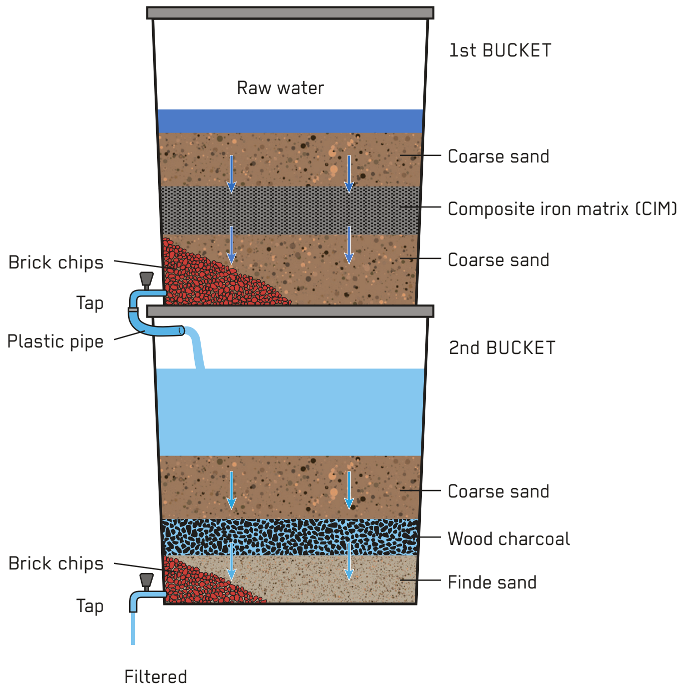
Arsenic Removal Filter

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 ** Medium	**Technical Complexity** * Low	**Maturity Level** ** Medium	



Arsenic is a groundwater contaminant naturally present in rocks and soils, though may also result from industrial activities. When present at levels over 10 µg/L, arsenic can detrimentally impact human health and should be addressed as soon as possible. It can be removed from groundwater by oxidation followed by filtration, precipitation, adsorption, ion exchange processes or reverse osmosis.

The predominant form of arsenic in groundwater is trivalent arsenic (As III), which is not as easily removed as pentavalent arsenic (As V) that attaches to various solids, such as iron oxides. Therefore, a pre-oxidation step of As III by air or chemicals is recommended prior to water treatment. Once oxidised to As V, household systems can remove it through adsorption, precipitation and ion-exchange.

Design Considerations: Most Arsenic Removal household systems are composed of two buckets/compartments, wherein As III is first oxidised to As V and then, in the second compartment, As V is removed by precipitation or adsorption on a prefabricated commercial filter material. The volume of water that can be filtered by household systems is in the range of 20–60 L/day. Removal efficiencies depend on the design and components of the filter, though are in the range of 85–99 %. Arsenic household filters are simple to operate, but the contact time must be respected, and filters generally need to run slowly. All materials will require regeneration once saturated, which is difficult to determine and requires water quality tests. A functional service chain must thus be established.
One low cost and commonly used technology is the Kanchan Arsenic Filter (KAF). It is a modified Biosand Filter **(H.5)** with zerovalent iron (often in the form of rusty nails) added to the diffuser basin. Arsenic in the water gets adsorbed onto iron oxide (from the rusty nails) and then becomes trapped on the surface of the sand within the filter.

Like other Biosand Filters, the body of the KAF can be made of concrete, plastic or stainless steel. It contains a column of finely crushed rock (sand) on which microorganisms live.

Materials: Appropriate filter materials include ion-exchange synthetic resins, activated alumina, activated carbon and iron-based solids (granular ferric hydroxide or iron-coated sand). An example low-cost material is a composite iron-matrix consisting of iron scraps that produce new adsorbent by the continued corrosion of iron. The precipitated arsenic containing trivalent iron is than removed by filtration through sand and activated carbon layers. Various strong-base anion exchange resigns are available, though they should be used only for low-sulphate waters due to a risk of releasing large amounts of arsenic in the presence of sulphate. Activated alumina is available in a granular form or as aluminium oxide, and the contaminants are exchanged with surface hydroxides of the alumina. The filter media can be filled in locally available buckets. For households connected to distribution network, membrane filters (nanofiltration or reverse osmosis) operated using available tap pressure might be an option.

Applicability: Consumption of water that is contaminated with arsenic over a long period can result in chronic arsenic poisoning. Long-term exposure to arsenic leads to changes in the pigmentation of skin and increases the risks of various diseases of the lung and heart. WHO set a guideline value for arsenic in drinking water at 10 µg/L, which is provisional based on treatment performance and analytical achievability. When present in moderate concentrations, the health effects are caused by long-term consumption, and the technology is relevant mainly for the recovery phase and protracted emergencies occurring in areas with a high risk of elevated arsenic content. However, when present in high concentrations, arsenic needs to be removed as soon as possible. Therefore, in high-risk areas, the arsenic measurements need to be carried out prior to the choice of water source, and when alternative sources are available, the source with no or low arsenic concentrations should be used. Risk maps are available at the Groundwater Assessment Platform showing regions with a high likelihood of elevated arsenic contents in groundwater.

Operation and Maintenance: The operation of Arsenic Filters is relatively simple, requiring a daily filling of water. The necessary contact time between water and filter bed, which depends on the filter design and material used, should be respected to ensure efficient Arsenic Removal. Maintenance activities include periodic cleaning/flushing and the disinfection and exchange of sand, activated carbon or iron elements in the filters. Regular water quality monitoring and maintenance should be supported by the distributor/vendor of the filters and relies on the cooperation of the user. When filter materials requiring regeneration are used, the regeneration should be done in service centres by well-trained staff, as the chemicals required must be handled carefully.

Health and Safety: The health impacts of ingesting arsenic over a long period include changes to the pigmentation of skin as well as other symptoms (e.g. bronchitis, vascular disease) and an increase in the risk of various cancers. In the short term, arsenic can increase the risk of heart attacks. These health impacts can continue even after the arsenic is removed. Arsenic-rich waste is produced by the filter systems and must be disposed of properly due to the high toxicity (e.g. landfills away from drinking water sources). The Arsenic Filters do not remove microbial contamination. There is a risk of contamination of water through poor hygiene practices, and post-filtration or post-disinfection might be required. Treated water must always be stored in filters or safe water storage containers. When ion-exchange resins are used, the raw water quality needs to be considered carefully, as other ions with a stronger affinity for the resin can displace As V, leading to an uncontrolled release of large quantities of arsenic into treated water.

Costs: Filters that can be constructed using locally available materials have costs starting from 20–40 USD. The costs of activated alumina and ion-exchange resins are high, and they might not be available locally.

Social and Environmental Considerations: Arsenic Removal Filters are well accepted when the population is aware of the health issues related to arsenic in water. However, introducing a new technology is a complex process that needs to be participatory from the outset and involve all stakeholders. Information and behavioural change interventions **(see X.16)** will be needed to increase the awareness of population in areas where this is not the case. The long-term effects of arsenic poisoning are not obvious, and users might be reluctant to use filters regularly. 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:

(+) Is relatively inexpensive and easy to use
(+) Uses locally available materials

(−) Water quality and composition strongly affect the removal efficiency; filters are not ideal for anion-rich water (e.g. sulphate and phosphate are competing ions)
(−) Difficult to predict filter lifetime and the subsequent replacement time
(−) Requires functional supply chain for effective replacement

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