6.8 Membrane processes

The membrane processes of most significance in water treatment are reverse osmosis, ultrafiltration, microfiltration and nanofiltration. These processes have traditionally been applied to the production of water for industrial or pharmaceutical applications but are now being applied to the treatment of drinking water. Their characteristics are given in Figure 6.2.

If two solutions are separated by a semi-permeable membrane, i.e. a membrane that allows the passage of solvent but not of the solute, the solvent will pass from the lower concentration solution to the higher concentration solution. This process is known as osmosis. It is possible, however, to force the flow of solvent in the opposite direction, from the higher to the lower concentration, by increasing the pressure on the higher concentration solution. The required pressure differential is known as the osmotic pressure and the process as reverse osmosis.

Reverse osmosis results in the production of a treated water stream and a relatively concentrated waste stream. Typical operating pressures are in the range 15 to 50 bar depending on the application. Membrane pore sizes are less than 0.002 µm. The most common application of reverse osmosis is desalination of sea water although the use of reverse osmosis for nitrate removal has also been proposed.

Ultrafiltration is similar in principle to reverse osmosis, but the membranes have much larger pore sizes (typically 0.002 to 0.03 µm) and operate at lower pressures. Ultrafiltration membranes reject organic molecules of molecular weight above 800 and usually operate at pressures less than 5 bar. Microfiltration membranes have pore sizes typically in the range 0.01 to 12 µm and do not separate molecules but reject colloidal and suspended material at operating pressures of 1 to 2 bar.

Nanofiltration uses a membrane with properties between those of reverse osmosis and ultrafiltration membranes; pore sizes are typically 0.001 to 0.01 µm. Nanofiltration membranes allow monovalent ions such as sodium or potassium to pass but reject a high proportion of divalent ions such as calcium and magnesium and organic molecules of molecular weight greater than 200. Operating pressures are typically about 5 bar. Nanofiltration may be effective for the removal of colour and organic compounds.

Microfiltration is a direct extension of conventional filtration into the sub-micron range. Microfiltration is capable of sieving out particles greater than 0.05 µm and will remove most bacteria and amoeboid cysts. It has been used for water treatment in combination with coagulation or powdered activated carbon (PAC) to remove viruses, bacteria, dissolved organic carbon and to improve permeate flux.

Membrane processes can provide adequate removals of pathogenic bacteria, *Cryptosporidium, Giardia* and, potentially, human viruses and bacteriophages. However, they should not be relied upon as the sole means of disinfection as there is no simple means to check membrane integrity to warn of potential break-through of micro-organisms.

Table 6.2 Characteristics of membrane processes