Environmental Studies
FACT SHEET
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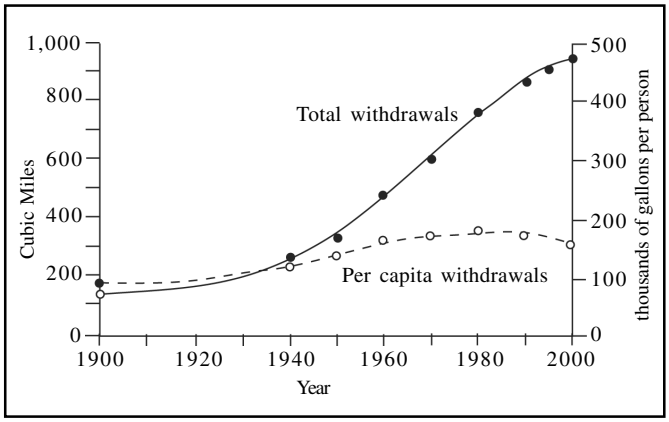
Desalination

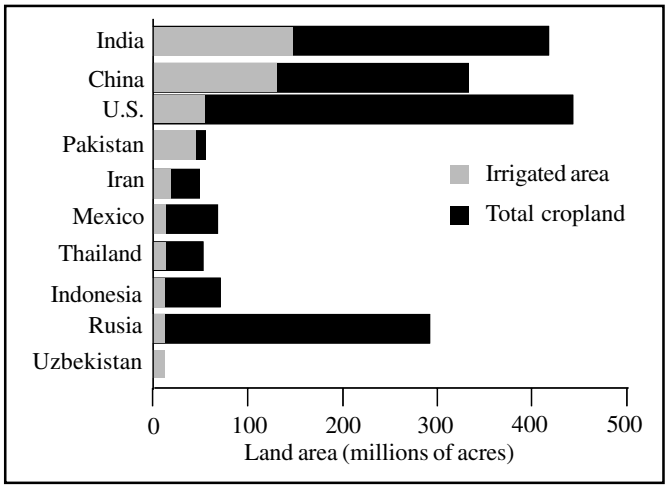
450 million people suffer from water shortage and water tables are falling on every continent. Although **per capita** withdrawal of water from rivers and aquifers has actually fallen over the last decade (a result of great increases in industrial efficiency), total demand for water is constantly increasing (Fig 1).

Fig 1. Annual global water withdrawals



This is as a result of increasing world population, increasing affluence – more thirsty appliances - and increasing use in irrigation (Fig 2).

Fig 2. Irrigation worldwide



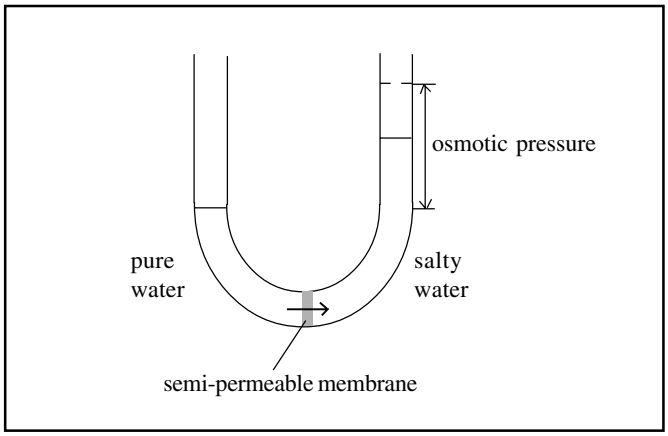
Global climate change may make the situation even worse! One way of increasing the basic supply of water is desalination.

Desalination involves the removal of salts and impurities from seawater. Since 97% of the water on earth is in the oceans, desalination has huge potential. Desalination is widely used in the Middle East (Saudi-Arabia gets 70% of its water by desalination), the Caribbean and the Mediterranean and now countries such as the US and those in temperate areas are developing plants too.

Desalination is an ancient technique. In its simplest form desalination involves **distillation** - heating water and condensing the steam. All of the impurities are left behind and the condensed steam is pure water. The problem with this approach is that it is expensive to heat water.

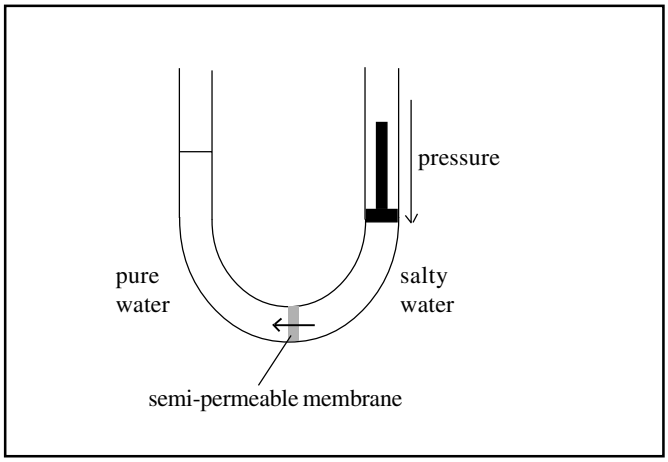
Modern plants use a process known as **reverse osmosis (RO)**. Salty water is separated from pure water by a semi-permeable membrane. Normally, the process of osmosis would lead water molecules to diffuse from the pure water side across the membrane into the salty water side (Fig 3).

Fig 3. Osmosis



However, in RO the salty water is subjected to very high pressures (much greater than the osmotic pressure pushing water molecules the other way) and this pushes the water molecules there through the pores in the membrane (Fig 4).

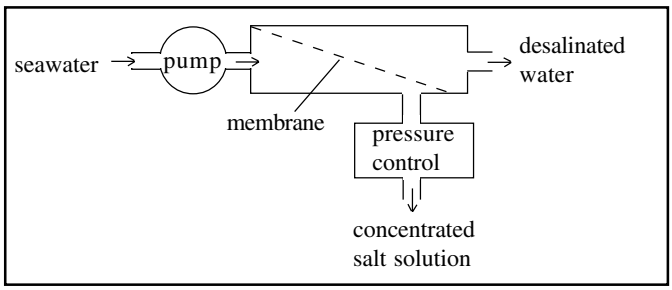
Fig 4. Reverse Osmosis



Some ions are effectively repelled by the membrane. The salt and other impurities are too big to pass through the pores and they are collected and removed. RO will remove organic compounds, dissolved ions, heavy metals and microorganisms (bacteria /fungi).

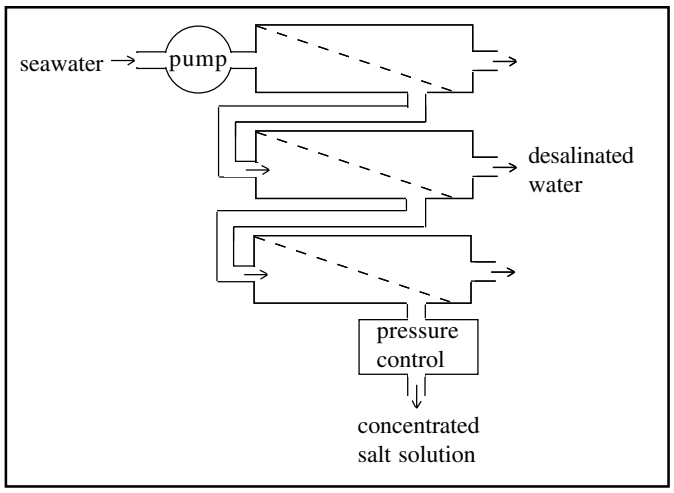
Fig 5 shows a typical industrial desalination plant.

Fig 5. Industrial desalination by reverse osmosis



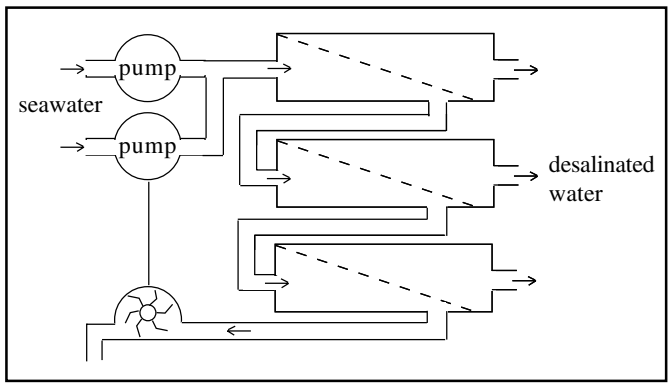
Sometimes, a series of tanks are joined together to increase the efficiency of the process (Fig 6)

Fig 6. Joined tanks



Reverse osmosis plants are usually smaller and more energy efficient than distillation plants. Some plants use the waste salt water – which is still pressurised – to drive a turbine that provides power for an additional pump that supplies seawater to the plant (Fig 7).

Fig 7. Energy efficient plant



However RO plants suffer from three problems:

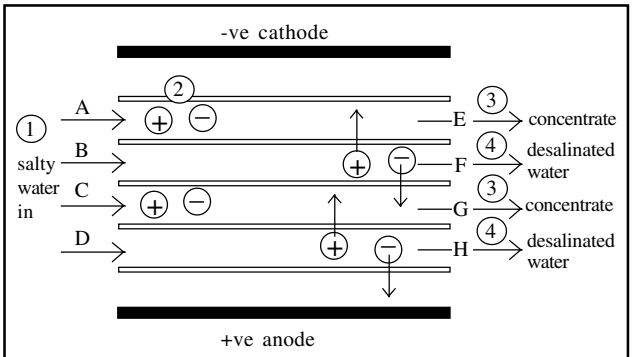
1. The membrane pores become clogged with impurities such as calcium salts, silica and microorganisms
2. Chloride ions harden the membrane
3. The membrane needs to be replaced after about three years – this is expensive.

Because of these problems the salty water is usually pre-treated (filtered) to remove microorganisms and sediment. New membranes made from improved polyamide films may overcome the need for this pre-treatment.

In some coastal cities in the Middle East water is first **softened** i.e. calcium and magnesium ions are removed and then the water is passed through **activated carbon filters** to remove chlorine and organic compounds, before it enters the desalination plant.

Electrodialysis is an alternative to RO

Ions and ionisable substances are transported across the membrane under the influence of an electrical potential rather than by direct pressure.



1. Salt water enters at A, B, C + D
2. Ions are pulled out of streams B and D
3. Concentrated salty water (waste) leaves at E and G
4. Pure (desalinated) water leaves at F and H

As with RO, electrodialysis leaves behind a concentrated residue that is usually put back into the sea. This residue needs to be disposed of quickly since it is very corrosive, which makes the plant expensive to build and maintain.

In both RO and electrodialysis, typically for every 100 litres of water that is treated, 10-50 litres of pure water is recovered i.e. the recovery rate is 10-50%. Much higher recovery rates than this require much more energy and are usually not economically worthwhile.

Case Study

The Inland Empire water Utility in San Bernadino County, California uses methane from cow dung to power a desalination plant that removes salts and nitrites from groundwater beneath orange groves and vineyards. Desalination is seen as a much more environmentally–friendly option than building new dams and California is encouraging ocean-side hotels, resorts and large corporations to invest in their own desalination plants.

An excellent general account of the water shortages facing the world: Scientific American February 2001

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