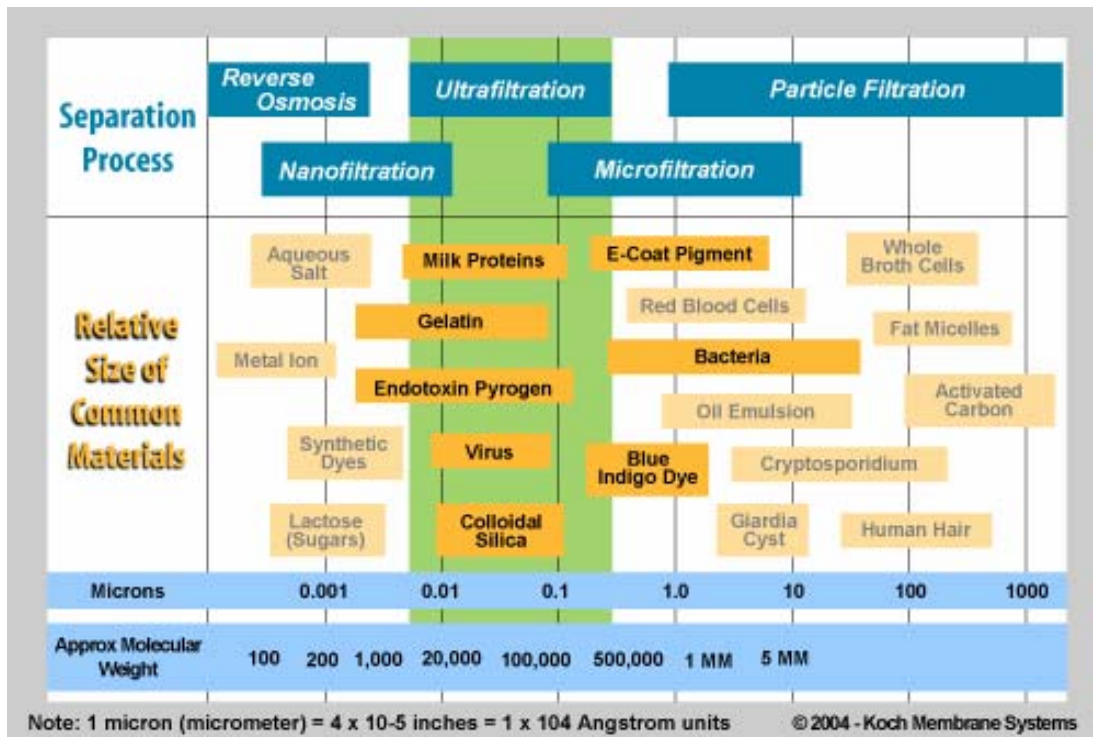


ULTRAFILTRATION, NANOFILTRATION AND REVERSE OSMOSIS

What is filtration?

Filtration is a process of removing particulate matter from water by forcing the water through a porous media. This porous media can be natural, in the case of sand, gravel and clay, or it can be a membrane wall made of various materials. Sometimes, large particles are settled before filtration; this is called sedimentation. For information on sedimentation and filtration, in general, see the [Conventional Water Treatment: Coagulation and Filtration](#) fact sheet.

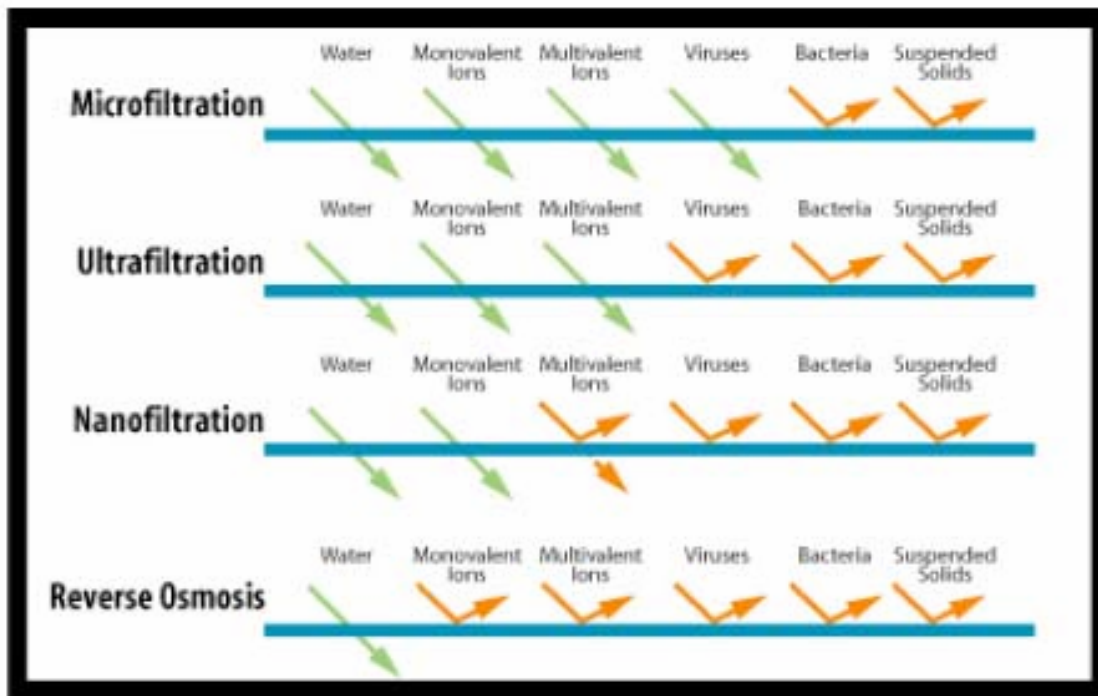
The size of materials that can be removed during filtration depends upon the size of the pores of the filter. The chart below summarizes the various separation processes relative to common materials that would be filtered out through each process. Particle filtration refers to conventional media filtration, while the other types are membrane filtrations.



Size of Materials That Are Removed By Various Separation Processes;

http://www.kochmembrane.com/sep_uf.html

The chart below summarizes the types of particles that are removed from the water with each type of membrane filter. The green arrow indicates that the particle is small enough to pass through the filter, whereas the deflected orange arrow indicates that the filter blocks the particle from passing through the filter.



Membrane Process Characteristics

Substances Removed From Water By Membrane Filtration Processes;

http://www.kochmembrane.com/sep_uf.html

What is ultrafiltration?

An ultrafiltration filter has a pore size around 0.1 micron. A microfiltration filter has a pore size around 0.1 micron, so when water undergoes microfiltration, many microorganisms are removed, but viruses remain in the water. Ultrafiltration would remove these larger particles, and may remove some viruses. Neither microfiltration nor ultrafiltration can remove dissolved substances unless they are first adsorbed (with activated carbon) or coagulated (with alum or iron salts).

What is nanofiltration?

A nanofiltration filter has a pore size around 0.001 micron. Nanofiltration removes most organic molecules, nearly all viruses, most of the natural organic matter and a range of salts. Nanofiltration removes divalent ions, which make water hard, so nanofiltration is often used to soften hard water.

What is reverse osmosis?

Reverse osmosis filters have a pore size around 0.0001 micron. After water passes through a reverse osmosis filter, it is essentially pure water. In addition to removing all organic molecules and viruses, reverse osmosis also removes most minerals that are present in the water. Reverse osmosis removes monovalent ions, which means that it desalinates the water. To understand how reverse osmosis works, it is helpful to understand osmosis.

Osmosis occurs when a semi-permeable membrane separates two salt solutions of different concentrations. The water will migrate from the weaker solution to the stronger solution, until the two solutions are of the same concentration, because the semi-permeable membrane allows the water to pass through, but not the salt. In the following diagram, (A) and (B) illustrate the process of osmosis.

In reverse osmosis, the two solutions are still separated by a semi-permeable membrane, but pressure is applied to reverse the natural flow of the water. This forces the water to move from the more concentrated solution to the weaker. Thus, the contaminants end up on one side of the semi-permeable membrane and the pure water is on the other side. In the diagram below, reverse osmosis is represented in (C).

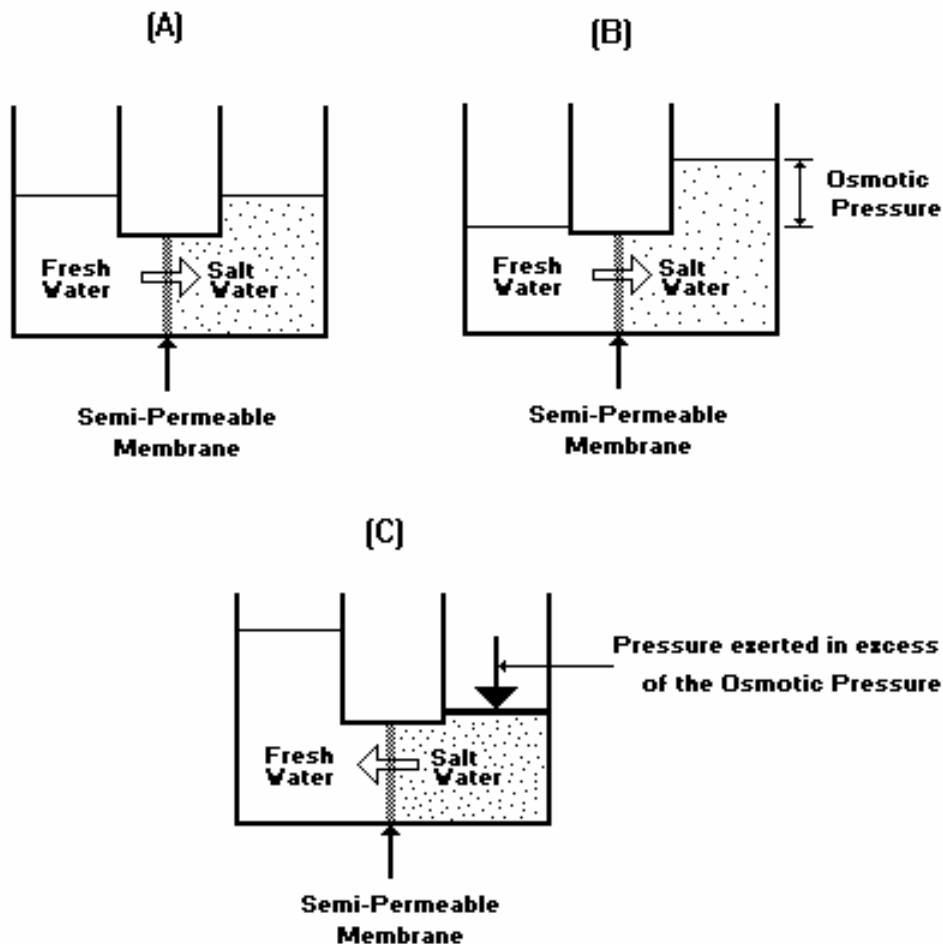


Figure 1 - Osmosis/Reverse Osmosis

Osmosis and Reverse Osmosis

What do these three processes remove?

Ultrafiltration removes bacteria, protozoa and some viruses from the water. Nanofiltration removes these microbes, as well as most natural organic matter and some natural minerals, especially divalent ions which cause hard water. Nanofiltration, however, does not remove dissolved compounds. Reverse osmosis removes turbidity, including microbes and virtually all dissolved substances. However, while reverse osmosis removes many harmful minerals, such as salt and lead, it also removes some healthy minerals, such as calcium and magnesium. This is why water that is treated by reverse osmosis benefits by going through a magnesium and calcium mineral bed. This adds calcium and magnesium to the water, while also increasing the pH and decreasing the corrosive potential of the water. Corrosive water may leach lead and copper from distribution systems and household water pipes.

What are the advantages of using ultrafiltration, nanofiltration or reverse osmosis to treat water?

All three of these membrane filtration processes are effective methods of treating water that cannot be treated using conventional treatment methods. Reverse osmosis, in particular, has been responsible for ending several nearly decade long Boil Water Advisories. For example, in 2003, a reverse osmosis system, together with a biological treatment process, was set up to successfully treat drinking water for the Yellow Quill First Nation, which had been on a Boil Water Advisory since 1995. The water in the First Nations community, which is located in Saskatchewan, contained high levels of organic matter, iron, manganese, ammonium and arsenic, to name a few. Besides the obvious benefit of providing safe drinking water to a community which had been under a Boil Water Advisory for approximately nine years, the reverse osmosis system (together with the biological treatment) allowed the community to treat their water using small quantities of chemicals. For more information about the water treatment facility at Yellow Quill First Nation, read [Watered Down Excuse, According to one scientist, high cost is no excuse for lack of safe drinking water in First Nations communities](#), written by Kim Peterson and published in The Dominion.

A portable reverse osmosis unit was brought in to Kashechewan, a First Nations community in Ontario, in October of 2005. The community had experienced water contamination issues for years, and in October 2005, approximately 1,100 of the 1,900 residents were evacuated, after *E. coli* was found in their water. The reverse osmosis unit was brought in by the military, and could provide 50,000 litres of water each day for the residents of Kashechewan, until their water treatment plant could be fixed. The picture below compares the colour of the untreated water to that of the water after being treated with reverse osmosis.



Water Before and After Reverse Osmosis Treatment at the Kashechewan First Nation

What are the disadvantages of using ultrafiltration, nanofiltration or reverse osmosis to treat water?

Compared with the benefits of using membrane filtration to treat water, there are very few disadvantages. If conventional water treatment processes can effectively treat the water, then constructing a reverse osmosis water treatment facility would be an unnecessary cost. But for the First Nations communities that have been on Boil Water Advisories for many years, a reverse osmosis treatment system can be a valuable investment that can provide safe drinking water for the residents.

Reverse osmosis removes a number of healthy minerals from water, in addition to the harmful minerals and particles. The removal of these minerals, including calcium and magnesium, can actually make water unhealthy, especially for people with inadequate diets and people who live in hot climates, as water can provide these necessary minerals. The addition of calcium and magnesium, as described above, can resolve these concerns.

The Safe Drinking Water Foundation has educational programs that can supplement the information found in this fact sheet. Operation Water Drop looks at the chemical contaminants that are found in water; it is designed for a science class. Operation Water Flow looks at how water is used, where it comes from and how much it costs; it has lessons that are designed for Social Studies, Math, Biology, Chemistry and Science classes. Operation Water Spirit presents a First Nations perspective of water and the surrounding issues; it is designed for Native Studies or Social Studies classes. Operation Water Health looks at common health issues surrounding drinking water in Canada and around the world and is designed for a Health, Science and Social Studies collaboration. Operation Water Pollution focuses on how water pollution occurs and how it is cleaned up and has been designed for a Science and Social Studies collaboration. To access more information on these and other educational activities, as well as additional fact sheets, visit the Safe Drinking Water Foundation website at www.safewater.org.

Resources:

Agriculture and Agri-Food Canada. 2003. Reverse osmosis: enjoy cleaner water. http://www.agr.gc.ca/pfra/flash/osmosis/en/revosmosistxt_e.htm.

Canada Mortgage and Housing Corporation. 2007. About Your House: Reverse Osmosis Water Treatment. http://www.cmhc-schl.gc.ca/en/co/maho/wawa/wawa_001.cfm.

Canadian Broadcasting Corporation. October 2005. Water purification unit heads to Kashechewan. <http://www.cbc.ca/canada/story/2005/10/29/kashechewan051029.html>.

Cooperative Research Centre for Water Quality and Treatment. December 2006. Consumer's Guide to Drinking Water. http://www.wqra.com.au/_dyn/media/r396/system/attrib/file/337.

United States Environmental Protection Agency. October 1999. EPA Drinking Water and Health: What You Need to Know! <http://www.epa.gov/safewater/dwh/dw-health.pdf>.

United States Environmental Protection Agency. 2007. Water & Health Series: Filtration Facts. http://www.epa.gov/safewater/faq/pdfs/fs_healthseries_filtration.pdf.

World Health Organization. 2004. Water Treatment and Pathogen Control: Process Efficiency in Achieving Safe Drinking Water. http://www.who.int/water_sanitation_health/dwq/en/watreatpath.pdf.