TREATMENT OF INDUSTRIAL WASTE WATER USING REVERSE OSMOSIS TECHNIQUE

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ABSTRACT

Reverse osmosis technique was used for the treatment of industrial waste water. Ions like calcium, magnesium, sodium, sulfate, and nitrate were found in the waste water of the General Company of Vegetable Oil with high concentrations which must be treated for reuse. Feed water containing the above mentioned ions was fed to the RO unit at feed flow rates (0.4 and 0.8 lit/min) and different operating pressure (2-4bar) .It is concluded that increasing operating pressure and feed flow rate improved the separation by a decrease in the concentration of ions in the product. High rejection was obtained for all ions present in feed water, ranging from (63.8-97.6%). Rejection of TDS was 87% when the concentration of TDS was reduced from 1192 to 154.94 ppm.

الخلاصة

تقنية التنافذ العكسي أستخدمت لمعاملة المياه الصناعية . أيونات الكالسيوم و المغنيسيوم و الصوديوم و االكبريتات و النترات توجد في المياه الصناعية المطروحة من الشركة العامة للزيوت النباتية وبتراكيز عالية يجب أن تعالج لغرض اعادة استعمالها. المياه الحاوية على الأيونات أعلاه تدخل الى وحدة المعالجة بالتناضح العكسي بمعدل جريان (0.4 و0.8 لتر/دقيقة) وتحت ضغط تشغيلي (2-4 بار).لقد استنتج ان زيادة الضغط ومعدل الجريان ادى الى تحسين عملية الفصل بتقليل تركيز الايونات في الماء الناتج. أزالة عالية لكل الأيونات الموجودة في المياه الداخلة تمت بمعدل (63.8-97.6 %). ومعدل أزالة لكمية المواد الصلبة الكلية الذائبة كان (87%) عندما أنخفضت هذه الكمية من 1192 الى 154.94جزء بالمليون.

INTRODUCTION

The use of reverse osmosis (RO) to remove salts and impurities from water had been a recognized technology to improve water quality therefore it had a valuable application in the reuse of waste water streams. The benefit includes; reduced discharge, reduced purchases and the conservation of water resources. In the reverse osmosis process, water passes through a semi-permeable membrane which removes inorganic minerals like radium, sulfate, calcium, magnesium, potassium, sodium, nitrate, fluoride and phosphorous. It also helps to remove some organic compounds including some pesticides (Zibrida et al., 2000). RO can be used for the removal of arsenic which occurs naturally and can contaminate drinking water through the erosion of rocks and minerals or through human activities such as fossil fuel burning, paper production, cement manufacturing, and mining. Natural contamination of groundwater by arsenic has become a crucial water quality problem in many parts of the world (Pawlak, 2006). Often, reverse osmosis units are used in combination with a mechanical filter and an activated carbon filter. The water passes through the mechanical filter first, where sand and large particles are removed, then through the reverse osmosis unit, and lastly through the activated carbon filter which removes organic compounds (Daniels, and Mesner, 2005).

Applications of membrane technologies for water and wastewater treatment is growing due to decreasing price of membranes and more stringent regulations for water quality. Membrane separation processes have following advantages in industrial applications:

- appreciable energy savings , - clean and easy to apply technology, -replaces several conventional processes like filtration, distillation, ion-exchange and chemical treatment with smaller and more efficient equipment - produces high quality products - allows greater flexibility in designing systems. During the last two decades significant advances have been made in the development and application of microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) processes. MF membranes reject suspended particles only, UF membranes reject suspended particles and high molecular weight compounds, NF membranes also reject low molecular weight compounds, and RO membranes also reject ions (Kochany, 2007, and Amjad and Zibrida, 1998).

Over 100 different materials are used to make RO membranes, however the two most commonly used membranes are made from cellulose acetate (CA) and polyamide thin film composite (TFC). These may come in spiral, tubular hollow fiber, and plate and frame. Hollow fiber (HF) and flat sheet are the most commonly used RO membrane configurations. Although HF RO elements provide more surface area, they are more prone to fouling..

Most studies on industrial waste water using RO were limited on either feed containing NaCl salt (Ahmed, 2000, and Mohammed, 2008) or feed containing dye (Mahmood, 2001). In the present study, investigation of five different monovalent and divalent ions (Ca^{++}, Mg^{++}, Na^{+}, SO_4^{--}, NO_3^{-}) was the point of view in the treatment of industrial waste water. The important parameter to be compared is the rejection percentage.

EXPEREMENTAL WORK:

(i) Experimental apparatus:

The Experimental apparatus consists of the following parts:

1) QVF feed tank with capacity of 20 liter.
2) Centrifugal pump is used to pump the feed at a pressure of 4-6 bar.
3) Rotameter of (0.2-2 lit/ min.).
4) 5-stage reverse osmosis system supplied by So-Safe Water Technologies.

1. Wound Polypropylene Yarn (WPP) or Spun Polypropylene (SPP) is used for pre-filtration to remove the sediments.

2&3. Activated carbon (GAC) and dual purpose carbon (DPC) used for the purification for taste and odor.

4. Desalination and purification using reverse osmosis membrane. Thin film composites membrane (The spiral – wound module type TFC – 8822HR) is installed for best permeate water quality.
5. Water polishing and purification unit using In-line granular activated post carbon cartridge (ILGAC-10).

The schematic diagram of the experimental apparatus is shown in Fig. 1.

(ii) Experimental Procedure:

Industrial water from the factories of The General Company of Vegetable Oil was analyzed for the specified ions; Ca^{++} , Mg^{++} , Na^{+} , SO_4^{--} , NO_3^{-} . Feed solution to the RO unit, containing the aforementioned was prepared. Table 1 shows the analysis of the prepared feed water. Salts of analytical grades from Merck Company were used.

Feed solution containing the specified ions, with the appropriate concentrations, was added to the 20 liter feed tank. The outlet valve was opened to fill the pipes with water. The pump was switched on and the feed rate of 0.4 and 0.8 lit/min was set. Operating pressure range was (2-4 bar) for each flow rate. Concentrations of the product solution were analyzed using Atomic absorption technique.

RESULTS AND DISCUSSIONS

Operating pressure affects the performance of RO units. Concentrations of the specified ions as a function of the operating pressure were drawn for both feed flow rates. The results are shown in Figs. (2-6).The effect of operating pressure and feed flow rate on the total TDS is shown in Fig 7. It is obvious that increasing the operating pressure or feed flow rate improves the degree of separation for each ion. However, the operating pressure has a pronounced effect compared with feed flow rate. Increasing operating pressure offers a pressure gradient across the membrane and the driving force will be higher, therefore water is forced to pass through the membrane and %rejection is increased. Considerably high pressures are necessary to overcome osmotic pressure which is mainly a function of concentration and molecular weight (Amjad and Zibrida, 1998 ;Singh and Heldman,1993).

When the feed rate was increased, concentration of ions in product solution and hence, TDS, were decreased and %Rejection was increased. This means that the degree of separation is increased by an increase of the throughput rate and increase of mass transfer coefficient between the membrane and feed flow.

% Rejection for 0.8 lit/min flow rate is also calculated in order to investigate the degree of separation for each ion as shown in Fig.8. 87% of TDS are rejected which is an acceptable value, and for individual ions, it can be seen from Fig.9, that SO_4^{--} and NO_3^- ions have the lower %Rejection while, NO_3^- has the lowest. Nitrate is so soluble and non-reactive; therefore it is very difficult to be removed from water. These results are in agreement with those obtained by Ellen, 2007. Therefore, it is possible to say that the best operating conditions are feed flow rate 0.8 lit/min and operating pressure 4 bars.

CONCLUSIONS:

1. The concentration of ions in the product solution decreases with increasing operating pressure. Increasing operating pressure are necessary to overcome the osmotic pressure and the driving force will be higher, therefore, TDS decreased.
2. The concentration of ions in the product solution decreases with increasing feed flow rate.
3. The percent of rejection for each ion differ from each other. Sulfate and nitrate were lower than other ions. Nitrate ions had the lowest % Rejection.
4. It is demonstrated that the RO process could effectively applied for the removal of calcium, magnesium, sodium, sulfate, and nitrate ions. The best operating conditions are feed flow rate of 0.8 lit /min and 4 bar operating pressure.

NOMENCLATURE

MF Microfiltration
NF Nanofiltration
ppm Part per million
RO Reverse osmosis
TDS Total dissolved solids
UF Ultrafiltration

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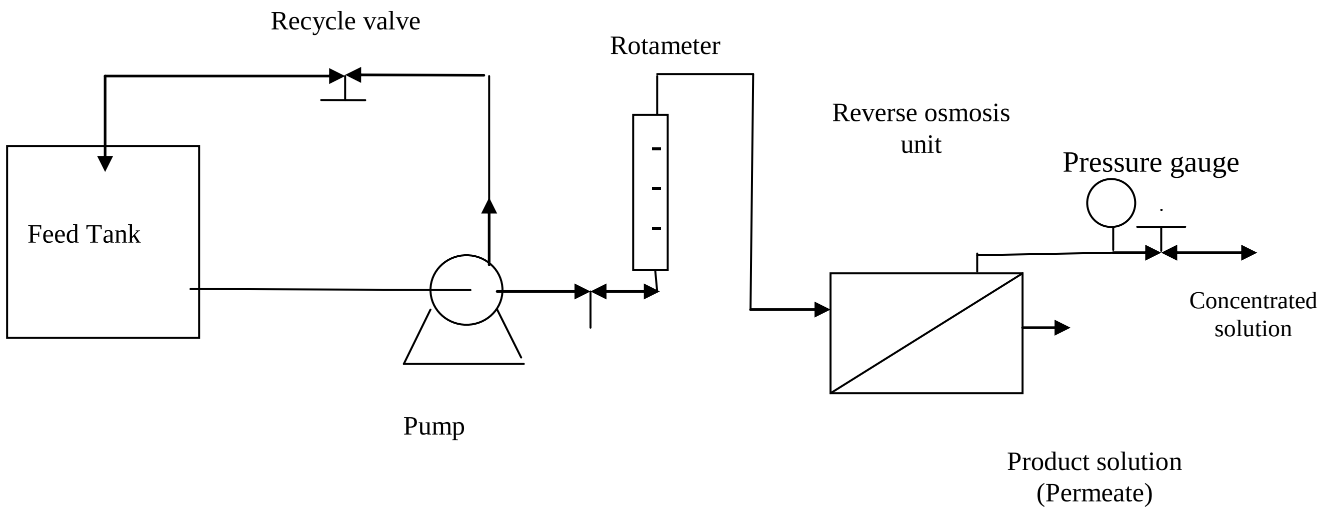

Fig. 1 Schematic diagram of reverse osmosis unit.

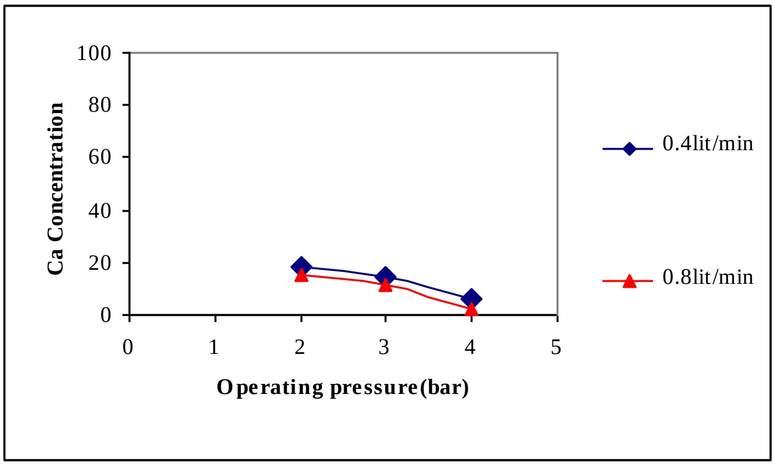

Fig. 2Concentration of Ca^{++} vs operating pressure.

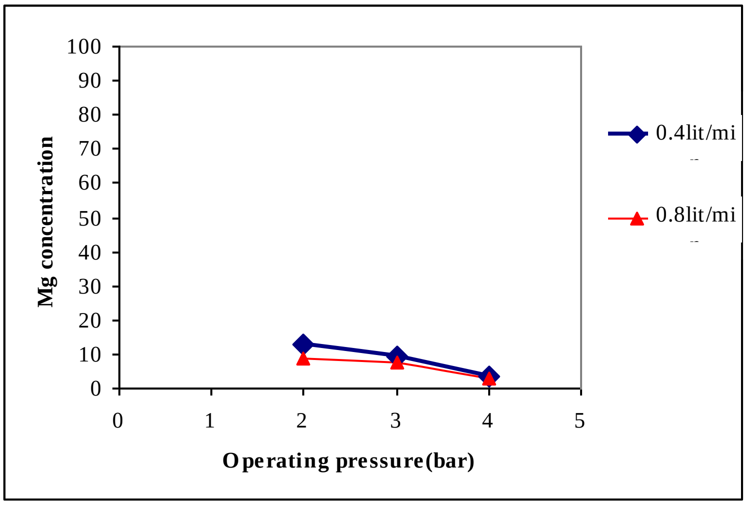

Fig. 3 Concentration of Mg^{++} vs operating pressure.

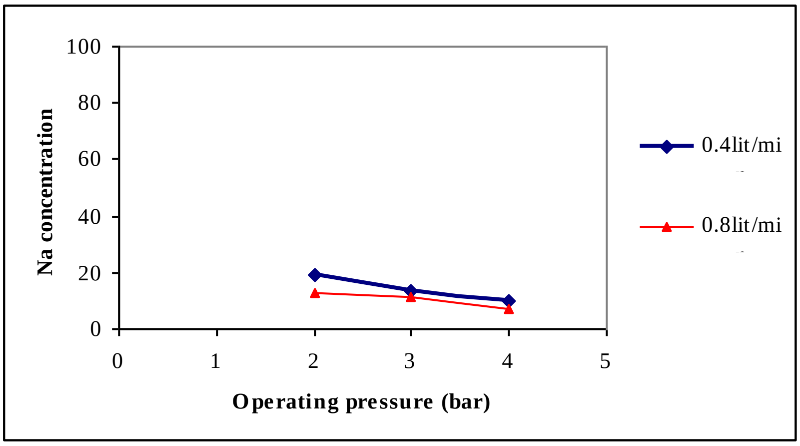

Fig. 4 Concentration of Na^{+} vs operating pressure.

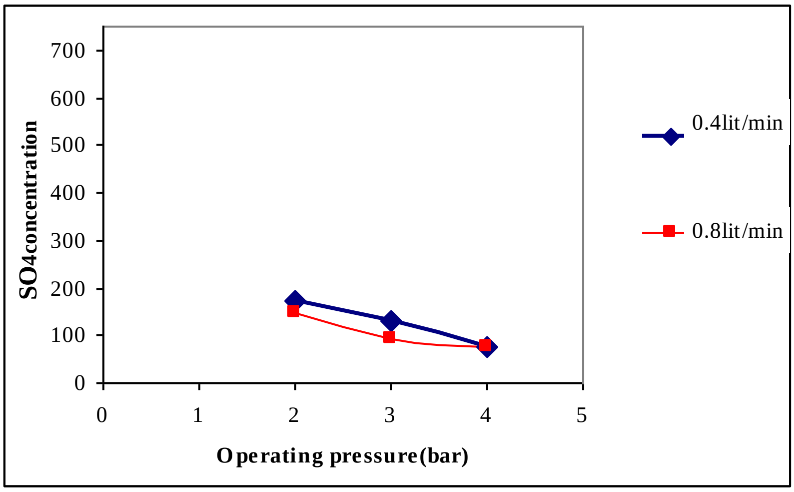

Fig. 5 Concentration of SO_4^{--} vs operating pressure.

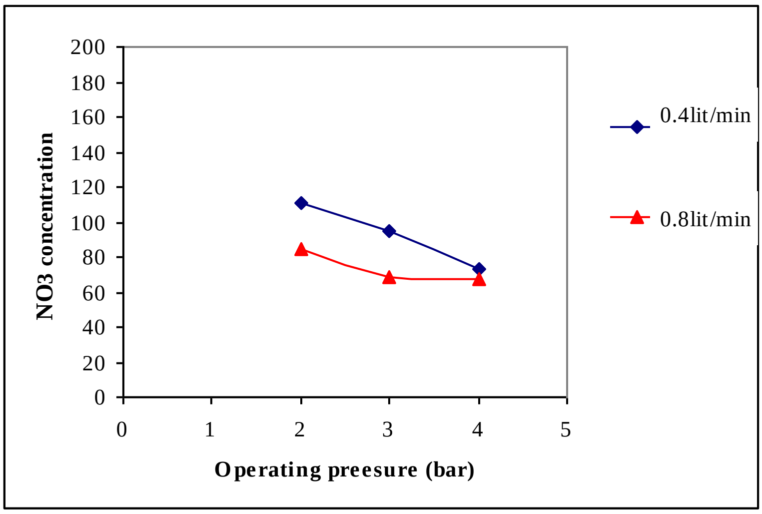

Fig. 6 Concentration of NO_3^- vs operating pressure.

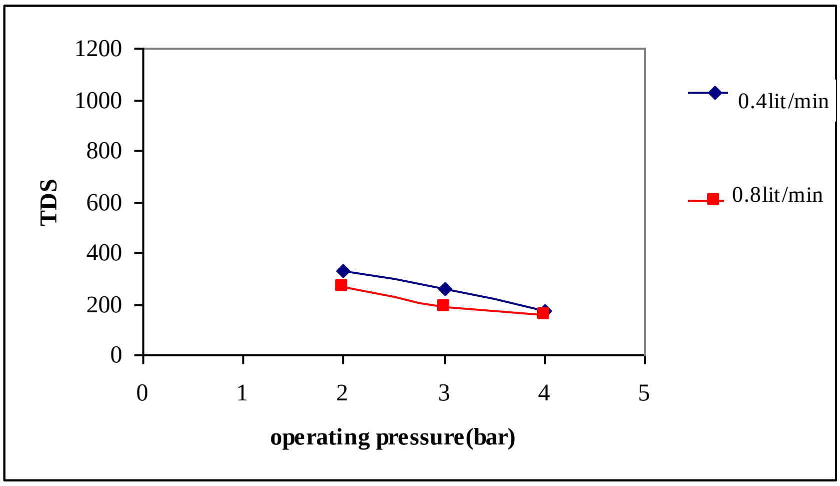

Fig. 7 Total dissolved solids vs operating pressure.

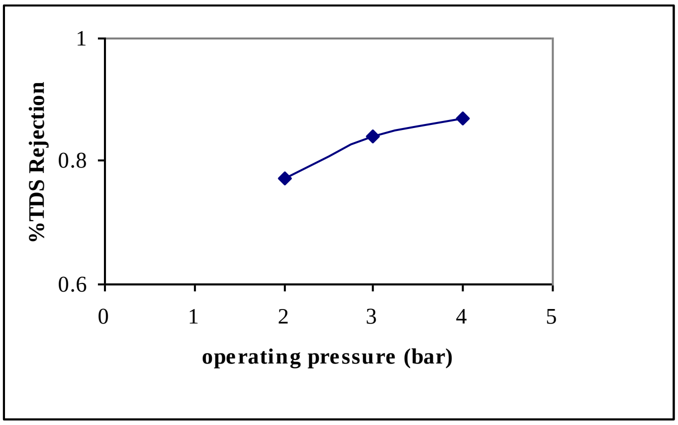

Fig. 8 % TDS Rejection vs operating pressure.

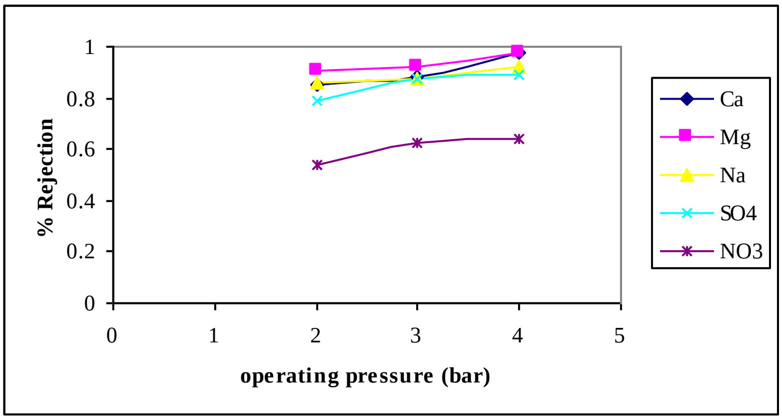

Fig. 9 % Rejection for different ions vs operating pressure.

Table 1. The initial concentrations of feed solution.

Feed water ion	**Concentration (ppm)**
Ca^{++}	100
Mg^{++}	100
Na^{+}	90
SO_4^{--}	717
NO_3^{-}	185
TDS	1192