
Mg mg/L	150	48.6	48.6	43.74	12.15	34.02	0.972	12.15	1.944
Ca mg/L	350	80	80	100	24	88	2	60	4.8
DO mg/L	> 5.0	4.6	4.6	5.7	6.5	5.5	7.8	6.1	8
SO_4^- mg/L	250	217	217	181	101	169	23	174	29
Cl^- mg/L	250	102.13	102.13	61.75	30.9	96.25	3.45	76	6.55
NO_2 mg/L	0.2	0.7	0.7	0.6	0.54	0.74	0.04	0.57	0.11
NO_3 mg/L	45	61	61	41	39	42	1.1	44.2	1.7
NH_4 mg/L	0.5	0.59	0.59	0.6	0.41	0.57	0.01	0.5	0.01
Na^+ mg/L	200	119.7	119.7	94	42.9	59.5	2.4	53.9	2.99
K^+ mg/L	1.0	67.9	67.9	6.69	4.39	20.7	0.78	4.78	0.34
Fe^{+2} mg/L	0.3	2.17	2.17	5.18	3.35	2.95	0.13	3.31	0.53
Mn^{+2} mg/L	0.4	0.39	0.39	1.25	0.35	0.99	0.01	1.11	0.04
Cu^{+2} mg/L	2.0	4.8	4.8	2.2	1.9	2.6	0.01	2.3	0.02
Cr^{+3} mg/L	0.05	0.003	0.003	0.003	0.001	0.002	0	0.02	ND
Zn^{+2} mg/L	3.0	2.08	2.08	1.95	0.97	1.1	0.011	0.615	0.025
Pb^{+2} mg/L	0.01	0.18	0.18	0.02	0.014	0.025	0.001	0.022	0.001
Cd^{+2} mg/L	0.003	0.07	0.07	0.05	0.01	0.04	0.001	0.03	0.001

96% and NO_2–N, recorded 95%, NO_3–N, recorded 97%, NH_4–N recorded 98%, Na^+ recorded 96%, K^+ recorded 96%, Fe^{+2} recorded 96%, Mn^{+2} recorded 99%, Cu^{+2} recorded 100%, Cr^{+3} recorded 100%, Zn^{+2} recorded 99%, Pb^{+2} recorded 96% and Cd^{+2} recorded 98%. Then the average of treatment efficiency for P7 equaled 97.27% and the data showed a descending order of the efficiency of these plants (P5, P6, P7, and P8 were 0.00, 54.31, 97.27, and 92.44, respectively) to removal of contaminates among study period that can be arranged as follows: P7>P8>P6>P1.

3.2. Effectiveness of reverse osmosis treatment

The evaluation of the permeate and feed water concentrations are presented in Fig. 11 and Table 4. The terms of EC, TDS, TH, Mg, Ca, $SO4^-$, Cl^-, NO_2–N, NO_3–N, NH_4–N, Na^+, K^+, Fe^{+2}, Mn^{+2},

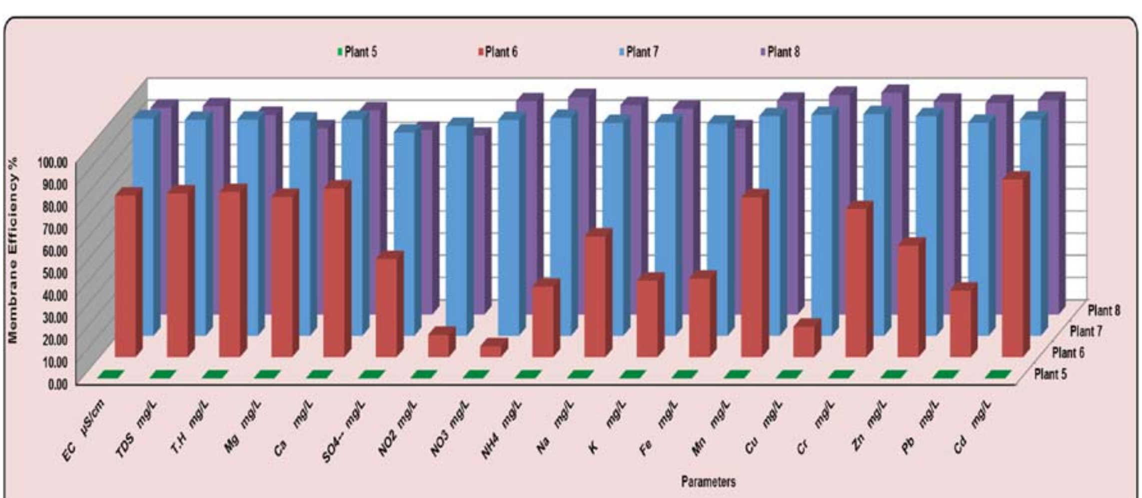

Fig. 10. Membrane efficiency % in treatment plants (P5, P6, P7, and P8) against contaminates under study.

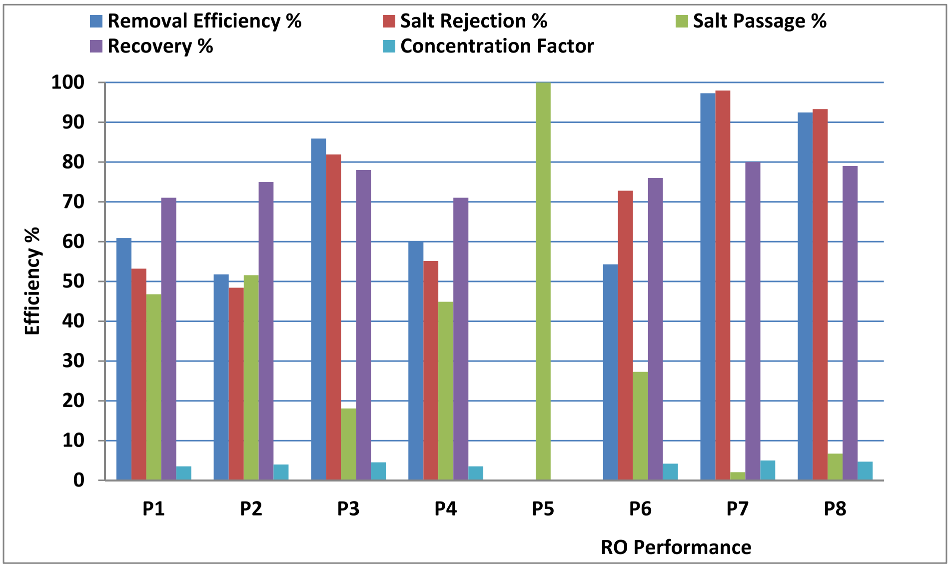

Fig. 11. Reverse osmosis performance in treatment plants (P1, P2, P3, P4, P5, P6, P7 and P8) against contaminates under study.

Table 4. Reverse osmosis Performance (removal efficiency %, salt rejection %, salt passage %, recovery %, concentration factor) in treatment plants (P1, P2, P3, P4, P5, P6, P7, and P8) against contaminates under study.

RO Performance	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*
Removal efficiency %	**60.90**	**51.79**	**85.90**	**60.16**	**0.00**	**54.31**	**97.27**	**92.44**
Salt rejection %	**53.22**	**48.43**	**81.93**	**55.13**	**0.00**	**72.76**	**97.94**	**93.28**
Salt passage %	**46.78**	**51.57**	**18.07**	**44.87**	**100.00**	**27.24**	**2.06**	**6.72**
Recovery %	**71.00**	**75.00**	**78.00**	**71.00**	**0.00**	**76.00**	**80.00**	**79.00**
Concentration factor	**3.50**	**4.00**	**4.50**	**3.50**	**0.00**	**4.20**	**5.00**	**4.70**

Cu^{+2}, Cr^{+3}, Zn^{+2}, Pb^{+2} and Cd^{+2}. Specially, maximum removal efficiency values were recorded 85.9, 97.27, and 92.44% for P3, P7, and P8, respectively. It was observed from these results that RO membranes highly reject all species of materials containing in the feed water. The salt rejection rate varied between 81.93, 97.94, and 93.28% for P3, P7, and P8, respectively, so this is remained stable during the RO operation which signified that the permeate quality was constant. The salt passage varied between 18.07, 2.06, and 6.72, so the lower the salt passage; the better the system is performing. A high salt passage can mean that the membranes require cleaning or replacement. The recovery were varied between 78, 80, and 79% but must be take care that household RO systems can operate at higher recovery rates, but doing so may shorten membrane life. The Concentration Factor was 4.5, 5, and 4.7 for P3, P7, and P8, respectively, so this can lead to higher potential for scaling on the surface of the RO membrane when the concentration factor is too high for the system design and feed water composition.

The results optioned that the plants (P3, P7, and P8) are the best to use were the removal efficiency, salt rejection, salt passage, recovery % and concentration factor values were recorded (85.9, 81.93, 18.07, 78.00%, and 4.50), (97.27, 97.94, 2.06, 80.00%, and 5.00),and (92.44, 93.28, 6.72, 79.00%, and 4.70), respectively. In addition to the plants (P1, P2, and P4) must be change RO membrane because may be expired and finally, the plant (P5) must be modified to RO system.

3.3. Conclusion

RO is an effective and proven technology to produce water that is suitable for drinking water applications that requirement. The plants (P3, P7, and P8) are perfect to use were maximum removal efficiency, salt rejection, salt passage, recovery % and concentration factor values were recorded (85.9, 81.93, 18.07, 78.00%, and 4.50), (97.27, 97.94, 2.06, 80.00%, and 5.00), and (92.44, 93.28, 6.72, 79.00%, and 4.70), respectively. Further post treatment after the RO system such as mixed bed deionization can increase the quality of the RO permeate and make it suitable for the most demanding applications. Proper pretreatment and monitoring of an RO system is crucial to preventing costly repairs and unscheduled maintenance.

Through the previous values for all plants under study, This study recommended changing the RO membranes for plants (P1, P2, and P4) and modifying P5 to an RO system. So, the correct system design, maintenance program, and experienced service support should lead to an RO system that provides many years of high-purity water.

Ethical information

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Conflicts of interest

There are no conflicts of interest.

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