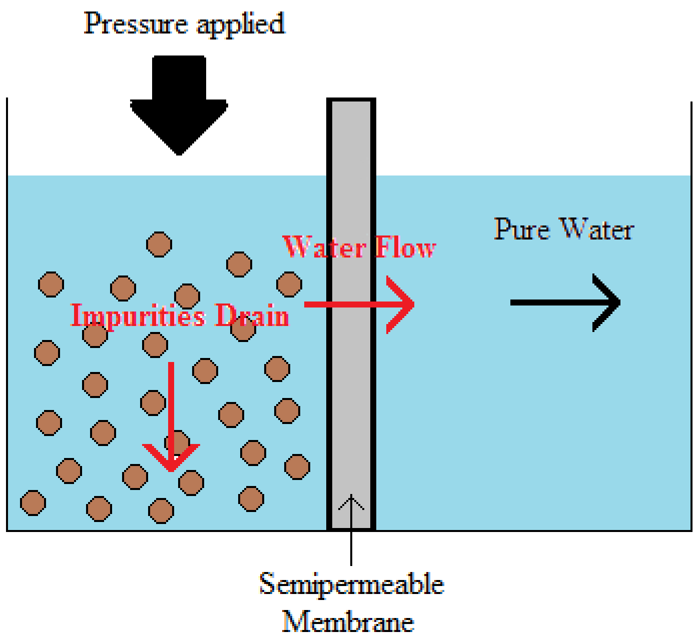
Membrane Filtration



Membrane filtration uses very fine filter membranes of varying pore size to filter out fine particulate matter, pathogens and, depending on the pore size of the filter, ions. With decreasing pore size, the amount of applied pressure required to force water through the membrane must increase, increasing energy costs (Witgens, 2005).

For basic irrigation purposes, membrane filtration is typically not used as most particles liable to cause clogging can be filtered out using coarser filters. However, if you are looking to use a pathogen control treatment highly affected by organic matter in solution (ie. some oxidation methods or, especially, UV), then membrane filtration may be of use. It may also be required for sensitive operations such as plant propagation, where the composition of the water must be strictly controlled. Membrane filtration may be used for the removal of a variety of small particles that would otherwise affect production. Membrane filter classifications are as follows, although pore size will vary within classifications (Fisher, 2011):

Membrane filtration type	Particle size filtered (micron)
Microfiltration	1 - 0.1
Ultrafiltration	0.1 – 0.01
Nanofiltration	0.01 – 0.001
Reverse osmosis	<0.001

Membrane filters tend to be targeted for treatment of a specific particle type, and subjecting the filter to other larger particles can drastically shorten lifespan. Because of how delicate the filter is and the high costs associated with this level of filtration, sufficient pre-treatment is crucial to ensure filters are operated effectively and no unnecessary expenses are incurred as a result of damage or fouling. Larger particles must be filtered out by coarser filters before the water reaches the finer filter. Some very fine membrane filters, such as those used in nanofiltration or reverse osmosis, may require water to undergo other forms of treatment (ex. water softening) before passing through. Because of the nature of these filters, and the fact that pre-treatment requirements and cost will vary significantly based on water source, the information below will provide only a short summary of information. For further information, it is crucial that growers contact filter manufacturers to get information on the use of these filters for their particular facility.

Microfiltration

Removes: Pathogens (except viruses)

Microfiltration can be used to remove fine suspended solids, such as larger pathogens (ex. protozoa and bacteria; Witgens et al., 2005). The technical aspects of microfilters are very similar to those of ultrafilters. Microfiltration may be used as pre-treatment to reverse osmosis. Microfilters are at a high risk of clogging if certain organic materials (especially microbially produced polysaccharides and proteins) are allowed to reach the filter. These materials are often removed by pre-treatment with chemical coagulation followed by media filtration (Fan et al., 2008)

Ultrafiltration

Removes: Pathogens (including viruses)

Ultrafiltration is typically used for the removal of smaller pathogens such as viruses, and organic macromolecules. Ultrafilters come in a variety of configurations, and the optimal configuration will depend on how clean the water being treated is. The filters are most commonly composed of polysulfone or cellulose acetate (Dhawan, 2010). Ultrafiltration may be used as pre-treatment to reverse osmosis (Fan et al., 2008). Ultrafilters are at a high risk of clogging if certain organic materials (especially microbially produced polysaccharides and proteins) are allowed to reach the filter. These materials are often removed by pre-treatment with chemical coagulation followed by media filtration (Fan et al., 2008)

Nanofiltration

Removes: Pathogens, calcium carbonate ($CaCO_3$), humic acids, pesticides/herbicides

Nanofiltration may be used for the removal of dissolved organic solids (ex. humic acids) and multivalent ions. At these very fine pore sizes, filtration relies somewhat on chemical interactions between the filter material and permeating water (Witgens et al., 2005). Nanofilters are typically in the shape of a spiral, and are composed of composite materials. The materials that may be filtered by nanofiltration are similar to those that are filtered by reverse osmosis. However, as it has smaller pores RO will remove dissolved organic matter more completely, as well as being able to remove salts and all other ions.

Nanofiltration is capable of removing humic acids, which are dissolved organic solids that will be present in water that has made extended contact with organic substrates such as soil or peat. Humic acid is indicated by a brown tint to the water and will be present in recirculating water (if any organic substrates are used), wastewater, or water retrieved from stationary water bodies such as ponds, lakes, or slow moving rivers. If allowed to remain in water that is being treated for pathogens, humic acids will be oxidized by chemical oxidizers, reducing the effectiveness of many chemical pathogen treatment methods. Presence of humic acid will also reduce UV treatment effectiveness (Fisher, 2011).

Nanofiltration can also remove $CaCO_3$ which can be a problem in operations taking water from groundwater or municipal water in areas with calcareous bedrock. $CaCO_3$ can precipitate out of solution in the irrigation system and form deposits, which may eventually be harmful to the irrigation system or to pathogen treatment systems (ex. pasteurizers).

If used in a facility that is recirculating water, pesticides will likely accumulate in irrigation water, eventually to phytotoxic levels. As such, removal will eventually be necessary. Removal of pesticides can be performed via nanofiltration or reverse osmosis, or by using ozone (Stewart-Wade, 2011).

Reverse osmosis

Removes: Pathogens, calcium carbonate ($CaCO_3$), humic acids, pesticides/herbicides, salts, single ions (ex. iron)

A reverse osmosis membrane is not considered to have pores. Rather, water may be taken up into the spaces between the membrane fibres by acetyl groups on the membrane surface (ROchemicals, 2012). While it can remove materials more completely than nanofiltration, reverse osmosis also requires higher applied pressure, which means increased energy use. For more information please visit our page on reverse osmosis for pathogen removal:

http://www.ces.uoguelph.ca/water/PATHOGEN/ReverseOsmosis.pdf

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