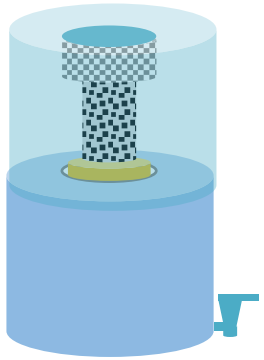
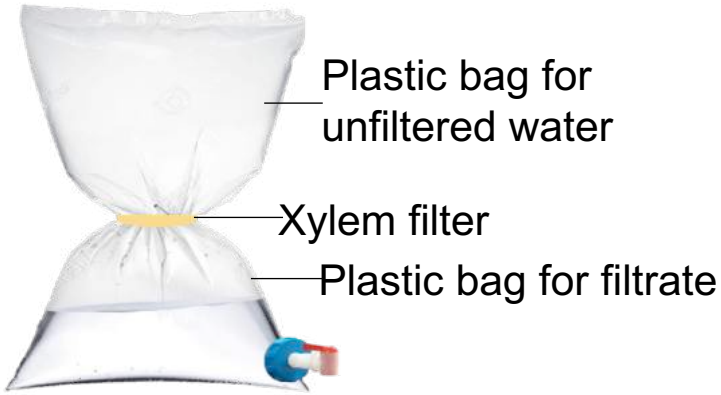
Guide for fabricating xylem-based filtration devices

Design of xylem-based filtration devices

Xylem filters could enable a diverse range of water treatment devices, ranging from household water filters to emergency use filters.



Household filter

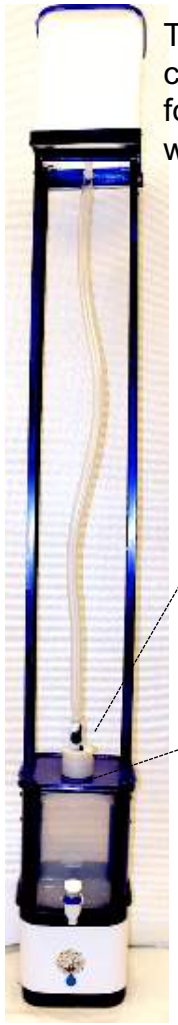


Emergency filter

A prototype for household water filtration has been shown in subsequent slides and the resource requirements for developing such as device have been listed.

Example prototypes of xylem-based filtration device

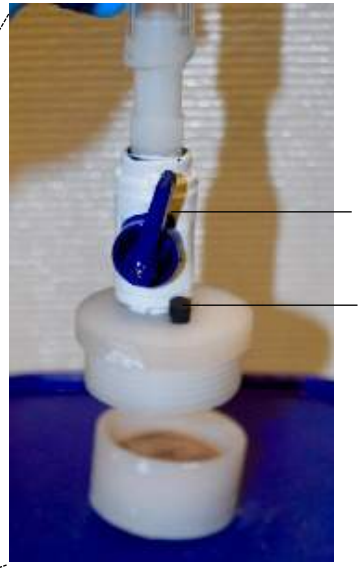
Prototype-I



Top container for feed water

0.7 meter gravity head

Bottom container with covered lid to prevent re-contamination and dispenser to access filtered water



Valve in filter holder to shut-off water supply while replacing filters

Rubber insert which can be pinched to remove air traps within the holder

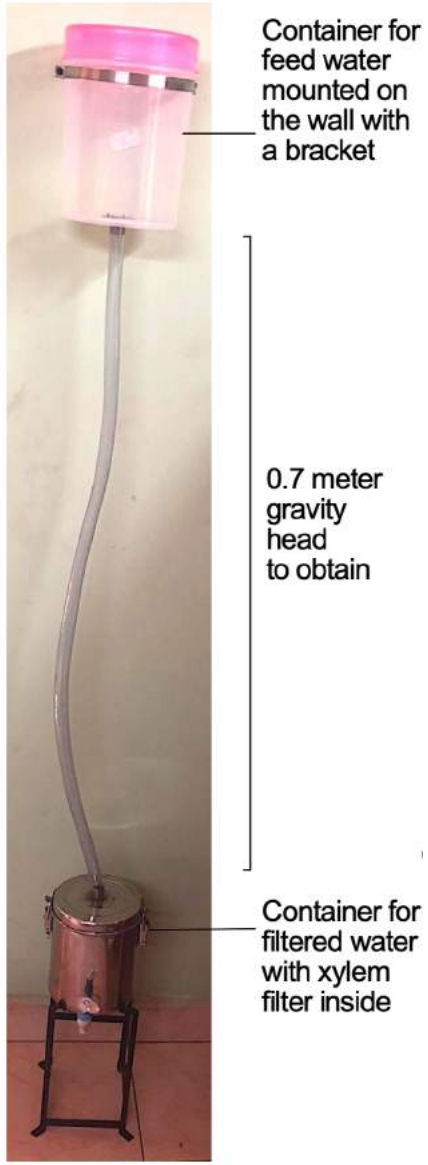
Upper part with O-ring to seal against the filter

Lower part with xylem filter having a smooth surface for leakproof sealing

Two-part holder with the xylem filter

Prototype-II (with same holder design as Prototype-I)

Example prototypes of xylem-based filtration device



Prototype-III

Filter holder made from steel

Resource requirement for fabricating prototype

Prototypes I and II were fabricated in the US, but they are amenable to local manufacture. The containers, O-rings, valves, tubing, dispenser and metal rods used in the device are commonly available items and can be sourced locally. The processes necessary for device fabrication (cutting, drilling, injection molding, etc.) are also well-established in the manufacturing industry. The device design could also be tuned as per the local availability of resources. Prototype-III was fabricated in India. The steel and plastic containers used in the device were purchased from a local shop whereas the rubber gasket used for mounting the filter was fabricated using a custom-designed mold at a local medium-scale machine shop.

Task	**Resources needed**
Storing unfiltered water	Food-grade container with appropriate capacity should be used. In Prototype-I and II, the container capacity is 5 L.
Providing gravitational head	The container with the unfiltered water has to be placed at a suitable height to provide the gravitational head to drive the water through the filter (lower head may be compensated for by larger filter area). While this could be achieved in different ways, a couple of mechanisms have been illustrated in Prototype I & II, where the container is placed on a sturdy stand, and in Prototype-III, where the container is mounted on the wall using a bracket. Food-grade tubing is needed to connect the container at the top to the filter holder.
Holding the filter in the device	Potential users in India highly preferred a holder with a screw-on mechanism (shown in Prototype-I). The particular holder, designed for 5 cm diameter, 0.375-inch thick filters, was machined from High Density Polypropylene, but the design is amenable to mass manufacture using injection molding. The key criteria that determine the successful functioning of the holder include: a) An O-ring of appropriate hardness, such that it conforms to the wood surface to seal it effectively. For the holder in Prototype-I and II, silicone O-rings with a shore hardness of 70 (procured from The Hope Group in Massachusetts, USA) were used. b) Appropriate depth and width of the O-ring grooves is critical. Excessively deep grooves compromise the ability of the O-ring to conform to the wood surface, while shallow grooves may cause the O-ring to fall out, making user handling difficult. Further, O-rings that are smaller than the holder diameter reduce the effective cross-section area available for filtration (while accommodating a larger size range of filters), but larger O-rings increase the chance of leakage (when variations in filter shape cause the O-ring to sit on or beyond the filter edge). For the holder in Prototype-I and II, the depth and width of the O-rings was 76% and 124% of their thickness respectively (conventional design values are 80% and 120%) and the O-ring diameter was 25% smaller than that of the nominal diameter of the filter. The inner diameter of the holder was 4.3 cm and the O-ring was designed to seal a filter with a diameter 4 cm or more. c) Preventing entrapment of air bubbles. Air trapped in the tubes and connectors can disrupt water flow. Using tubes and connectors with sufficiently large diameters and avoiding narrow constrictions in the flow pathway can avoid trapping of air. In Prototype-I and II, 0.25 inch diameter tubes and the connectors were used, and a vent consisting of a small hole plugged with an insert made of styrene butadiene rubber (SBR) procured from McMaster Carr (part number 9545K38) was also provided to release any air trapped within the holder.
Controlling water flow from the top container	A valve may be used between the top container and the filter, such that users can turn off the water supply when the device is not in use or while replacing the xylem filter cartridge.
Storing the filtered water	Food-grade container with appropriate capacity and a lid to prevent re-contamination should be used. The container should also have a dispenser to access the filtered water. This container should be placed at a height of at least 10-15 cm above the floor such that glasses, bottles, or other utensils can be placed below the dispenser.
Filter stand	The filter stand in Prototype-I was fabricated using 0.25-inch thick aluminum angle rods (90°). However, stands could be fabricated in several other ways.