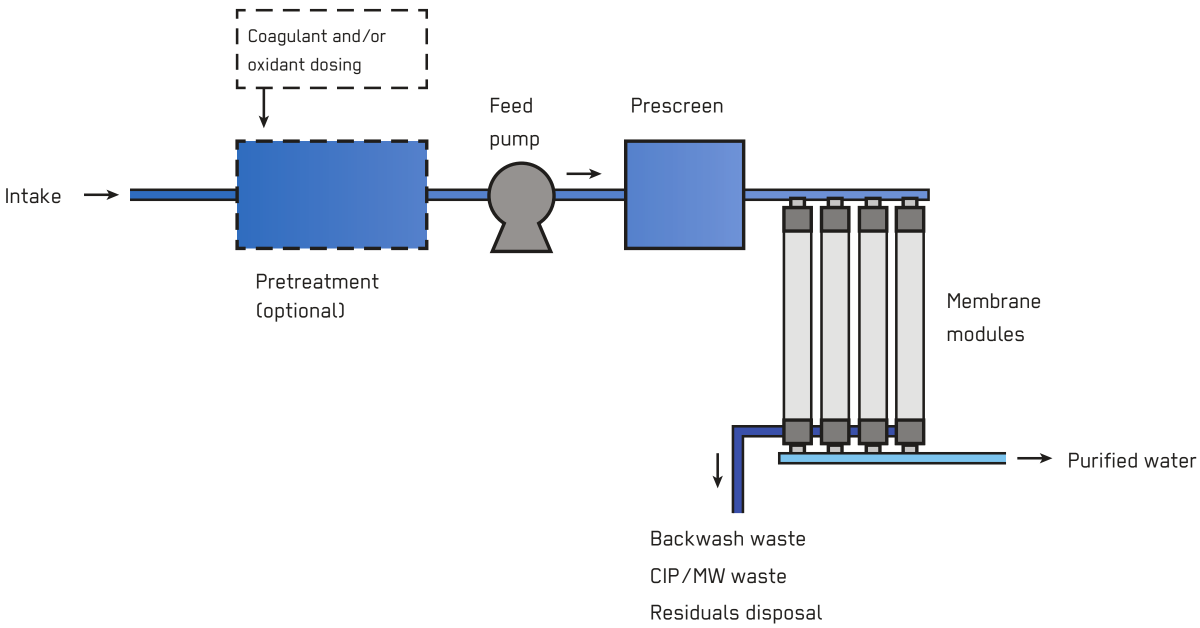
Microfiltration (MF)

Response Phase	Application Level	Management Level	Objectives / Key Features
* Acute Response ** Stabilisation ** Recovery	** Household ** Neighbourhood ** City	** Household ** Shared ** Public	Turbidity removal, pre-treatment and partial pathogen removal
Local Availability	**Technical Complexity**	**Maturity Level**	
* Low	** Medium	*** High	



Microfiltration (MF) membranes provide excellent filtration with low final water turbidity (typically less than 0.1 NTU) and high removal levels for pathogenic protozoan cysts/oocysts, Giardia and Cryptosporidium and bacteria. As a final treatment step, Chlorination (T.6) or Ultrafiltration (T.10) as well as Nanofiltration/Reverse Osmosis (T.15) can be used. MF is applicable in all emergency phases and at different scales (see H.4 for household scale).

MF uses membranes to filter water. Raw water is forced through the membrane by a pressure difference, and components of the water are retained based on the size of the pores in the membrane. The smaller the pores, the greater pressure that must be exerted. MF membranes used for water treatment have pore sizes of 0.1–0.5 µm. These membranes remove particles and protozoa and can remove a 4-log (99.99 %) or higher amounts of Giardia/Cryptosporidium and bacteria, though usually remove under 1-log of viruses. Post-treatment usually includes disinfection, such as Chlorination **(T.6)**. MF-based plants are usually factory prefabricated and skid-mounted, although there are also single-membrane modules available. Most of the MF membrane modules in skid-mounted systems are made of small, string-like hollow fibres that are mounted in cylindrical (pipe-like) vessels or tanks due to the extremely high packing density (2,000–15,000 m²/m³), depending on the system type.

Design Considerations: Membrane-based filters have two fundamental design differences over non-membrane filtration: dead-end-filtration (feed is pushed completely through the membrane) and cross-flow filtration (feed flows over the membrane, not all of the feed is filtered). Typical MF membranes run as dead-end-filters. Pre-treatment always includes a protective pre-screen (typically auto-backwashing type rated at about 300 micron). Additional pre-treatment (e.g. Assisted Sedimentation, **T.4**) can augment the removal of dissolved materials or reduce the fouling potential of water with a high organic matter content. Automatic in-line coagulation followed by direct

MF is used for waters with a high fouling potential to reduce membrane plugging. Usually membrane-friendly coagulants like poly-aluminium-chloride and/or aluminium-chlorohydrate are preferred. Prefabricated and skid-mounted MF systems mostly include a control system to regulate operating conditions during cycles, including pump-driven filtration, backwash frequency, chemical cleaning (typically once a month) and integrity tests (to ensure the membranes are not damaged).
Typically, systems auto-backwash with filtered water every 20–30 minutes depending on the raw-water quality. An MF unit does not produce filtrate during the roughly 3-minute auto-backwashing period, so a break tank is required for filtrate storage. About 85–95 % of the feed water becomes usable filtrate, and the rest is discharged as spent backwash or chemical cleaning waste. A major design parameter is flux, indicating the filtrate flow per membrane area. If the flux is set too high for an application, it can result in membrane fouling. Reversible fouling can increase the operating pressure, though can be managed by regular backflushing and chemical cleaning (typically 1 day/month). Irreversible fouling will require advanced chemical cleaning and can permanently damage the membrane. Running some MF membranes dry can also lead to permanent damage. There are MF systems that operate at constant flux and/or constant pressure. Most projects conduct onsite piloting before design, though if this is not possible, trial-and-error experimentation is advised.

Materials: Typically, the entire MF system is purchased together because the ancillary equipment, including support racks, pumps, valves, pre-screen(s), air compressor(s) and computer system (for backwash and water quality monitoring), are just as important as the membranes. Consumables include membrane elements (5–10-year service life if operated correctly), membrane repair kits, electricity and chemicals (e.g. citric acid and sodium hypochlorite for cleaning and disinfection; caustic (sodium hydroxide and sodium bisulfide) for neutralisation).

Applicability: Compared to Ultrafiltration **(T.10)**, MF is more often used as pre-treatment for Nanofiltration/ Reverse Osmosis **(T.15)** or to reduce turbidity for subsequent disinfection by other methods. In such cases, MF is typically applied where efficient and cost-effective automation is required. These systems can be set up very quickly (automated skid-mounted-systems). MF can be applied in remote locations and urban areas, since it is easily scalable, and can be used in all phases of an emergency, including the acute response.

Operation and Maintenance: Well-trained operators are advised for a long, reliable service life. Although the systems are usually automated or semi-automated, operating mistakes can cause major damage to membrane elements (broken fibres, fouling). Regular tasks include the daily verification of instrument accuracy and integrity testing, a daily check of chemical levels, a weekly calibration of chemical feed pumps and instrument cleaning, and a weekly review of the data, which includes considering revisions of any operating parameters, such as flux, chemical cleaning frequency and a volt-amp check on electric motors.

Health and Safety: MF membranes retain high levels of bacteria and protozoa (also cysts) of up to 99.9–99.9999 % (3-log to 6-log reduction values, LRV), while the removal of viruses is usually under 1-log. Retentate disposal must be carefully considered, since it contains the contaminants found in the feed water. Depending on the constituents and local regulations, retentate can be directed back to the source water, such as a river, disposed in the municipal sewer, diluted and used for irrigation or treated on-site before disposal. Treatment before disposal and reuse is recommended when disposal in municipal sewers is not possible. Chemical cleaning agents can be corrosive and require trained operators and personal protective equipment.

Costs: The initial acquisition costs are comparatively high due to the high costs of membrane modules and need for advanced axillary equipment. While the MF membrane alone is relatively cheap (10–20 USD/m^2 of the membrane), the costs of the entire modules vary between 70–120 USD/m^2. By caring for the system by means of frequent and appropriate cleanings, the filter will have a service life (depending on the manufacturer) of up to 10 years, resulting in relatively low costs per user over time.

Social and Environmental Considerations: MF filters are well accepted by users and institutions, as the turbidity of water is visibly improved. Establishing it as a new technology requires training, O & M capacity development and willingness of local staff. The energy requirements for operating MF systems are comparable to conventional water treatment systems.

Strengths and Weaknesses:

- (+) Produces excellent filtrate quality in terms of turbidity and pathogen removal
- (+) Is usually fully automated and can be operated unattended or manually
- (+) Requires little space for these very compact systems

- (−) Limited flow based on the optimal flux of the membrane
- (−) Uses special components, e.g. the membranes themselves are likely only available in specific areas
- (−) Rarely inter-changeable, so one manufacturer's membranes cannot be installed in another's system
- (−) Requires trained operator

→ **References and further reading material for this technology can be found on page 217**