Desalination of Sea Water using Both Electrodialysis and Reverse Osmosis as Complementary Methods

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Abstract— Desalination process separates nearly salt free water from sea or brackish water. So, desalination process is becoming a solution for water scarcity all over the world. Two membrane methods of water desalination namely Electrodialysis (ED) and reverse osmosis (RO) are used in this study as complementary methods. The results show that both ED and RO can be used as integrated system. This system is economic and cost effective compared with each individual method provided using the ED system before the RO. In this study, it was approved that seawater can be used as it is an electrolyte. In a world faced with increased urbanization, population growth, climate change and degradation of water supplies, the importance of a reliable source of technology to provide fresh water emphasizes the importance of seawater desalination. Over the years a variety of seawater desalination methods have been developed throughout the world. The most common technologies available for desalination around the world are membrane reverse osmosis (RO), thermal distillation (TD) and Electrodialysis (ED).The shortage of drinking water is a major problem in the global. In these areas, it is essential to make use of water from underground reservoirs, most of which are over exploited and suffer from saline contamination given their proximity to the sea. The desalination of brackish water (salt water) is a means of obtaining low cost drinking water. Electrodialysis is a technique based in the transport of ions through selective membranes under the influence of an electrical field. This technique has proved its feasibility and high performance in the desalination of brackish water, the desalting of amino acids and other organic solutions, effluent treatment and or recycling of industrial process streams and salt production.

Keywords: Sea Water, Electro-Dialysis, Reverse Osmosis, Hardness

I. INTRODUCTION

In this century, the most crucial problem afflicting people around the world is global water scarcity. The rapid growth in population has resulted in greater demand on the quantity of drinking water, leading to catastrophic water shortage in arid and water-stressed region areas. It is projected that by year 2030, the global needs of water would increase to6900 billion m3 from the current 4500 billion m3. So, about53% increase in the amount of drinking water is needed by year 2030. Consequently, the present surface water resources will no longer be sufficient to meet the future needs form a kind.

With the fact that only around 0.8% of the total earth's water is fresh water. The global installed desalination capacity by water sources and the use of seawater as feed brine have contributed more than half of the total capacity produced worldwide. Desalination is necessary in arid countries and in cases where good-quality water is required for industrial Purposes and fresh water is not available.

Membrane based processes include reverse osmosis (RO), membrane distillation (MD) and Electrodialysis (ED). For the treatment of brackish groundwater, Electrodialysis or Electrodialysis reversal is robust against scaling problems and they can effectively remove disinfection byproduct precursors, such as bromide and organic matter. The most important industrial application of ED is the production of drinking water from brackish water and seawater as well as demineralization of solutions of widely varying industrial fluids encountered in the food, chemical and pharmaceutical industries

During the past 30 years, reverse osmosis (RO) is increasingly used in seawater and brackish water desalination, water treatment and wastewater reclamation due to the superior and stable quality of the water produced and the relatively low cost. In this study, the desalination process was carried out using both the Electrodialysis and reverse osmosis as complementary methods to avoid their disadvantages. Electrodialysis process was applied firstly followed by reverse osmosis.

II. DESALINATION TECHNOLOGIES

Desalination is a technological process whose outcomes are fresh water and highly concentrated brine. The beginning of industrial use was first recorded in the middle of the 20thcentury. Since that time, much has changed. Nowadays there are more than 15 000 desalination plants around the world, mostly seaside and in areas with water scarcity. Despite the great number, potable water reached by technology is only about two percent of world consumption. The main problem is energy requirement.

Up to present time, many desalination principles have been tested and are still constantly developing. Major technologies are divided in two groups, distillation processes, membrane processes. Certainly there are utilized its combination and some next unconventional methods.

A. Electrodialysis (ED/EDR)

Electrodialysis (ED) or Electrodialysis reversal (EDR) is an Electrochemical charge-driven separation process where dissolved ions are separated through ion permeable membranes under the influence of an electrical potential gradient. Ion exchange membranes, fabricated from ion exchanges polymers, have the ability to selectively transport ions with a positive or negative charge and reject ions of the opposite charge. An electrical potential is used to move salts through a membrane, leaving fresh water behind as product water. Electrodialysis (ED) desalination process has generally been used for brackish water desalination. In a saline solution, the dissolved ions such as sodium (+) and chloride (-) travel to the opposite electrodes passing the

rough. Membranes are basically positioned in an alternate form, with the anion selective membrane followed by cation selective membrane. In this process, the content of salt water channelled is diluted, while the concentrated solutions are formed at the electrodes. Electrodialysis (ED) unit consist of several hundreds of cells bound together with electrodes, referred to as a stack. Feed water passes through all the cells simultaneously to provide a continuous flow of desalinated water and a steady stream of concentrate (brine) from the stack.

An Electrodialysis reversal (EDR) unit operates in the same process as Electrodialysis (ED), except that both the product and concentrate channels are identical in construction. The reversal process is useful in breaking up and flushing out scales, slimes, and other deposits in the cells before they build up. Flushing helps in reducing the problem of membrane fouling.

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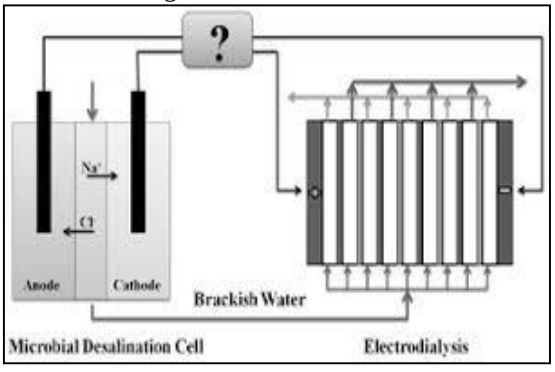
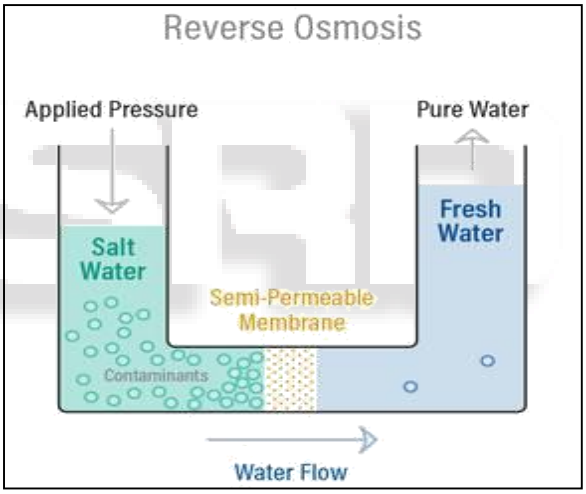


C. Reverse Osmosis (RO)

Reverse osmosis is a process in which water passes through a semi-permeable membrane from a lower-concentration solution to a higher-concentration solution. Reverse osmosis is used for both brackish water and seawater desalination as well as for waste treatment and water recovery/reuse. This process occurs in both plant animal tissue including the human body (e. g secretion and absorption the small intestine). When pres-sure is applied to the higher concentration part of the membrane the re-verse process occurs, whereby water diffuses through the semi-permeable membrane from the high-concentration solution to the lower-concentration solution. Figure 30 shows the basic process of a reverse osmosis.

The seawater has been pumped under pressure across the surface of the membrane, water molecules diffuse through the membrane leaving a concentration brine solution on the feed-side of the membrane and fresh water on the low-pressure product side. Brine solution is rejected as wastewater and is usually between 10% and 50% of the feed water depending on the salinity and pressure of the feed water. A typical RO desalting plant consists of three sections, namely pre-treatment section, membrane section and post treatment section which is discussed below.



The main advantages of RO plants include the following:

- Low energy consumption.
- Low thermal impact of discharges.
- Fewer problems with corrosion.
- Higher recovery rates (about 45 percent for seawater
- Removal of contaminants (such as trihalomethane-precursors, pesticies and bacteria).
- Plant footprint is smaller than other desalination processes.
- Flexible to meet fluctuations in water demand.

The disadvantages of RO plants include the following:

- Sensitivity to feed water quality.
- Membrane fouling calls for frequent chemical cleaning of the.

III. MATERIALS AND METHODOLOGY

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membranes under the influence of an electrical potential gradient. Ion exchange membranes, fabricated from ion exchanges polymers, have the ability to selectively transport ions with a positive or negative charge and reject ions of the opposite charge. An electrical potential is used to move salts through a membrane, leaving fresh water behind as product water. Electrodialysis (ED) desalination process has generally been used for brackish water desalination. In a saline solution, the dissolved ions such as sodium (+) and chloride (-) travel to the opposite electrodes passing the rough. Membranes are basically positioned in an alternate form, with the anion selective membrane followed by cat ion selective membrane. In this process, the content of salt water channelled is diluted, while the concentrated solutions are formed at the electrodes. Electrodialysis (ED) unit consist of several hundreds of cells bound together with electrodes, referred to as a stack. Feed water passes through all the cells simultaneously to provide a continuous flow of desalinated water and a steady stream of concentrate (brine) from the stack.

Schematic connections for Electrodialysis process

A. Relevance and applications to the field (industry/ technology/ agriculture/ health/ society etc

Selecting the best suitable desalination by Electrodilysis and Reverse osmosis technology is very important, depending on different site-specification, including the concentration of organic and inorganic material in the incoming feed water, the required quality of the treated water, the level of pre-treatment that maybe required prior to desalination, the availability of energy and chemicals to treat the water, and the ease with which waste concentrates can be disposed. Many other aspects that should be taken into consideration include. The availability of construction and operating personnel, waste concentrate disposal, environmental considerations, maintenance requirements and costs.

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IV. PHOTO GALLERY

Fig. 1: Hardness Test

Fig. 2: Chloride Test

Fig. 3: Acidity Test

Fig. 4: Alkalinity Test

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