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Application and Future Prospects of Reverse Osmosis Process

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15.1 Introduction

Many studies and researches have been done to improve and find new and efficient water treatment technologies. Conventional water treatment method cost more and it needs big facilities. Several nanotechnologies are applied worldwide to fulfill fresh water demand such as microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO). The NF and RO processes can supply potable water in huge quantity for industrial applications and the quality of water is better than conventional treatments. They can remove various organic and inorganic impurities from seawater, surface water, and groundwater. In surface water treatment, stringent regulations and quality concerns are the major factors. The main drawback is spiral wound NF or RO systems in treating surface waterfoul rapidly (Reiss, 2005).

In conventional desalination processes, the alternative energy sources such as wind energy, solar energy and nuclear energy can be used to save our environment. A hybrid process may be the suitable option as well to implement (Van der Bruggen and Vandecasteele, 2002).

In membrane technology, many advanced studies have been made in the last two decades and mass production has made wastewater reclamation feasible for large scale application. Two main membrane processes used in wastewater reclamation such as MF/UF and RO (Cheremisinoff, 2002; ECW542, 2018). In this study, a brief introduction on RO technique and the potential applications and concerns of RO are discussed (Table 15-1).

15.2 Reverse Osmosis

The RO is a process of forcing the water under pressure using a semipermeable membrane to produce potable water from polluted or saline water. Consequently, it allows the potable water molecules only, whereas it rejects salts and other dissolved elements (Reverse Osmosis, 2018). The RO membrane allows smaller components of the solution to pass freely

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Table 15-1 Compares Membrane Structures (Cheremisinoff, 2002)

Technology	Structure	Driving Force	Mechanism
Microfiltration	Symmetric microporous (0.02–10 μm)	Pressure, 1–5 atm	Sieving
Ultrafiltration	Asymmetric microporous (1–20 nm)	Pressure, 2–10 atm	Sieving
Nanofiltration	Asymmetric microporous (0.01–5 nm)	Pressure, 5–50 atm	Sieving
Reverse osmosis	Asymmetric with homogeneous skin and microporous support	Pressure, 10–100 atm	Solution diffusion
Electrodialysis	Electrostatically charged membranes (cation and anion)	Electrical potential	Electrostatic diffusion

through the holes such as solvent molecules but not allows large molecules or ions (Warsinger et al., 2016; Reverse Osmosis, 2018). It is very popular technique for potable water production from saline water and seawater (Reverse Osmosis, 2018; Crittenden et al., 2005). It also can remove other common organics like Humic and Fulvic acids. Consequently, the RO process has many promising applications (Chapter 6, 2018).

15.3 Applications of Reverse Osmosis

Around the globe, the RO is a popular technique to produce drinking and cooking water (Reverse Osmosis, 2018).

15.3.1 Drinking Water

The RO process is used in worldwide, especially in Middle East, to produce pure water in huge quantity. For saline or seawater treatment, it may have the highest users compared to other techniques. However, in USA Marine Corps, the RO unit is replaced by both the Lightweight Water Purification System (LWPS) (470 L/h) and Tactical Water Purification Systems (TWPS) (4,500–5,700 L/h) (Fuentes, 2018).

15.3.2 Water and Wastewater

Singapore produces pure water (NEWater) from domestic wastewater using the RO process. In Los Angeles and other cities of United States, the water shortage problem is solved using rainwater collected from storm drains, which is purified by RO (Reverse Osmosis, 2018).

15.3.3 Wine Industry

About 60 RO machines were used in wine industry in Bordeaux, France, in 2002 (Reverse Osmosis, 2018; Reverse Osmosis in Wine Filtration, 2018).

15.3.4 Sirup Production

The RO process is used in maple sirup producing industry for removing water from sap, which is boiled to make sirup. It can remove about 75%–90% of the water from sap (Reverse Osmosis, 2018).

15.3.5 Hydrogen Production

The RO process is sometimes used in hydrogen production, to prevent formation of minerals in electrodes (Reverse Osmosis, 2018).

15.3.6 Reef Aquarium

The RO process is used in reef aquarium to mix seawater artificially (Reverse Osmosis, 2018).

15.3.7 Window Cleaning

The RO process is used in cleaning windows. As an alternative of washing the windows with detergent, they are scrubbed with the purified water (Reverse Osmosis, 2018).

15.3.8 Leachate Treatment

The use of RO process is limited in landfill leachate treatment (Reverse Osmosis, 2018).

15.3.9 Desalination

The RO process is used extensively in desalination due to its relatively low energy consumption. In 2011, the RO process was used in 66% of desalination pants, according to the International Desalination Association (IDA). In 2013, the largest RO plant was built in Sorek, Israel. It can produce 165 MGD and the water price is \$0.58 /m^3 (Reverse Osmosis, 2018; Next big future, 2018; Talbot, 2018).

15.3.10 Defluoridation

Defluoridation is a process used for the removal of fluoride from water/drinking water. Figure 15-1 shows that the RO integrated with adsorption for defluoridation. In India, this type of treatment was performed where two adsorbents, namely, a hybrid anion exchange resin embedded with zirconium oxide nanoparticles and activated alumina were used in column experiments. They found that fluoride can be successfully removed from the reject water of the RO unit using adsorption (Samrat et al., 2018).

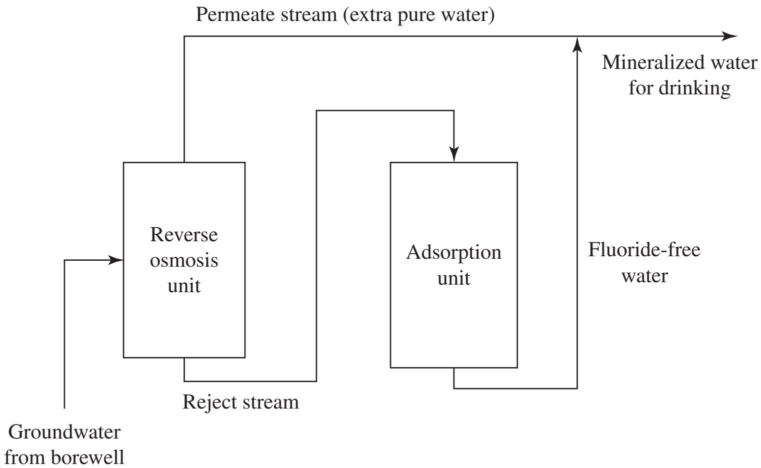

FIGURE 15-1 RO integrated with adsorption for defluoridation (Samrat et al., 2018).

15.4 Concerns in Reverse Osmosis Process

The fouling of RO systems is a major concern of many providers and users. The abundance of transparent exopolymer particles (TEP) in surface waters has been unnoticed for many years. Any newly developed technique may be installed to examine the role of TEP in the fouling of RO systems (Villacorte et al., 2009). In residential areas, RO units use a lot of water due to its low back pressure, only 5%–15% of the water used to treat, whereas the rest is released as wastewater (Reverse Osmosis, 2018; Singh, 2017). In commercial operations, the concentration of total dissolved solids in product water indicates that the effective contaminant removal rates are reduced (Reverse Osmosis, 2018; Health Risks From Drinking Demineralised Water, 2018).

The RO process is excellent in removing various impurities; however, it also removes beneficial minerals. Calcium and magnesium are very important minerals for our health, where the RO may remove over 90% minerals. It is great concern of World Health Organization (WHO). It may have adverse effects on human and animal health for drinking such demineralized water (Reverse Osmosis Water Exposed – What They Don't Tell You, 2018).

15.5 Conclusions

Nowadays, the RO is a common and extensively used technique in the world to purify salty water and wastewater. As like any other techniques, it has pros and cons. The RO not only removes dangerous impurities using its fine filtration process, but it also eliminates many necessary minerals such as calcium and magnesium. Hence, the health effects of drinking such demineralized water (although potable to drink) in long-term should be monitored to analyze. Therefore, the manufacturers of RO membrane modules can think to add some necessary minerals at the end of process or can find a suitable solution to reject the minerals during treatment. The fouling of RO systems is another major concern of many providers and users. Any newly developed technique may be installed to reduce/remove the fouling problem in RO systems.

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