Water Treatment with Reverse Osmosis Systems

Membrane Filtration of water

Water filtration using a membrane which is a semi permeable synthetic material is called membrane filtration. These membranes are highly permeable to some constituents and less permeable to others. To remove a constituent from the water, the water is pumped against the surface of a membrane, resulting in a separation of product and waste streams, as shown in Figure 1. These membranes are called pressure driven membranes since certain pressure is applied with water on the same.

![Figure 1. Schematic of separation process through semi permeable membrane.](image)

Pressure driven membranes used in water treatment are classified into two broad categories as follows;

1. Membranes used to separate ions from solution, that is, those are used for reverse osmosis (RO) and nanofiltration (NF)

2. Those are used to separate suspended particles from water, that is, microfiltration (MF) and ultrafiltration (UF).

In this article we only focus to RO systems.

What is RO

Before knowing the RO it is important to know the theory of Osmosis. The Osmosis is a natural phenomenon discovered early in 1748 which is diffusion of fluid (usually water) through a semi-permeable membrane from a solution with a low solute (ions in solution) concentration to a solution with a higher solute concentration until equilibrium of fluid concentration on both sides of the membrane is reached. Figure 2 shows the osmosis and reverse osmosis schematically.

![Figure 2. Schematic diagram of Osmosis and Reverse Osmosis.](image)

Two Different Filtration Systems

In pressure filtration there are two different systems.

1. Dead End Filtration
2. Cross flow Filtration

Dead End Filtration

Dead end filtration involves all of the feed water passing through the membrane, leaving the solids on the membrane. This is shown in Figure 3.

![Figure 3. Dead End Filtration](image)
Dead end filtration is a batch process. That means particulates will be accumulated and eventually blocked the filter such that water can no longer pass through. Hence the filtration system will be needed to be taken off, cleaned and placed back or replacement depending on the filter clogging condition.

**Cross flow Filtration**

In cross-flow filtration, feed water passes tangentially over the membrane surface rather than perpendicularly to it. Water and some dissolved solids pass through the membrane while the majority of dissolved solids and some water do not pass through the membrane. Hence, cross-flow filtration has one influent stream but yields two effluent streams. This is shown in Figure 4. The diagram shows how the influent stream, with an applied pressure greater than the osmotic pressure of the solution, is separated into two effluent streams. The solution that passes through the membrane is called the permeate or product, and the solution retained by the membrane is called the concentrate, reject, waste, brine.

![Figure 4. Cross Flow Filtration](image)

This system will helps to keep the filtration surface free from solids unlike the previous filtration system. Hence, this system is likely to use in RO membrane elements. As a result, it is required to maintain a minimum flow rates across the membrane surface to effectively scour the surface for preventing accumulation of dissolved solids and foulants.

**RO Membrane Arrangements**

The membrane is made of thin, multi-layered sheets with microscopic pores that let water pass through while acting as a barrier to stop dissolved particles like salt. It uses semi-permeable spiral wound, thin film membranes to separate and remove dissolved solids, organic material, submicron colloidal matter, viruses, and bacteria from water. Feed water is delivered under pressure to the membranes, where reverse osmosis takes place. Water permeates through the minute pores of the membrane and is delivered as purified product water. The impurities in the water do not pass through the membrane, and are instead concentrated in the reject stream which is flushed to the drain.

![Figure 5. Exploded view of Membrane Element](image)
Key Features in RO Skid
Generally, following key elements can be identified in a small scale reverse osmosis skid. Those elements are shown in Figure 6.
1. 5 Micron filter (Just before the High pressure pump)
2. Pre filter pressure gauge
3. Post filter pressure gauge
4. High pressure pump
5. Flow Meters
6. Pressure vessels /
   Pressure membranes
7. Feed control valve
8. Reject control valve
9. Recycle control valve (Optional)
10. System pressure gauge
11. Low pressure switch
12. Control panel

Figure 6: 12 m3/day Pure Aquare Brackish water RO Skid

RO in CKDu Area
Kidney disease prevailing in the dry zone has become the subject of renewed discussion, after the submission of final report by the World Health Organization. The key findings of this report identify long-term exposure to Arsenic and Cadmium as the cause of the diseases. It rules out drinking water as the possible source of exposure but points to the food chain as a possibility.

Even though the real root cause for the disease is not yet finalized the disease has been attributed to heavy metals, pesticides etc, connected with agriculture. In addition to these factors hard water and fluoride/fluoride in combination with aluminum (from cooking utensils) will be a positive impact on the disease.

However, subsequent to the several studies and researches carried out on Chronic Kidney Disease (CKDu), it has been widely accepted that supply of good quality water is one of the most important intervention for disease mitigation. As per the previous paragraph it is a clear fact that the treatment method should satisfy with removing divalent and monovalent ions from the raw water. However NF is good for removing divalent ions but weak on removing
monovalent ions. Hence, to remove both the divalent and monovalent ions RO plants were introduced in CKDu areas.

5. Carry out Land clearance and civil work by the relevant RSC.

6. Installation of RO plant, feed, backwash pump and distributing water meters with adequate storage tank (Figure 8).

7. Commissioning of RO plant and handing over to the CBO.

Pilot Plant at Anuradhapura District - Thambalagollewa

In launching the pilot project in the said area following strategies were adopted

1. Verifying the number of CKDu patients reported in the area.

2. Selecting a ground water source with a satisfactory yield to cater the drinking and cooking demand.

3. Status of the electricity supply. (i.e. to check whether the supply is single phase and no voltage fluctuation).

4. Establishing a Community Base Organization (CBO) for running the small RO unit under the supervision and guideline of NWSDB.

Pilot Plant Details

The RO unit (12 m³/day) consists of pretreatment such as multimedia pressure filter, activate carbon pressure filter and antiscalent dosing unit.

The Figure 10 shows the RO flow rates and pressure diagram of the pilot plant. These values can be obtained by adjusting the
pressure regulating valve and reject control valve.

Figure 10 Pressures and Flow Diagram

Written By:
AGM (R&D)
CE (R&D)