40. Desalination

Desalination describes a range of processes which are used to reduce the amount of dissolved solids in water. Dissolved solids are often referred to as total dissolved solids (TDS), and are measured in mg/l. As a means of producing potable water, desalination is usually an expensive option. It is often associated with electricity generation plants, from which both electricity and waste heat are available. This Technical Brief outlines the processes and techniques involved, but also presents low-cost methods of desalination by distillation.

Desalination is used to produce potable water from water sources containing dissolved chemicals, and is most often used when water sources are salty; producing fresh water from sea water or brackish water. Natural waters may be classified approximately according to their TDS values:

Type of water	TDS value (mg/l)
Sweet waters	0-1000
Brackish waters	1000-5000
Moderately saline waters	5000-10 000
Severely saline waters	10 000-30 000
Seawater	More than 30 000

The main application of desalination techniques is the production of fresh water on ships, islands, and in the coastal regions of some very arid Middle Eastern countries. The water that is produced may be so pure that consumers do not like the lack of taste, and small quantities of salt water may then be added to improve the flavour.

There are several methods of water desalination. The most appropriate method can be selected on the basis of the TDS value of the raw water.

Process	TDS value (mg/l)
Ion exchange (not described here)	500-1000
Electrodialysis (not described here)	500-3000
Reverse osmosis (standard membranes)	500-5000
Reverse osmosis (high-resistance membranes)	Over 5000
Distillation	Over 30 000

Of the desalination methods available, the two main ones are:

- **reverse osmosis;** and
- **distillation followed by condensation.**

Reverse osmosis

Osmosis is a technique which plants use to absorb water from the soil and to transport the water up the stem to all parts of the plant. Dilute and more concentrated solutions are separated by a semi-permeable membrane, which acts like a very fine filter. The semi-permeable membrane allows water molecules to pass, but prevents the movement of salt or other dissolved chemical molecules.

If two saline solutions (or water and a saline solution) are separated only by a semi-permeable membrane, there will be a transfer of water through the membrane to the more concentrated saline solution. The passage of water will continue until a stable condition is reached, with the difference of liquid levels across the semi-permeable membrane being referred to as the osmotic pressure. The osmotic pressure varies with temperature and the concentrations of the two solutions (Figure 1a).

By applying pressure (in excess of the osmotic pressure) to the salt-water solution, the process can be reversed, and water molecules from the salt-water solution can be forced through to the other side of the semi-permeable membrane (Figure 1b).

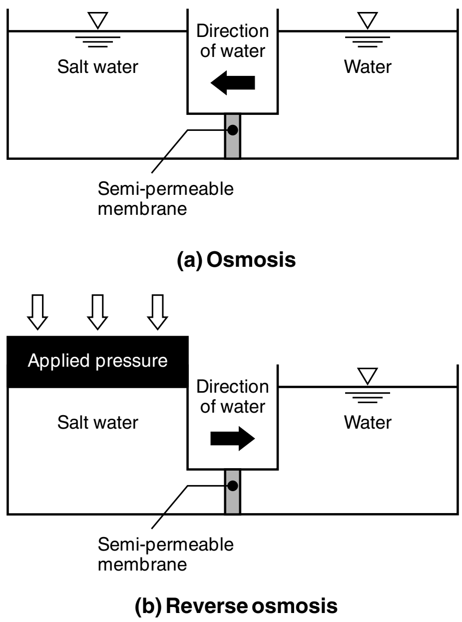

Figure 1. Osmosis and reverse osmosis

The flow of water through the semi-permeable membrane is very slow, so a large area of membrane is needed. The membrane is easily torn, and needs to be supported carefully. Membranes are frequently wrapped into a spiral, or formed into bundles of tubes which are sealed at one end (Figure 2). Reverse osmosis installations require further refinements in order to prevent damage or blockage and to operate successfully. The salt water needs to be filtered first to remove particles which might damage the membranes, and chemical additives may be needed to control the pH and to minimize the deposition of salt on the membrane surface (Figure 3).

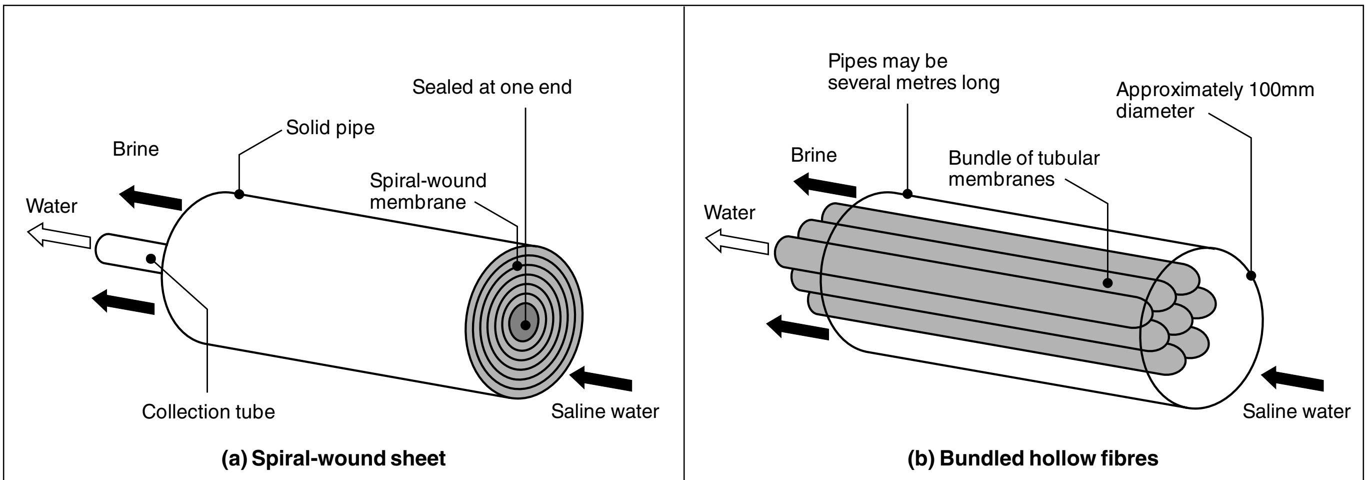

Figure 2. Reverse osmosis: Membrane support techniques

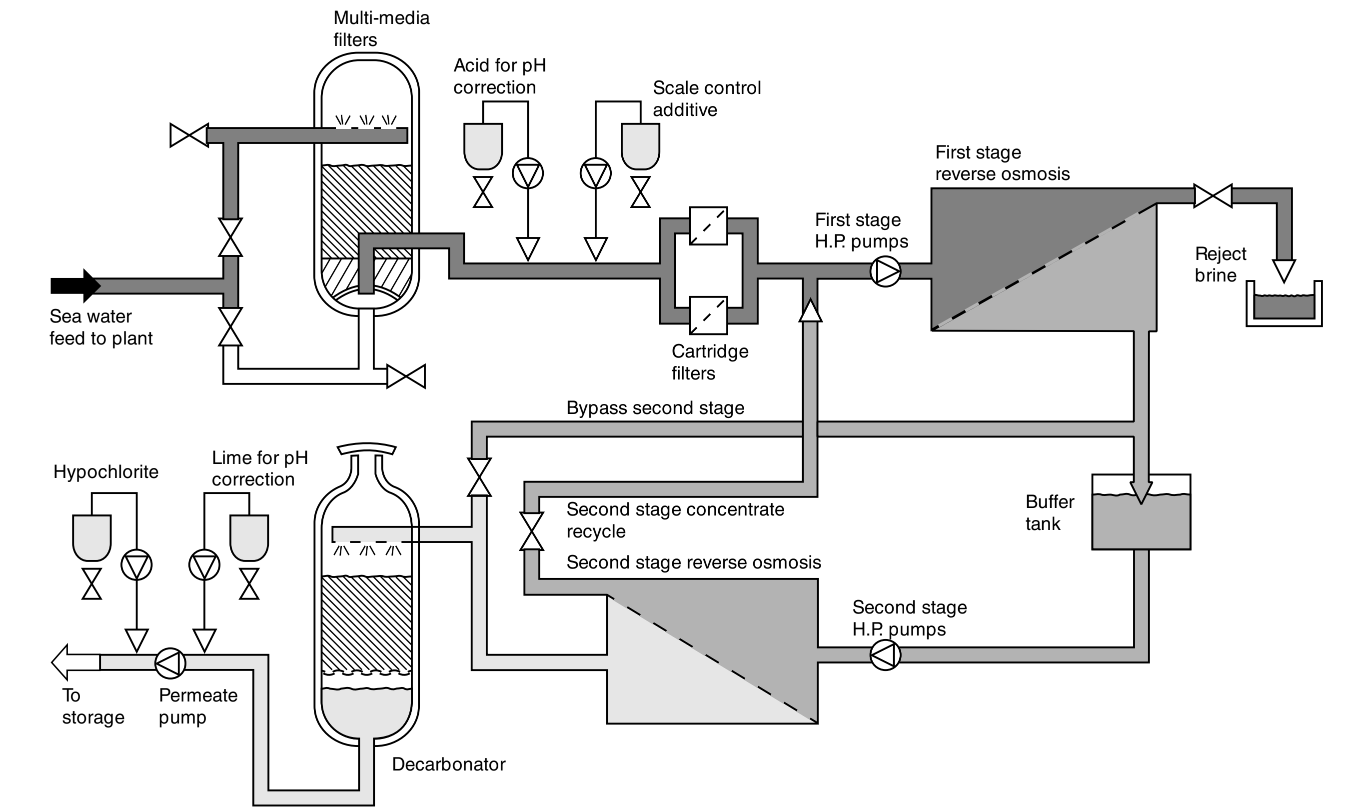

Figure 3. Schematic diagram of a reverse osmosis plant for sea water

Distillation

The collection of water by distillation and condensation is a survival technique which can be used to collect small quantities of water from the ground. A hole is dug in the ground, and a cup or bowl is placed in the bottom of the hole. A sheet of plastic is stretched across the hole, its edges are weighted with soil to hold it in place, and a small stone is placed in the centre. Water evaporates from the soil, condenses on the underside of the plastic sheet, and collects in the cup or bowl (Figure 4). Solar energy can be used to evaporate water from salt water for household or community water supplies by constructing sealed units covered with glass (Figure 5). There are problems with these units: growth of algae on the underside of the glass sheet must be controlled, and the unit must be effectively sealed.

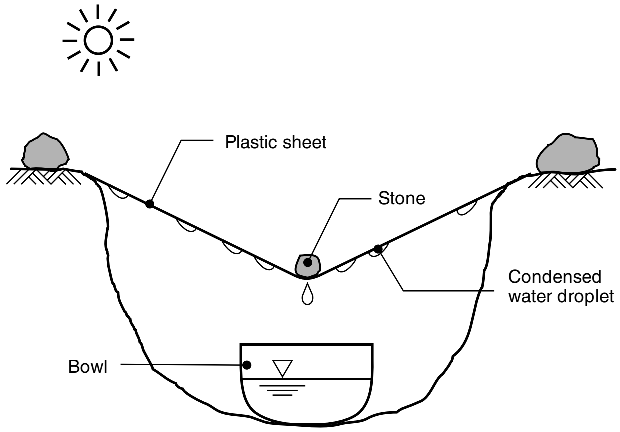

Figure 4. Simple distillation and condensation

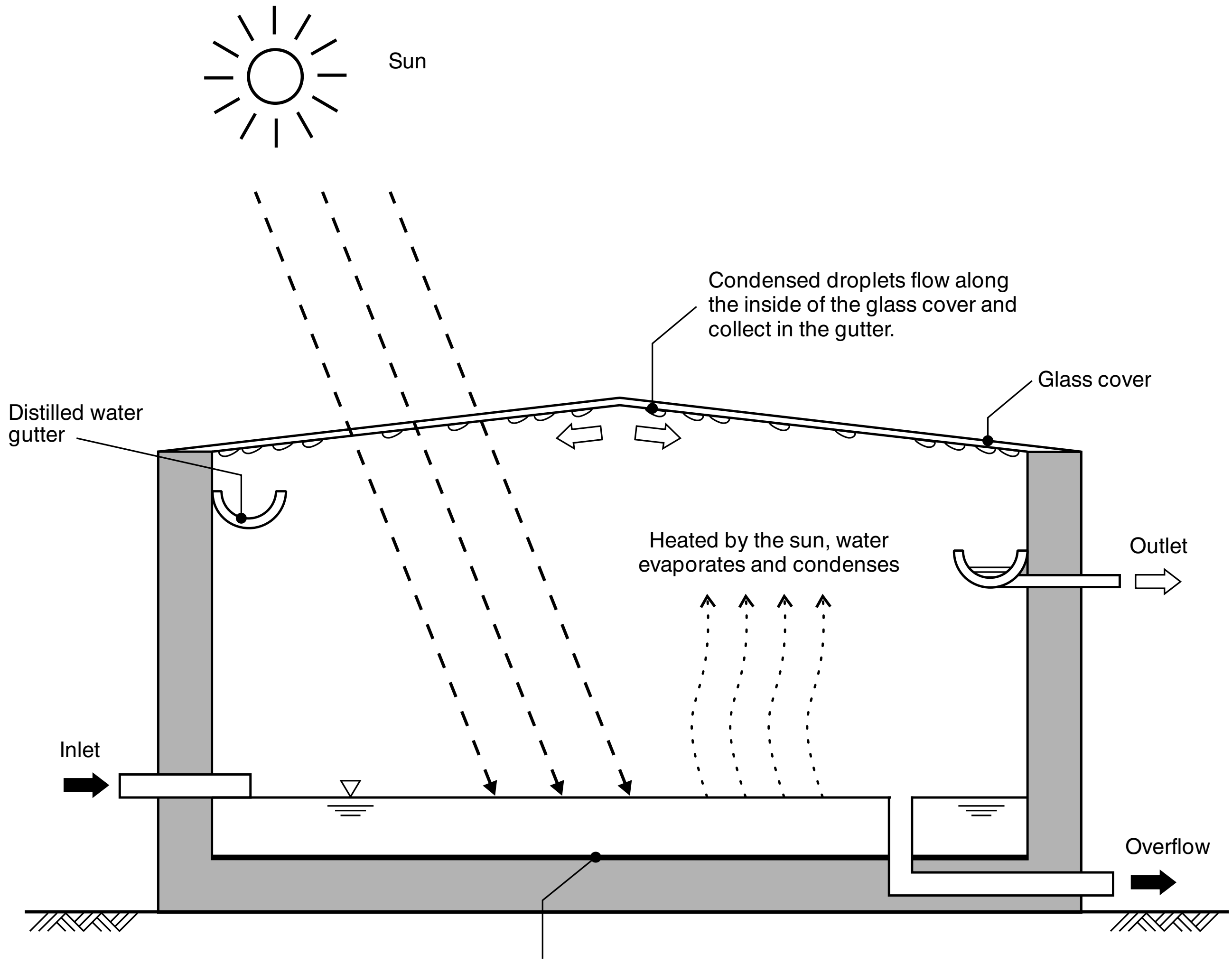

Figure 5. Section of a typical solar still

Desalination

Alternative low-cost distillation method

A simple, low-cost method to desalinate sea water by distillation is used in some countries where fuel is available. It requires basic kitchen utensils: two pots, one four times the size of the other, and a plastic sheet. The smaller pot is placed inside the larger one and weighed down with a stone.

Sea water is poured into the outer container up to the brim of the inner one. The larger pot is sealed using a plastic sheet and a piece of string so that the plastic sheet sags in the middle (Figure 6). This home-made still is then placed on any heat source such as a stove or wood fire, at low temperature. In a few minutes the sea water in the outer container starts to evaporate. As the plastic sheet prevents the steam from escaping, the droplets condense into the smaller vessel. Residual salt remains in the outer pot.

To conserve fuel, a still can be placed on top of a cooking-pot which is used everyday, such as a rice pot. As it boils or simmers, the 'waste' heat is usefully harnessed.

Care should be taken to ensure that all pots are stable and out of reach of young children.

Large-scale distillation

Large-scale distillation units use a process known as *Multi-stage flash distillation*. This conserves energy, but the equipment used is expensive and sophisticated. Multi-stage flash distillation units operate on the principle that by raising the pressure in a sealed container, the boiling point of a liquid can be raised; and that by lowering the pressure in a sealed container the boiling point of a liquid can be reduced.

Steam is used to heat a saline solution, which is driven through a series of 15 to 40 evaporation chambers. Each evaporation chamber is at a lower temperature and pressure than the preceding one, and some water vapour is evaporated or 'flashed off' from each chamber as the temperatures and pressures decrease. The hot salt water or 'brine' can cause corrosion or an accumulation of chemical deposits, and chemical additives are needed to control this.

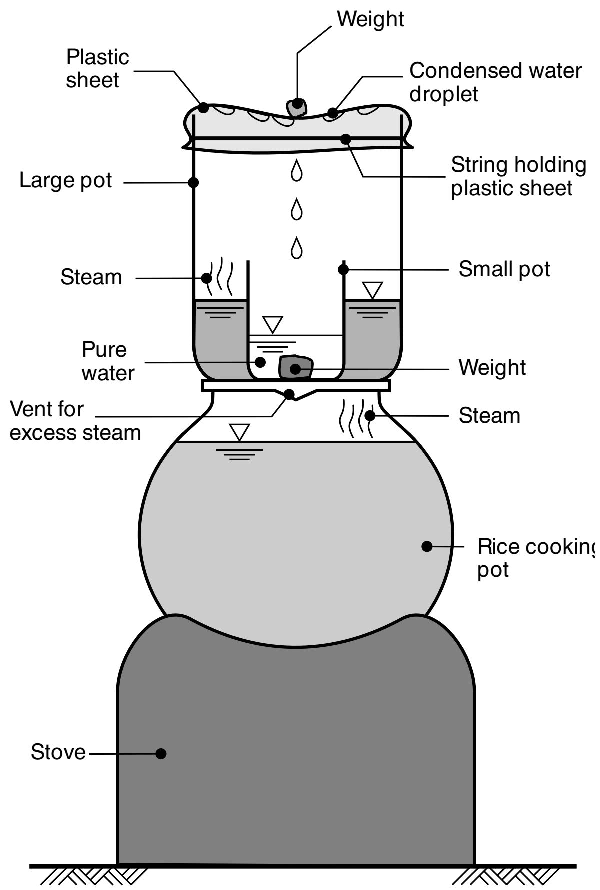

Figure 6.
A simple, low-cost method of desalination by distillation and condensation

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Further reading

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Prepared by Michael Smith and Rod Shaw

WEDC Loughborough University Leicestershire LE11 3TU UK
www.lboro.ac.uk/departments/cv/wedc/ wedc@lboro.ac.uk