Study the relation between different water parameters for Evaluating the Reverse Osmosis Unit performance In Al-Dora Refinery Water treatment plant.

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Abstract

Reverse Osmosis is an excellent process applied in the works of water desalination usually for the production of water relatively free of salts for industrial purposes especially in establishments causing thermal pollution, as in Al-Dora refinery. The aim of this research is to analyze the water parameters, including (Total Dissolved Solids (TDS), pH-value, Turbidity, residual chlorine, Total Hardness and Alkalinity) which affect the efficiency of the (RO) unit in AL-dora refinery water treatment plant, and comparing concentrations of these parameters with the allowable standards. The weekly mean of daily readings have been taken for the period from 2008-2011, where the removal efficiency(RE%) of the unit was good and within the standard specifications , the relation between RE% for TDS and the other variables are strong during the period (The correlation coefficient magnitude is 0.865). ,except the year 2010,which is not within the standard specifications because of :Tigris river level descent, badness of pretreatment system lead to increase the salts and damaged membranes for desalination.

Key Words: **Reverse Osmosis, TDS, Removal Efficiency**.

دراسة العلاقة بين خواص الماء المختلفة لتقييم أداء وحدة التنافذ العكسي في محطة معالجة ماء مصفى الدورة

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الخلاصـــة

تستخدم طريقة التنافذ العكسي عادة في أعمال تحلية المياه لانتاج ماء خالي نسبيا من الاملاح للاغراض الصناعية وخصوصا في المنشآت التي تتعامل مع التلوث الحراري للماء، اذ تم في هذا البحث تحليل خواص الماء المؤثرة على كفاءة وحدة التنافذ العكسي لمحطة معالجة مياه مصفى الدورة وتتضمن الاملاح الذائبة والاس الهيدروجيني والكدرة والكلور المتبقي والعسرة الكلية والقاعدية ومطابقة تراكيز هذه الخواص مع المواصفات القياسية المسموحة وذلك باعتماد المعدل الاسبوعي للقراءات اليومية لوحدة التنافذ العكسي للفترة من 2008-2011، اذ تميزت هذه الفترة بكفاءة أزالة جيدة والتي هي ضمن المواصفات القياسية كما يوجد أرتباط قوي بين نسبة ازالة الاملاح والمتغيرات الاخرى بلغ مقدار معامل الارتباط 0.865، فيما عدا عام 2010 حيث تميزت هذه السنة بكفاءة أزالة غير جيدة والتي لا تقع ضمن المواصفات القياسية المسموحة من قبل الشركة المصنعة وذلك بسبب: أنخفاض منسوب مياه نهر دجلة الذي سبب في زيادة نسب الاملاح، فضلا عن سوء نظام المعالجة الاولية مما أدى الى ضرر الاغشية المستخدمة في ازالة الاملاح.

الكلمات المفتاحية: التنافذ العكسي، الأملاح الذائبة الكلية، كفاءة الازالة.

Introduction

Reverse Osmosis (RO) is a solution separation process in which a solvent (usually water) is passed through a semipermeable membrane while both suspended solids and solute are retained. The solvent is passed through the membrane by applying a pressure that overcomes the solutions natural osmotic pressure as shown in (figure, 1). (6)

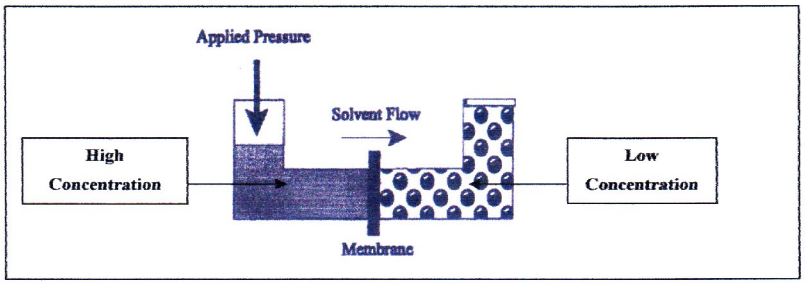

Figure (1): Reverse Osmosis process.

The aim of this work is to study the efficiency level of Reverse Osmosis unit of Al-dora refinery water treatment plant for removing salts (TDS) from water. The parameters which affect the efficiency of the Reverse Osmosis (RO) unit during the period from 1/1/2008 to 1/5/2011 are analyzed and discussed to reach the main objective of this study.

Reverse Osmosis Process Description:

Reverse Osmosis system consists of four major components.(11) They are:

1. Pretreatment system.
2. High pressure pump.
3. Membrane assembly.
4. Post treatment system.

A pretreatment step has the following objectives: (3)

1. To remove excess turbidity and suspended solids.
2. To inhibit or control scaling and the formation of compounds.
3. To disinfect and prevent biofouling (microorganism growths) and equipment contamination.
4. Chlorine has been the most frequently used disinfectant for killing the presence of microorganisms.

The function of high pressure pump is to raise the pressure of the pretreated feed water to the level appropriate for the membrane and for the feed water being used. The pressure required depends on the concentration and temperature of the feed water, osmotic pressure increases with increasing concentration.(7)

RO Membranes Classfication:

Membranes are thin sheet like materials which form a barrier in the feed water path. They are usually permeable to some species and impermeable to others. Reverse Osmosis membranes, while allowing water to pass through, retain 90– 99% of all inorganic substances in solution, 95 – 99 % of the organic constituents. (5)

There are several kinds of membranes materials include: Cellulose Acetate, Cellulose Triacetate, and Thin Film Composite Membranes. (5)

The used main membranes include spiral wound, hollow fiber, and tubular (10; 2). A Comparison of Reverse Osmosis system Types:

1. System costs:-
   Tubular ,plate and frame>> hollow fiber , spiral.
2. Flexibility in design:-
   Spiral >> hollow fiber >plate and frame > tubular
3. Cleaning behavior :-
   Plate and frame > tubular> spiral > hollow fiber.
4. System Space Requirements :-
   Tubular >> plate and frame > spiral > hollow fiber.
5. Susceptibility to Fouling :-
   Hollow fiber >> spiral> plate and frame> tubular.
6. Energy Requirement :-
   Tubular> plate and frame >hollow fiber > spiral

The Factors that Influence Performance of a Reverse Osmosis System:

1- Pressure
2- Temperature
3- Salt Concentration
4- Recovery

Permeate recovery is important parameter in the design and operation of Reverse Osmosis systems. Recovery rate of feed water to product (permeate) is defined by equation. (4; 9)

Recovery (%)= (Qp/ Qf) * 100 %

Where:
Qp = Product water flow rate = [m³/day]
Qf = Feed water flow rate = [m³/day]
5 - pH-value

Advantages & Disadvantages of Reverse Osmosis Process:

Advantages of RO Process:-
•Suitable for both sea and brackish water.
•Low power requirement compared with (Multi Effect Desalination and Vapor compression).
•Simple Operation and build cheap.
• Flexibility in site location
• The use of chemicals for cleaning purposes is low. (1; 8)

Disadvantages of RO Process:
• Requires high quality feed water.
• High pressure requirements.
•Long construction time for large plants.
• Relatively high capital and operating costs.
•Reverse Osmosis membranes are expensive and have a life expectancy of 2-5 years. (1; 8)

Analysis & Discussion of Data

The Salt Rejection (%) of the unit:

Salt rejection expresses the effectiveness of a membrane to remove salts from the water.

It can be calculated from the following equation:

Salt rejection (%) = (1- TDS out / TDS in) *100

The data in the (figure 2) that represents the salt rejection (%) covers the period from 2008-2011. From observing the figure, where the removal efficiency of the unit (RE %) appeared good, which is already within the specifications of the unit as designed by (Vivendi Company) for the desalination works by Reverse Osmosis, and its value must be 93%. It was also found that the removal efficiency of the unit was not so good and ranged between 82% - 90% in year 2010. The unit output efficiency is not within the standard specifications.

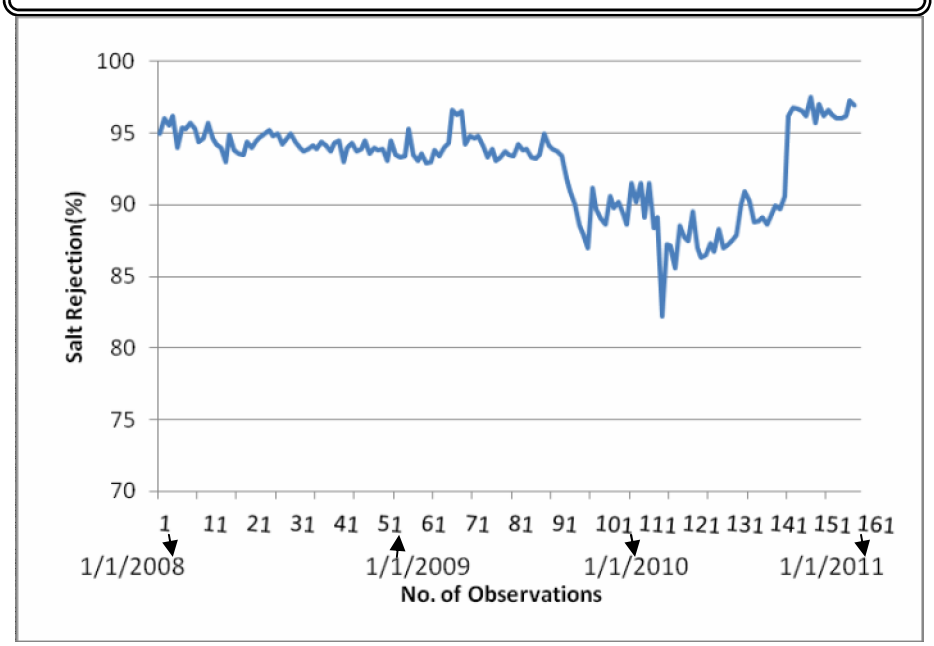

Figure (2): Salt Rejection (%) of RO unit for the years (2008-2011).

Analysis of Water Parameters

1. Turbidity data analysis:

In (figure, 3) we show plots of turbidity entering the unit, it can be seen that (turbidity in) values are within the specified standard by Vivendi Company of 1 NTU. Except the year 2010, there are some of values are not conformable to the specifications, also (figure, 4) shows plots of turbidity exited the unit, it can be seen that (turbidity out) values are conformable to the specified standard company of 0.5 NTU.

It is clear from this figure that efficiency of unit to remove the turbidity is not good in the year 2010 and (turbidity out) values are not conformable to the specifications, this is because of several things such as damaged membranes .

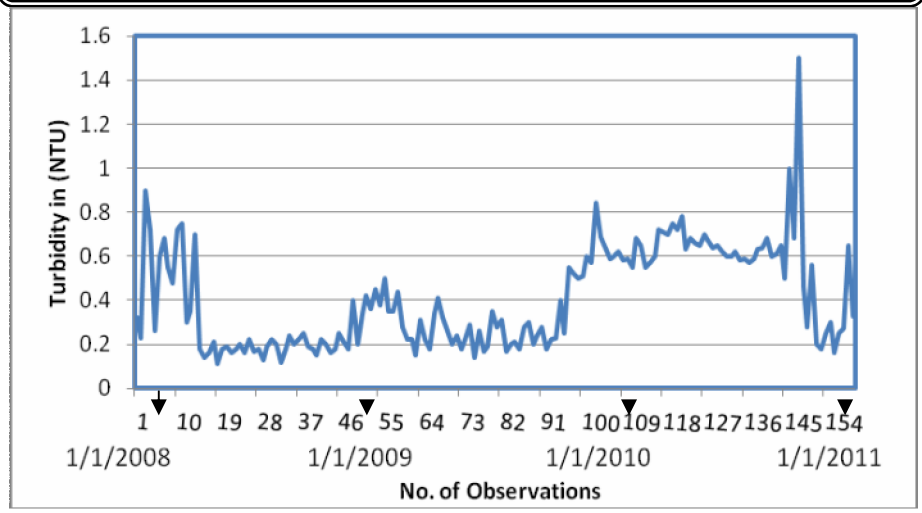

Figure (3): Turbidity of water entering the RO unit during the period (2008-2011).

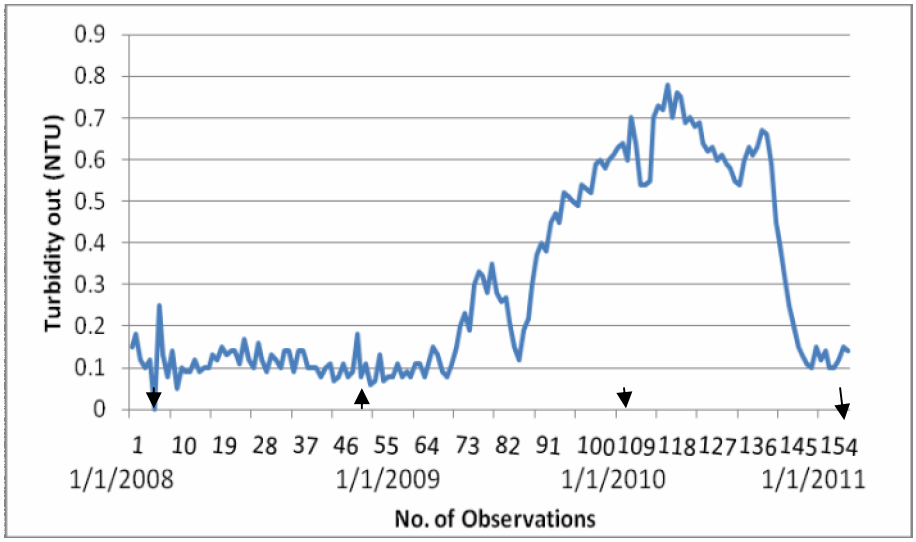

Figure (4): Turbidity of water leaving the RO unit during the period (2008-2011).

2. Residual Chlorine data analysis:

In (figure. 5) we show plots of chlorine in water exited the unit (Cl_2 out) , it can be seen that (Cl_2 out) values are below 0.05 mg/l, which is conformable to the specifications by Vivendi Company of 0.05 mg/l. On the other hand, it can be seen from figure that for (Cl_2 out) there are a 44 observations from the 160 observations are not conformable

to the specifications, where the exit value more than 0.05 mg/l (the limit).

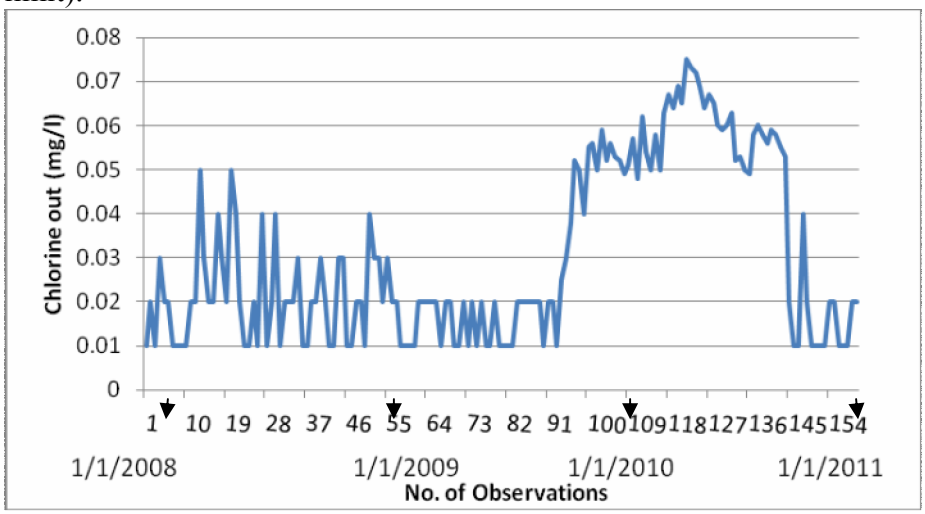

Figure (5): Chlorine of water leaving the RO unit during the period (2008-2011).

3.Total Hardness data analysis:

The test of total hardness is one of the important tests to know the quantity of salts in water to know its influence on the unit efficiency. In (figure, 6), it can be seen that (T.H. out) values vary between 8– 21 mg/l, where some of the (T.H. out) values are not conformable to the standards specifications by Vivendi Company ≤ 12.It is shown throughout the year 2010.

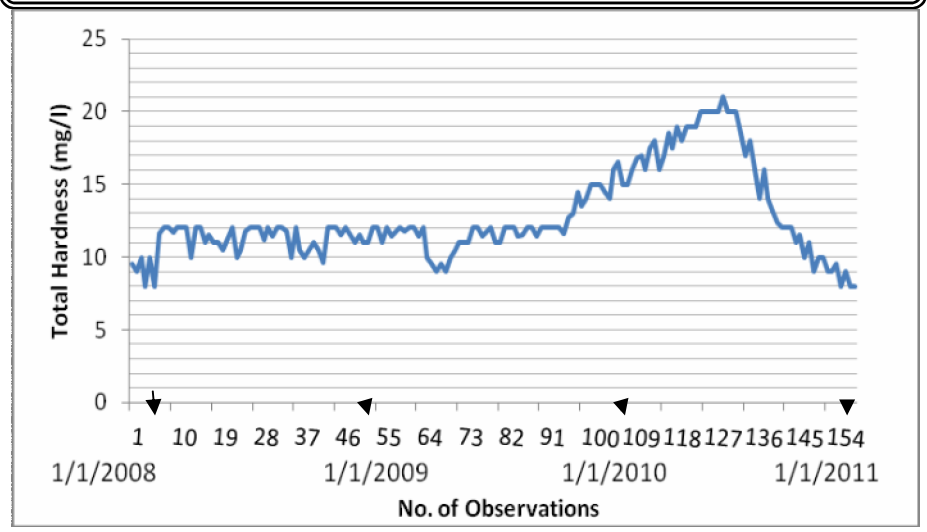

Figure (6): Total Hardness of water leaving the RO unit during the period (2008-2011).

4-Alkalinity data analysis:

In (figure 7) we show plots of Alkalinity exited the unit, it can be seen that (Alk.. out) values vary between 12 – 30 mg/l, where some of the (Alk.. out) values are not conformable to the standards specifications by Vivendi Company ≤ 25.It is shown throughout the year 2010. It is clear that the unit was not to work well and regularly throughout the year 2010, that is because of damaged membranes and the unavailability of chemical materials of the required for desalination.

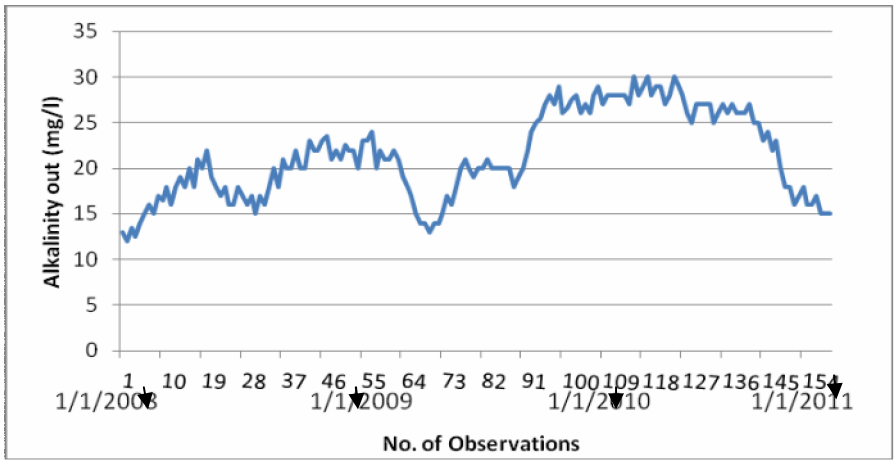

Figure (7): Alkalinity of water leaving the RO unit during the period (2008-2011).

Salt Rejection- water parameters relationship :

Regression Model between the unit efficiency to remove TDS (Salt Rejection) and the other variables (pH, Residual Chlorine, Turbidity, Total hardness and alkalinity). The correlation coefficient between the unit efficiency to remove salts and the other variables are strong.. The following relations explain that:

1-Salt Rejection % = 97.837 – 11.051 * Turbidity – 0.290 * pH …… (1)

The correlation coefficient magnitude is 0.766

2-Salt Rejection % = 96.331 – 11.256 * Turbidity – 10.249 * Cl_2 ……(2)

The correlation coefficient magnitude is 0.795

3--Salt Rejection % = 108.175 – 0.528 * T.H. – 0.7 * Alkalinity ……(3)

The correlation coefficient magnitude is 0.865

One notice from the preceding that the unit work is good and successfully for the period from 1/1/2008 to 1/1/2010 and form 1/1/2011 to 1/5/2011 and that is because the parts of the unit and membranes still work good as well as that all inputs of the unit (TDS, turbidity, pH, Cl_2,T.H.,Alkalinity.) are suitable for the required specifications of the unit work. Except the year 2010 , is clear that the unit was not to work well and regularly that is because of damaged membranes and the unavailability of chemical materials of the required for desalination.

Conclusions

It is clear that the concentration of (TDS out) began to increase apparently throughout the year 2010; where the RO unit doesn't work with the specified efficiency, and that may be attributed to several factors, some of are membranes life expiry or the anti scalant dosing was not enough to prevent the precipitation of salts on the membranes, unavailability of the staff experience, non continuous maintenance to the unit or badness of pretreatment system.

It can be observed, that the variables such as(pH, chlorine, turbidity,T.H. and alkalinity) have strong effects upon the efficiency of unit removal of TDS.

The pretreatment system had a significant effect on reverse osmosis unit efficiency.

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