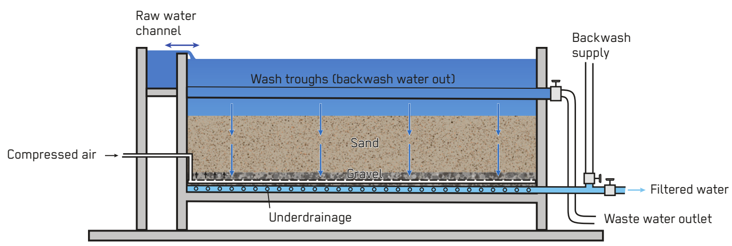
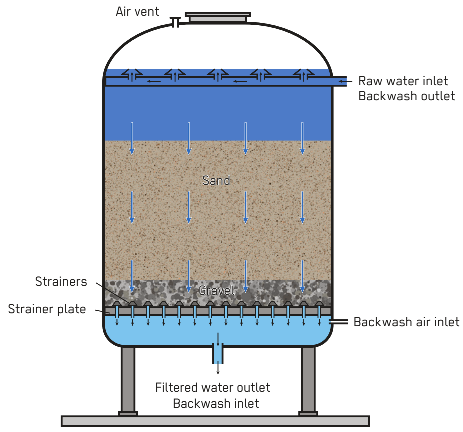
Rapid Sand Filtration

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





Rapid Sand Filters use coarse sand as a filtration medium to remove fine suspended solids from water with varying levels of turbidity (or 'muddiness'). It is a pre-treatment step prior to a final disinfection process, such as Chlorination (T.6), and can be used in all phases of an emergency.

Rapid Sand Filters consist of a tank or basin containing the filter media with a gravel support at the base, an underdrain system to collect filtered water and inject backwash water, and troughs along the top of the filter (0.5 metres above the unexpanded filter bed) to collect the backwash water. Rapid Sand Filters mainly remove particles from the water using physical processes, the most important of which is adsorption, though sedimentation and straining also play a role. Rapid Sand Filters require backwashing. Pressurised Rapid Sand Filters are often part of compact water treatment units designed for emergencies.

Design Considerations: Rapid Sand Filters can be used directly or in combination with other pre-treatment processes, depending on raw water turbidity. It works well where raw water quality is around 25 NTU (where NTU is a measurement of turbidity). For higher turbidity (up to 100 NTU), Rapid Sand Filtration can be combined with a hybrid form of an upflow Roughing Filter **(T.1)** using higher-than-normal flow rates. For water over 100 NTU, a standard Roughing Filter **(T.1)** or conventional (Assisted) Sedimentation **(T.4)** can be used. Rapid Sand Filters reduce turbidity by at least 90 %, aiming to reach a suitable turbidity for the subsequent treatment process (i.e. less than 5 NTU for Chlorination **(T.6)** or about 10 NTU for Slow Sand Filtration **(T.9)**). They may also reduce bacteria by 60–90 %, depending on conditions, and can slightly reduce colour, taste and heavy metals. For groundwater with high iron and manganese content, they are often used after aeration to filter out precipitates.

Sand is the most used filtration medium, and it should be fairly uniform in size with an effective range from 0.4–1.2 mm. Sometimes a coarser layer is added on top of the sand (e.g. anthracite or coconut husks) to reduce the rate of blockage. Flow direction can be either down or up, and water is driven either by pumping or gravity. For decentralised applications, gravity downflow filters are mainly installed for ease of inspection and maintenance. Pressure filters (or closed filters) make longer filter runs possible and are used in industrialised settings and emergency water treatment kits. They can be operated at a flow of between 15–30 m/hour (a compaction of m^3/m^2/hour). Gravity filters (or open filters) are open to atmospheric pressure and operate between 5–15 m/hour. Even with adjustment (controlling flow with valves), the flow will reduce after some days, at which point backwashing is carried out in the upflow mode using either pumps or gravity. If done by gravity, it requires a clean water tank installed high enough above the backwash troughs of the filter to provide the desired backwash flow rate (a height difference of 4–6 metres tends to be sufficient). For pressure filters, a pressure drop (around 0.5 bar with a stable flowrate) is an indication of clogging. When designing, it is important to consider that a pure sand filter expands by up to 30 % during backwashing.

Materials: Materials include the filter compartment(s), water inflow and outflow system with control mechanism, underdrain system, filter media, pumps (or raised water tank) and (optional) compressed air system for backwashing.

Applicability: Rapid Sand Filters require sufficient local capacity and financial resources (e.g. larger urban or industrialised contexts). As pressure filters, they can be used in the acute and stabilisation phases of an emergency. Larger-scale units are possible in the recovery phase (test characteristics of the water, followed by a small pilot plant).

Operation and Maintenance: O & M requirements are significant, with the main tasks related to flow control and backwashing. Backwashing is frequent, at every 0.5–2 days for up to 30 minutes; where the raw water is turbid and the runs between backwashing are shorter than 6 hours, design changes must be considered. The operator must ensure that the backwash flow rate is high enough to expand the filter bed, yet low enough that filter material is not washed out of the wash troughs (at least 0.5 metres above the unexpanded filter bed). Backwash rates vary from 12–90 m/hour depending on sand size and ambient temperature (slower rate possible at lower temperature). Compressed air may also be used in some filters for backwashing. Gravel layers below the coarse sand support the medium and prevent the drain from clogging with sand. The gravel should not be displaced by the backwashing procedure. General plant maintenance will also be needed (e.g. application of anti-corrosive agents to metal parts, lubricating valves).

Health and Safety: Rapid Sand Filtration is a pre-treatment method and should not be used as a single-step treatment process for drinking water. Sludge dislodged during backwashing should be disposed of safely where coagulation has been used as part of the system to avoid metals such as aluminium entering the water supply.

Costs: Capital costs for the filter can vary in the range of 100 USD/m^3/day capacity. Ongoing costs for O & M are around 13 USD/m^3/day capacity, which is higher than for Slow Sand Filters **(T.9)** due to more frequent supervision plus pumping for backwashing. For backwashing alone, up to 180 work hours are required per year. Costs can be reduced by designing smaller pumps for pumping to a raised water tank rather than larger pumps for backwashing.

Social and Environmental Considerations: Rapid Sand Filters are well accepted by users/institutions, as they visibly improve turbidity. Establishing it as a new technology requires training, O & M capacity development and willingness of local staff. Sludge produced during filter backwashing should be treated (dewatered) and safely disposed of. Disposal of untreated sludge into the environment may lead to health and environmental risks.

Strengths and Weaknesses:

(+) Can be constructed with local resources
(+) Treats stable suspensions with high concentrations of colloidal matter when combined with coagulation

(−) Uses filtered water for backwashing
(−) Has high maintenance requirements
(−) Has high operational costs
(−) Requires more time and resources for installation than coagulation and sedimentation

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