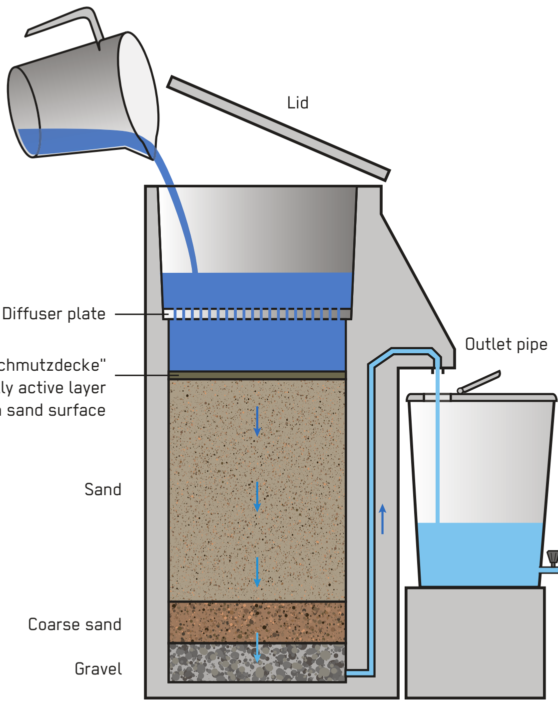
Biosand Filtration

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



Biosand Filters (BSF) remove suspended solids and microbial contaminants from water with varying levels of turbidity through a combination of physical and biological processes. They are an adaptation of the continuous-flow traditional Slow Sand Filter (T.9) and can be used intermittently, making them suitable for household use.

A BSF consists of a container filled with filter media and a gravel support at the bottom. Contaminated water is poured into the filter and filtered by gravity. Filtered water flows through the outlet tube and into a safe storage container. BSFs can greatly reduce pathogens and suspended solids in the water through a combination of physical, chemical and microbiological processes within the filter bed **(see also T.9)**. These processes include predation, adsorption, natural death and mechanical trapping. Microorganisms in the source water develop into a biological layer in the top layers of the filter sand. Full development of the biolayer may take up to several months depending on the volume and quality of the source water used. During the first month, microbial removal performance of the BSF is low, and users should additionally disinfect the filtered water.

Design Considerations: The average BSF is 0.9 m high by 0.3 m wide. Empty containers weigh between 70–135 kg (concrete) or 3.5 kg (plastic). To ensure the required uniform flow, the outlet tube is embedded in the container wall or affixed to the outside and is free of taps, hoses or control valves and is above the sand layer. This ensures that when the filter is at rest, it maintains 5 cm of water above the sand surface, called the standing water. BSFs must be kept saturated, as the sand is the habitat for the organisms responsible for the biological filtration process. The filter is operated in batches of 10–12 L. Two layers of gravel at the bottom of the filter ensure uniform flow through the sand and prevent sand from entering the outlet tube. For slow sand filtration, a raw water turbidity of between 10–50 NTU is recommended. BSFs can be operated using water with a higher turbidity, but more maintenance is required.

Sand size is a critical design parameter, with an effective size ranging from 0.15–0.30 mm (higher efficiency at the lower end) and a uniformity coefficient of between 1.5–3 (meaning not too uniform and not too diverse). Sand depth tends to be between 0.45–0.5 m, while water height varies according to the flow. When filled, the water depth on the filter is usually around 20–30 cm, reducing to approximately 5 cm when not in use to allow adequate oxygen diffusion. A filtration rate of around 0.1–0.4 m/h, resulting in a flowrate of around 25 L/hour, is required to support biological activity. The inlet should be designed to ensure even flow distribution and reduce disturbance of the top sand layers.

Materials: The BSF container can be made of concrete, plastic, stainless steel, galvanised metal or any other waterproof, rust-proof and nontoxic material. Concrete containers, cast using a steel mould, galvanised iron filters or filters from available plastic containers can be made locally. Other container types may need a centralised manufacturing facility or can be imported. A simple lid can be made of wood or non-rusting sheet metal. A diffuser basin made from plastic or rust-proof sheet metal is preferable to a diffuser plate, as it eliminates spill over and resulting damage to the biolayer. Filter media, including two layers of gravel, must be free of contamination and sieved to achieve the proper size (sand < 0.7mm, separation gravel 0.7–6 mm and drainage gravel 6–12 mm). All filter media must be washed to remove organic matter. A simple jar test can be used to determine when sand has been sufficiently washed.

Applicability: The BSF is suitable for household use but is not recommended for the acute response because of the time required for biological activity to ripen within the filter. Household filters may be considered in the recovery phase for dispersed populations. The filter is heavy and difficult to move, making is unsuitable for people who relocate often. Concrete BSFs require a minimum of one week to cure before installation can occur. Plastic or metal BSFs can be installed more rapidly, but a maturing period is still needed.

Operation and Maintenance: Operation of the BSF requires the user to pour water from the same source into the filter each day to maintain the biological layer. Treated water must be collected with a clean, safe storage container. Over time, the sand surface becomes clogged with accumulated sediments and organic matter, slowing the flow. When the flow rate is no longer acceptable, the filter must be cleaned. For household BSFs, this involves a swirl-and-dump process, which is performed by agitating the surface of the sand and removing dirty standing water. After maintenance, the biological layer takes time to regain its efficiency level, though this takes less time than when the filter is first installed. The outlet tube, lid and diffuser should also be cleaned on a regular basis with soap or chlorine and treated water. BSFs should never be fed with chlorinated water, as this will damage the biological layers.

Health and Safety: BSFs reduce turbidity, organic content, microorganisms, oxidised iron and manganese concentrations in water. Protozoa are removed by over 99.99 %. The removal efficiency for bacteria and viruses depends on the operational conditions and varies in the range of 70–99 % for viruses and 98.5–99 % for bacteria. Design and operating conditions affecting performance include sand size, sand bed depth, temperature, water hardness and other water quality parameters as well as the time the filter has been in operation. The long-term effectiveness of BSFs depends on O & M quality, and close and comprehensive support is essential to retain effectiveness.

Costs: The total cost of the BSF ranges from 10–100 USD depending on the materials used and context. For users, a key advantage of the BSF is that there are no recurring costs for consumables, though lids, diffusers and safe storage containers may require periodic replacement. The sand does not require replacing. The filters have usually a long lifespan (5–10 years).

Social and Environmental Considerations: BSFs have been used in over 70 countries and are generally considered an affordable, effective and sustainable means of providing clean water to households. They provide an effective treatment of any non-chlorinated water, and anyone can be trained to construct and install filters locally. Concrete filters keep water cooled. However, regular ongoing support is required to ensure correct operation by users, the water quality remains stable and the filters do not fall into disuse.

Strengths and Weaknesses:

(+) Removes turbidity and iron and reduces microbial contamination. Can be modified to remove arsenic **(see H.14)**

(+) Has high user acceptability (easy to use, improves taste)

(+) Can be produced from local materials using local resources

(+) Needs only one-time installation with low maintenance requirements (no chemicals, energy or consumables)

(−) May take up to several months for biological layer to develop

(−) Less effective for virus removal (> 80 %) and at low temperatures

(−) Must be used regularly and with a consistent water source to maintain an effective biological layer

→ **References and further reading material for this technology can be found on page 222**