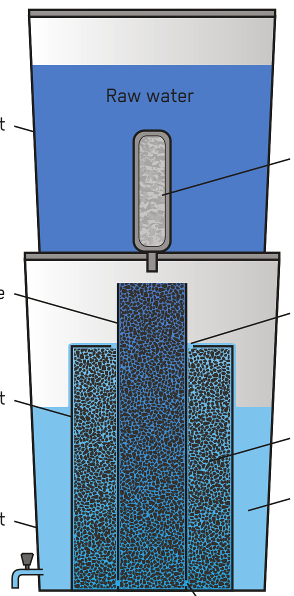
Fluoride Removal Filter

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



Fluoride is a groundwater contaminant naturally present in rocks and soils (commonly volcanic-derived sediments). At levels over 1.5 mg/L, it can detrimentally impact human health. As the health impacts result from prolonged consumption, Fluoride Removal is mostly relevant for the recovery phase and protracted emergencies.

Fluoride can be removed from groundwater by adsorption on calcium-phosphate- or aluminium-oxide-based filter materials, by precipitation and coagulation treatment processes or by reverse osmosis. By adding chemicals such as calcium and aluminium salts, precipitates form that bind fluoride and can be removed by conventional sedimentation and filtration steps. The Nalgonda technique uses aluminium sulphate and calcium hydroxide (lime) as coagulants. Other techniques include electrocoagulation and the Nakuru technique, the latter being a mixture of precipitation and adsorption processes. For adsorption and ion-exchange, fluoride-contaminated water is passed through a layer of porous material ('contact bed') that removes fluoride from water through ion exchange or adsorption to the contact bed material. Appropriate contact bed materials include activated alumina or calcium-phosphate-based materials such as synthetic hydroxyapatite and bone char. An important advantage of adsorption techniques is that many filter materials can be regenerated.

Design Considerations: Techniques requiring the daily addition of chemicals for fluoride Coagulation and precipitation (e.g. Nalgonda technique) are not so practical at household level, as the daily operation (chemical dosing, stirring, settling, sludge removal) is time-consuming and error-prone. Adsorption/ion-exchange methods are therefore preferred for household systems, where the amount of water filtered is usually in the range of 20–40 L/day. The filters are usually composed of two chambers, one filled with adsorbent or ion-exchange resin and the other for storing clean water. When water is bacterially contaminated, ceramic filter elements are used before or after the fluoride treatment. For filtration at household level, it is important is to calculate the predicted time of filter material saturation based on its uptake capacity, the fluoride concentration of raw water and the amount of water filtered per day. Close to the point of saturation, the fluoride in the treated water should be analysed by the filter distributor, and the material should be replaced or regenerated if necessary. Regeneration will need to be organised off-site and performed by trained staff (handling of acids and bases). The Fluoride Removal capacity decreases with each regeneration cycle. Most techniques can remove over 90 % of fluoride, although higher pH/alkalinity can make some techniques less effective (e.g. activated alumina and Coagulation/precipitation are less effective at higher levels).

Materials: Fluoride Removal Filters can be constructed locally using buckets. Bone char as well as synthetic hydroxyapatite can also be produced locally, though require training and investment in production facility. Activated alumina might not be locally available.

Applicability: Fluoride is an essential building block for the formation of tooth enamel and bones, but the consumption of drinking water with high concentrations over a long period can lead to the serious degradation of teeth and bones. The guideline value set by the World Health Organisation for fluoride in drinking water is 1.5 mg/L. Risk maps are available (e.g. at Groundwater Assessment Platform) showing regions with a high likelihood of elevated fluoride content in groundwater. Depending on the number of family members and capacity of the household system used, there may be a need to separate treated water used for drinking and cooking purposes and untreated water used for handwashing, bathing and laundry, and care must be taken not to mix the containers. As the health effects are due to long-term consumption, the technology is more suited to the recovery phase and protracted emergencies occurring in areas with a high risk of elevated fluoride content. When Coagulation is used for other reasons, the fluoride concentration may also be reduced.

Operation and Maintenance: The operation of household Fluoride Removal Filter systems is generally simple for users. The necessary contact time between the water and filter bed, which differs depending on the filter material, should be respected to ensure efficient Fluoride Removal. Regular water quality monitoring, replacement and/or regeneration of material should be organised by the distributor/vendor of the filters and requires user cooperation. When the uptake capacity of household filters is reached, fluoride is removed by passing a basic solution over the filter bed, followed by an acidic solution for reactivation. The chemicals need to be stored and handled carefully and should be done by well trained staff in a service centre. The filter media can then be reused for further Fluoride Removal.

Health and Safety: Fluoride Removal technologies do not remove microbiological contamination and post-filtration or post-disinfection might be required. Treated water must always be stored in filters or safe water storage containers. The sludge, regeneration solutions or saturated filter media pose health and environmental hazards and need to be disposed of safely (e.g. landfill away from drinking water sources). The operators involved in the production or regeneration of filter media need to be trained in personal safety measures, such as the correct use of protective equipment.

Costs: The costs of the simple locally made filters can vary between 20–40 USD when production facilities are in place. Bone char production is labour and infrastructure intensive, and these costs must be considered. For commercial products needing import and transport, the costs can increase up to 50–100 USD per filter. However, the regeneration of the material reduce the ongoing costs. In some affected countries (e.g. Ethiopia, Kenya), small providers adopted business models based on loans or service delivery.

Social and Environmental Considerations: Bone char may not be acceptable in some areas due to religious or cultural reasons. The need for water treatment may not be obvious to users, and information campaigns and behavioural change interventions **(see X.16)** might be needed. The sludge, the regeneration solutions or saturated filter media pose environmental hazards and need to be disposed of safely away from sources of drinking water or land used in agriculture.

Strengths and Weaknesses:

- (+) Has high fluoride uptake capacity for some processes (e.g. activated alumina)
- (+) Can regenerate filter material for some processes
- (+) Requires only short contact time for some processes (e.g. bone char)

- (−) Can be more labour-intensive (e.g. bone char production)
- (−) Can be less effective depending on pH (activated alumina)
- (−) Requires skilled operators for media regeneration
- (−) Bone char production requires skill (e.g. kiln at correct temperature) to prevent variations in quality

→ **References and further reading material for this technology can be found on page 223**