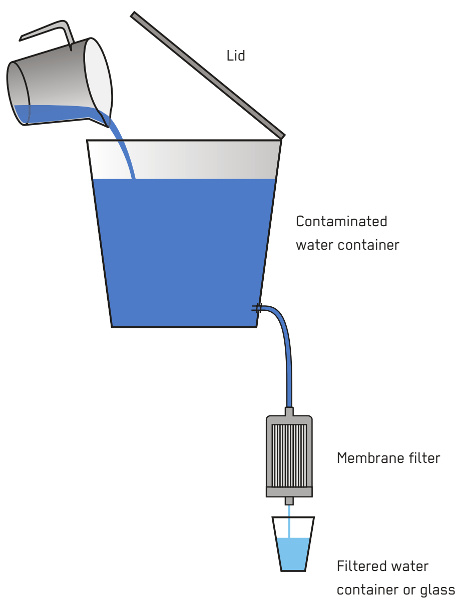
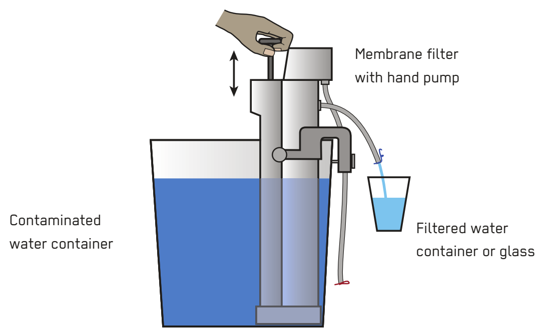
Membrane Filtration

Response Phase	Application Level	Management Level	Objectives / Key Features
** Acute Response ** Stabilisation ** Recovery	** Household ** Neighbourhood City	** Household * Shared Public	Point-of-use treatment, mechanical pathogen removal
Local Availability	**Technical Complexity**	**Maturity Level**	
* Low	* Low	** Medium	





Household Membrane Filters generally use ultrafiltration (UF) or microfiltration (MF) membranes as flat sheet or hollow fibre modules. Water is filtered by gravity or manual pumping. Particles, colloids, protozoa, bacteria and viruses are retained on the membrane surface. The removal performance depends on the pore size of the membrane and its manufacturing quality.

Membrane Filtration refers generally to MF, UF, Nanofiltration and Reverse Osmosis membrane-based systems **(T.3, T.10, T.15)**. MF membranes usually have a pore size of 0.1–0.5 µm and remove particles, bacteria and protozoa from water. They are less efficient for viral removal. UF membranes have smaller pores (common membranes for drinking water treatment are in the range of 0.01–0.08 µm) and remove particles, bacteria, protozoa and viruses. Nanofiltration and Reverse Osmosis are usually used at household level as pressurised modules installed under the sink that filter piped water from the distribution network. These filters are not common in emergencies at a household level unless they were already in use, though they are sometimes applied in health care facilities for high-quality water. Therefore, the focus here is on MF and UF Membrane Filters operated by gravity or manual pumping as autonomous systems for single or multiple households.

Membranes can be fouled when a layer of retained material forms on the surface with time, reducing the flow rate. Depending on the filter design, this fouling layer is removed by backwashing (flow of a small amount of clean water in the reverse direction) or cleaning (addition of chemicals, shaking or flushing of the surface). Fouling is intensified by a high content of natural organic matter in the raw water and a high turbidity. Depending on the type and concentration of organic matter, membrane fouling can become irreversible, leading to a continuously reduced flow rate and increased clogging. This irreversible fouling can sometimes be recovered by chemical cleaning.

Design Considerations: Household Membrane Filters are usually simple and easy to use. Flow through the Membrane Filter depends on the membrane characteristics (permeability), surface area of the membrane as well as the applied pressure and degree of fouling caused by the raw water. For gravity-driven systems, a new membrane module can provide over 40 L/hour of treated water per m^2 of membrane where there is a hydrostatic pressure difference of around 100 cm.

Materials: Membrane Filters are supplied as ready-to-use systems that include storage containers or as modules that need to be placed into or attached to the locally available buckets or jerrycans. The filter material is light and difficult to break. Depending on the manufacturer, manual pumps are provided as an integrated part of the system to generate pressure and increase the flow rate. Manual pumps may require maintenance or replacement if damaged. The filters are often not freely available on the market in many countries.

Applicability: Household Membrane Filters can be distributed in all response phases when water is generally available but the quality is poor or unknown and there is a risk of contamination during storage or at home. Membrane Filters are particularly applicable when the population is dispersed and large-scale installations of the water treatment systems are not feasible. Some UF systems are also applicable in areas with turbid water or waters containing high iron content where other systems clog or fail. The number of systems and products on the market is rapidly growing, but distribution is still mostly conducted via NGOs and projects.

Operation and Maintenance: Most Membrane Filtration systems require backwashing and cleaning and will clog if this is not done regularly. The potential of filters to clog during operation with turbid waters is a function of the membrane type and configuration as well as the backwashing mechanism and frequency of backwashing. Some products have automatic backwashing systems. Sometimes, clogging can be reduced pre-filtration using simple screens, which should be cleaned regularly. Training is needed to operate some of the products available on the market. Irreversible clogging of Membrane Filters is an easy indicator of failure, showing that the filter must be replaced. Usually, a failure free operation of 1–2 years is guaranteed by the manufacturer for surface waters (with elevated turbidity and organic matter content), while filters can be operated longer with clear water and low organic matter content. Manufacturers usually specify the expected volume of filtered water before clogging for a defined water turbidity and organic matter content. When membranes are delivered, they may contain glycerol in the pores and on the surface, which is washed out during first use. This might generate some foam that can be discharged, but is usually harmless if consumed. After the glycerol is removed, the membrane can irreversibly clog if it becomes dried (e.g. during storage), so it should be kept wet or in humid environments when not in use.

Health and Safety: Although Membrane Filters show reliable performance, the quality of products may vary considerably. When production quality is assured and verified, UF filters are one of the most reliable technologies for removing protozoa and bacteria, achieving 6-log removal rates. For virus removal, membranes with small pores (< 20 nm) and a narrow pore size distribution perform well. Membranes with larger pores (> 40–60 nm, e.g. all MF membranes and some UF membranes) may have limited performance. Most systems produce concentrated effluent during backwashing, with a higher concentration of microorganisms than raw water, which must be discharged properly. Backwashed water used for other purposes in households can present a health risk.

Costs: Membrane-based filters cost between 15–100 USD per system. The design, membrane area and production quality define the filter costs. Usually, the systems operate without consumables and are robust. Therefore, there are no operational costs. The lifespan varies between 6 months and 5 years, depending on the quality of the product, backwashing/cleaning frequency and the quality of water filtered. Filters are usually not available locally, and transport costs and import regulations increase the costs and delivery times.

Social and Environmental Considerations: Membrane Filters are usually well accepted. Since suspended particles are fully removed without changing the taste and odour of water, treated water is usually perceived as safe and clean. Most membrane-based systems have relatively high initial flow rates compared to other HWTS products. Some systems are not self-explanatory to install and operate. To achieve good uptake of the technology, proper training and explanation of the principle of filtration and its operation and maintenance (O&M) is required. The membrane field is developing quickly, and new products and technologies based on UF appear on the international market every year.

Strengths and Weaknesses:

- (+) Has high removal rates for bacteria and protozoa. Virus removal depends on pore size of the membrane. Dense, high quality UF membranes achieve high removal rates for viruses
- (+) Many systems are able to handle turbid waters
- (+) Are light, small and easy to transport; no damage during transport is expected
- (+) Easy to operate and maintain when operation principle is understood

- (−) Requires frequent backwashing, flushing or some sort of cleaning
- (−) Filter operation is not always intuitive, and training is usually needed
- (−) Clogs quickly when operated incorrectly

→ **References and further reading material for this technology can be found on page 221**