TOT 2

Small-scale Water Treatment

4. Removal of Specific Contaminants

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- Iron and manganese removal
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Removal of Specific Contaminants

- High concentrations of specific contaminants like iron, manganese, arsenic, fluoride or nitrate may be present in some water sources
- Method of removal depends on the type of the impurity or contaminant present in water sources
- Treatment methods like adsorption, chemical coagulation, ion-exchange and different types filtration, and their combinations are used for removing specific contaminants in centralized treatment systems
- Applying these methods for removing specific contaminants at household level is often challenging and complex

Iron and Manganese in Groundwater

Iron and Manganese

- **common constituent of groundwater**
- **Iron - up to 40 mg/L ; Manganese - up to 5 mg/L**

No health consequence of iron, taste threshold 0.3 mg/L;
Taste threshold of manganese: 0.1 mg/L
Guideline value of manganese: 0.05 mg/L

Problems with iron and manganese

- **Staining, coloration, bad taste**
- **After-growth in the distribution system**
- **Incidence of increased turbidity**
- **Increased O&M cost for cleaning pipes**

Iron Removal Methods

Forms of iron: Fe (II) dissolved (No oxygen)

Fe (III) insoluble (oxygen present)

- **Oxidation and Rapid Sand Filtration**

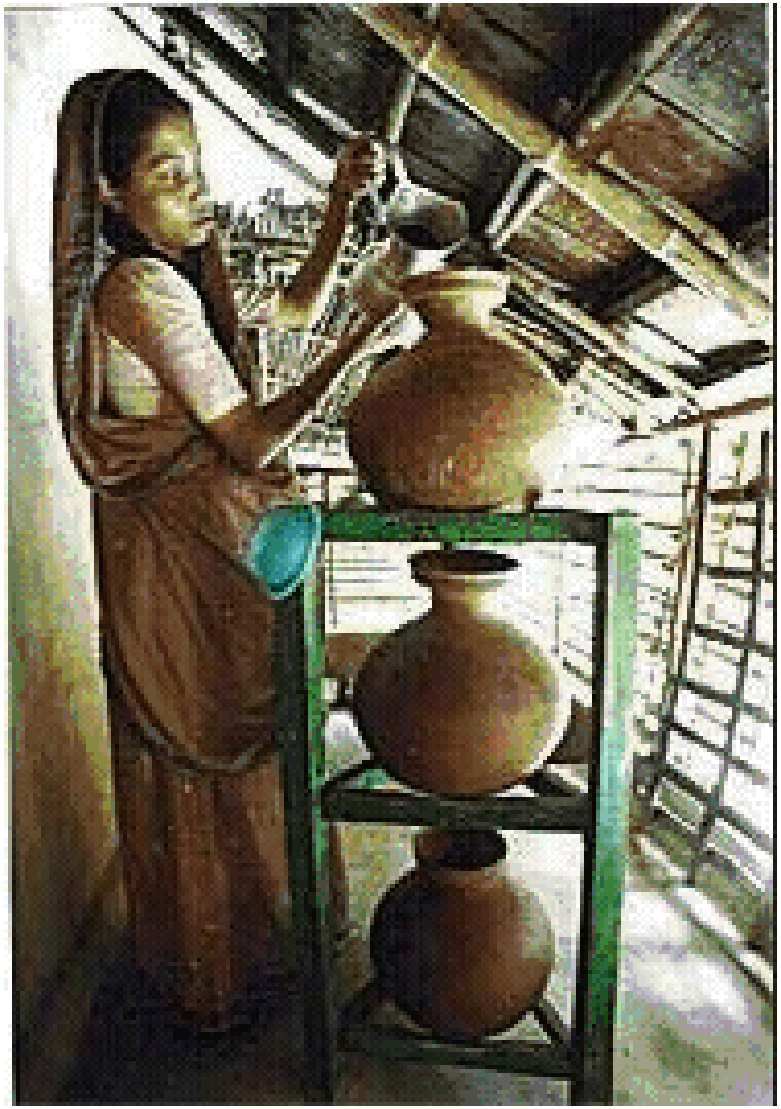
  Oxidation O_2 (Aeration)

  Cl_2, $KMnO_4$, O_3, H_2O_2, ClO_2

- **Limestone Filtration**
- **Oxidising Filters (Manganese green sand)**
- **Ion Exchange**

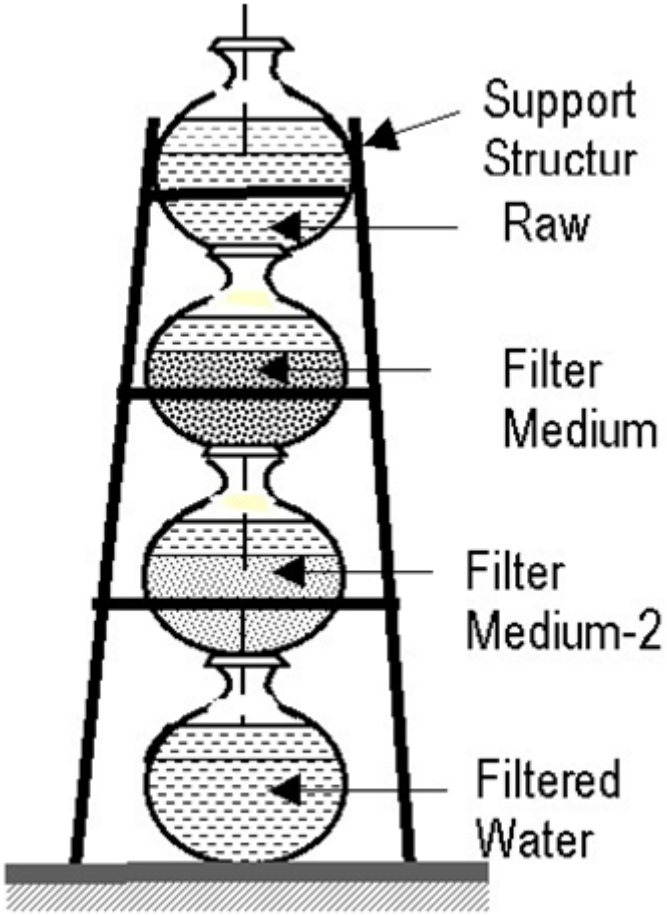
** **Manganese (present in dissolved form as Mn^{2+}) is also removed to large extent together with iron by these methods.**

Household-level iron removal system

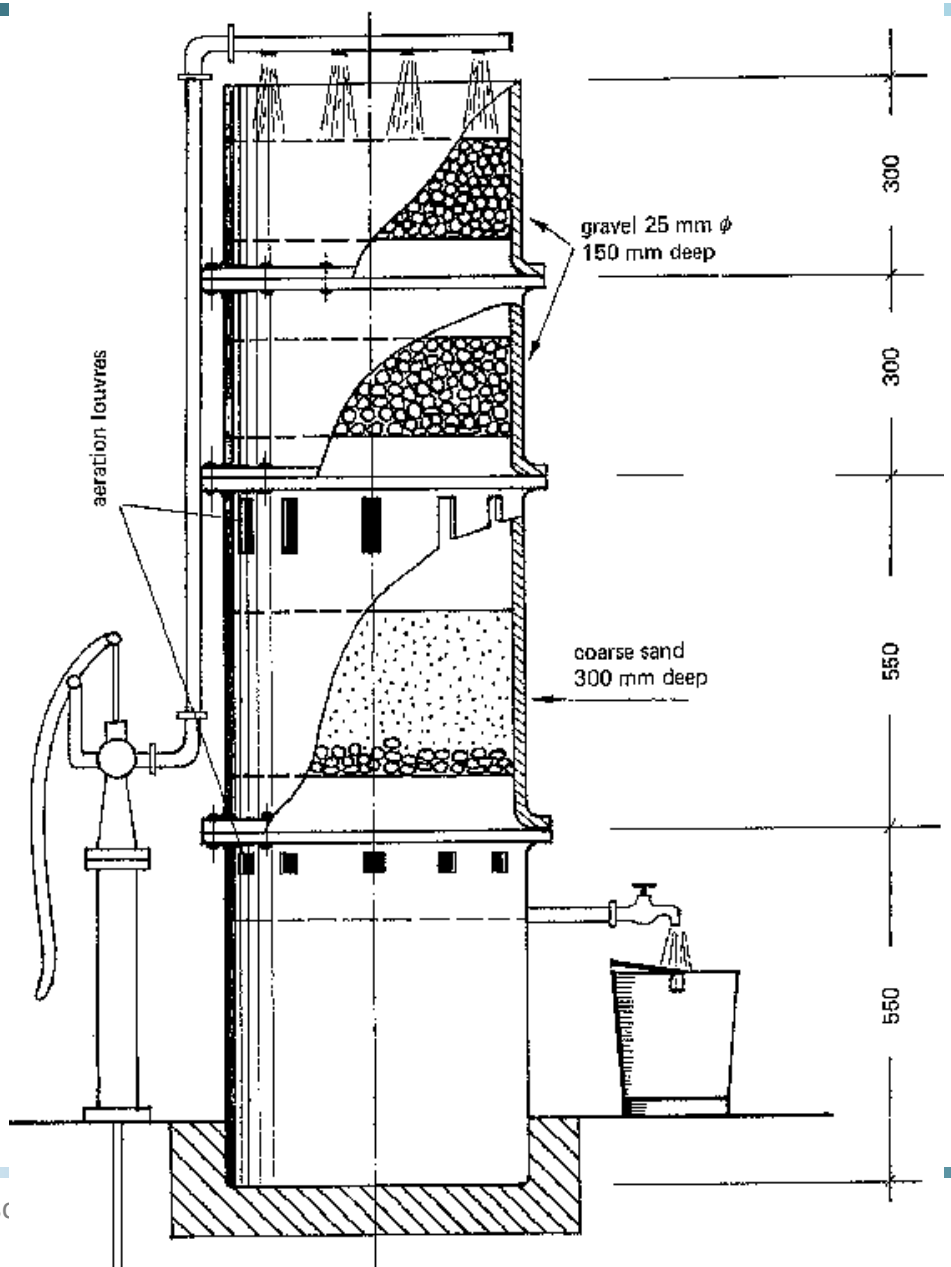


(Aeration + Sand Filtration)

Kolshi Filter (Bangladesh)



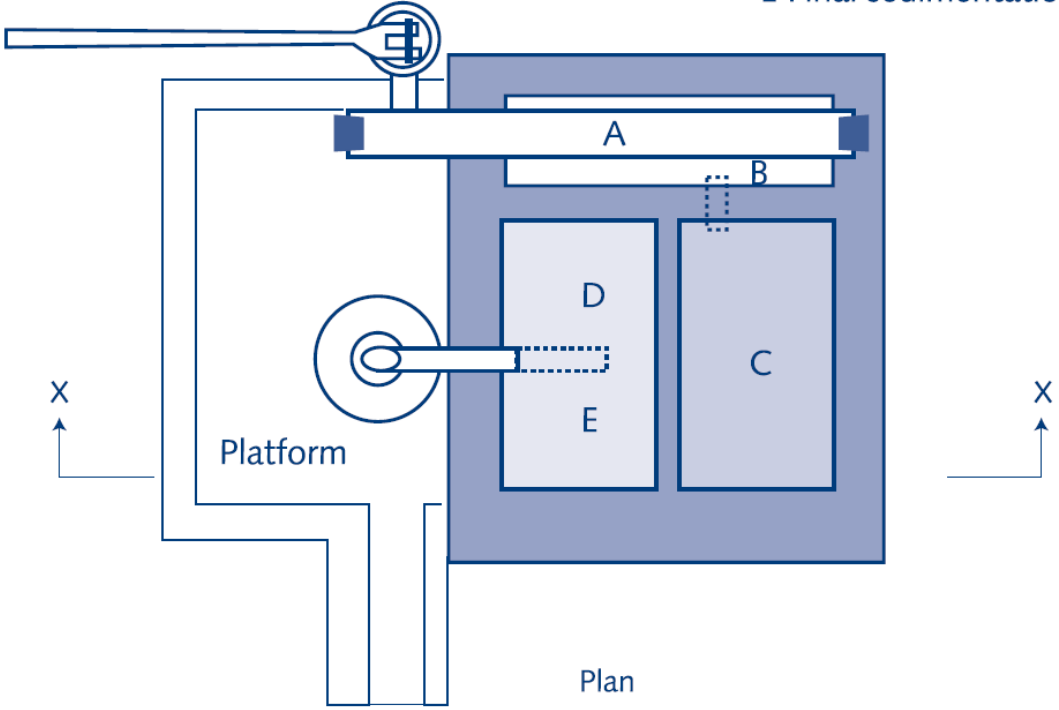
Manual device for iron & manganese removal

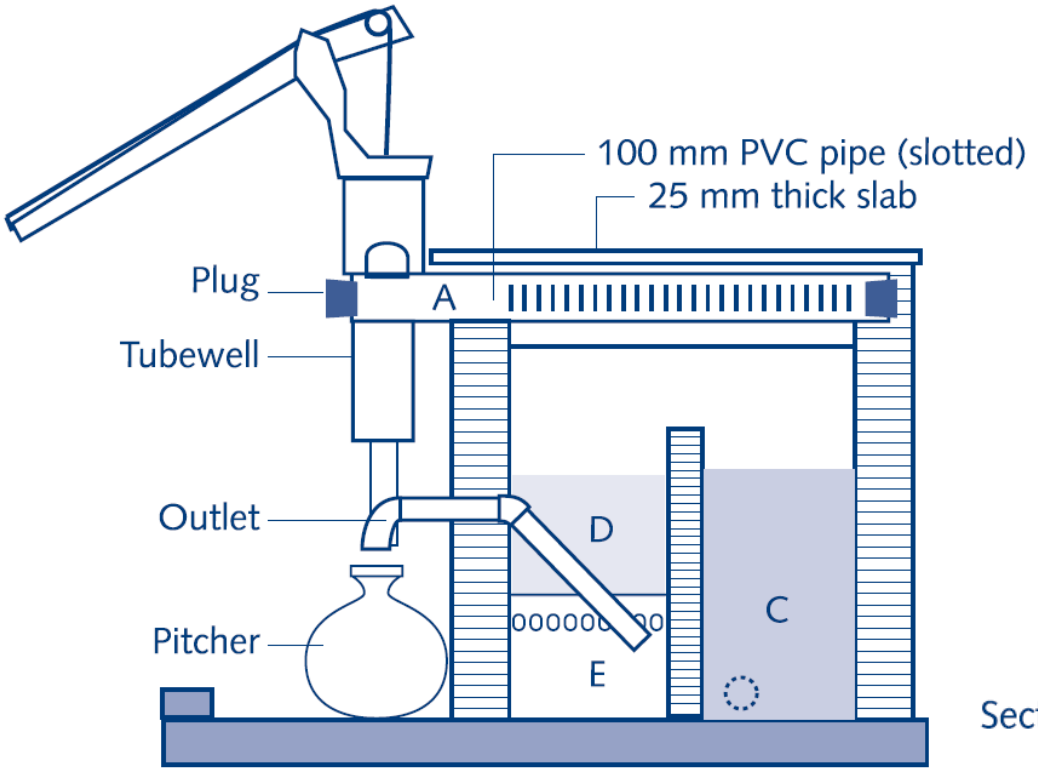


Capacity = 200 L/h

Source: Heber (1985)

Iron removal from groundwater at handpump level





A – Aeration
C/D – Filtration + Adsorption

Source: IRC (2002)

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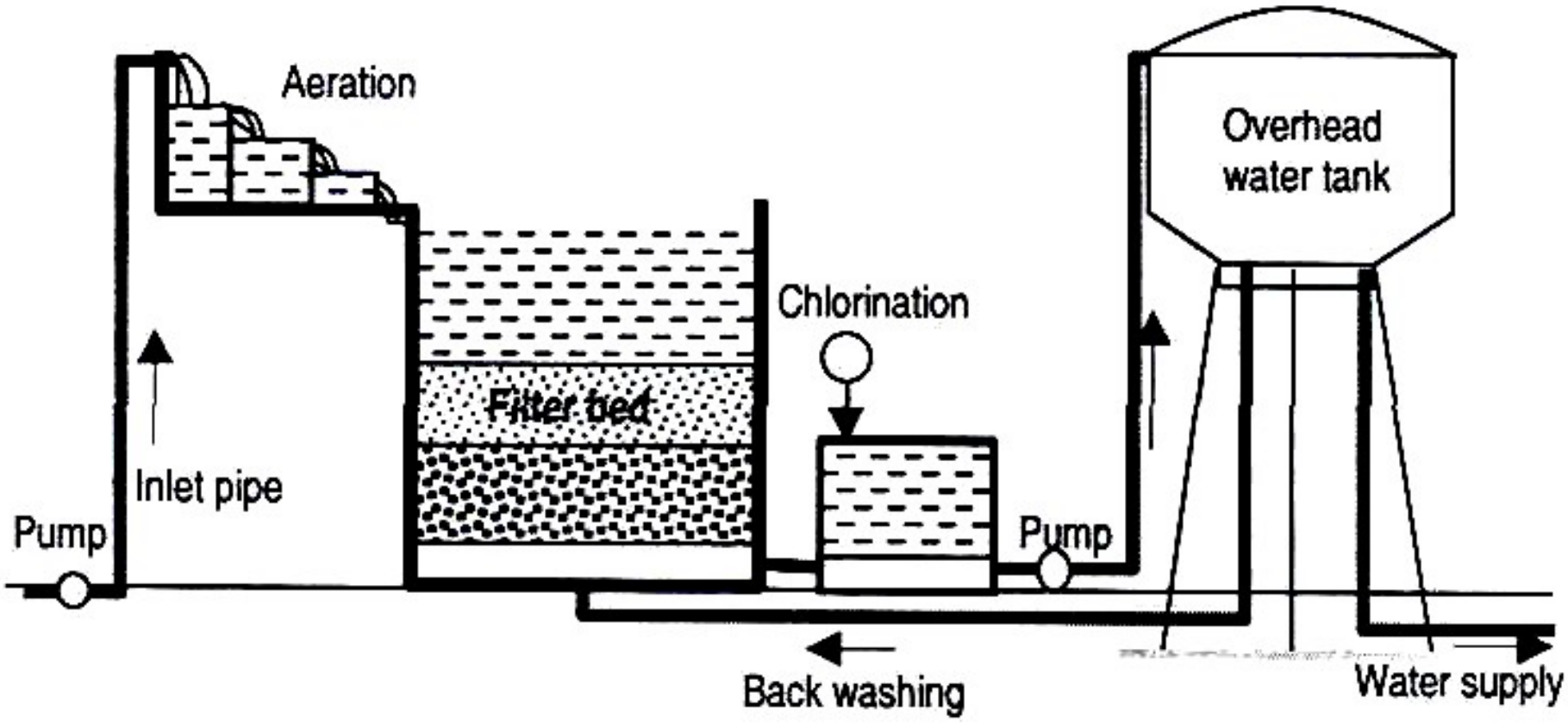
Small-scale iron-manganese removal plant



Source: IRC (2002)

Fluoride in Groundwater

- Fluoride exists fairly abundantly in the earth crust
- primarily present as F^- ion
  or as a complex with aluminum, beryllium or iron
- Global problem affecting > 25 countries
  - concentration in groundwater: up to 12 mg/L

Sources of contamination in drinking water

- Natural: dissolution of fluoride bearing minerals
- Anthropogenic: agriculture and industry
  (fertilizer & aluminum factories)

Problems with Fluoride

Deficiency - dental caries of children (< 0.5 mg/L)

Excess - dental fluorosis, skeletal fluorosis

Dental Fluorosis **- discoloured, blackened, mottled or chalky white teeth**

Skeletal Fluorosis **- severe and permanent deformation of bones and joints**

- **Fluorosis is irreversible and no treatment exist**
- **The only remedy is prevention: intake of fluoride within safe limits (from food and water)**
- **WHO guideline value for drinking water: 1.5 mg/L**

Fluoride Removal Methods

1. Chemical Precipitation

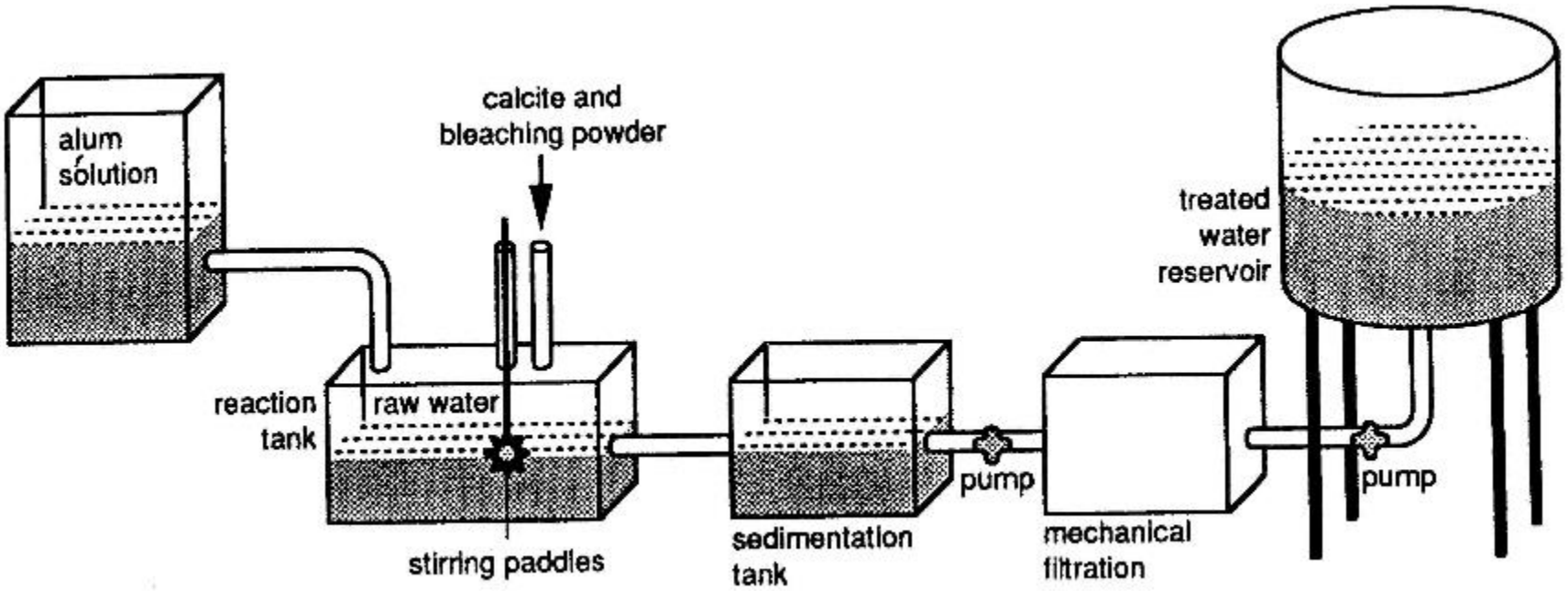
2. Adsorption
   - Bone char
   - Activated alumina

3. Ion exchange

4. Membrane Processes
   - Reverse Osmosis
   - Electrodialysis

Nalgonda Process for Defluoridation

- **Chemical precipitation methods using alum, lime and bleaching powder**

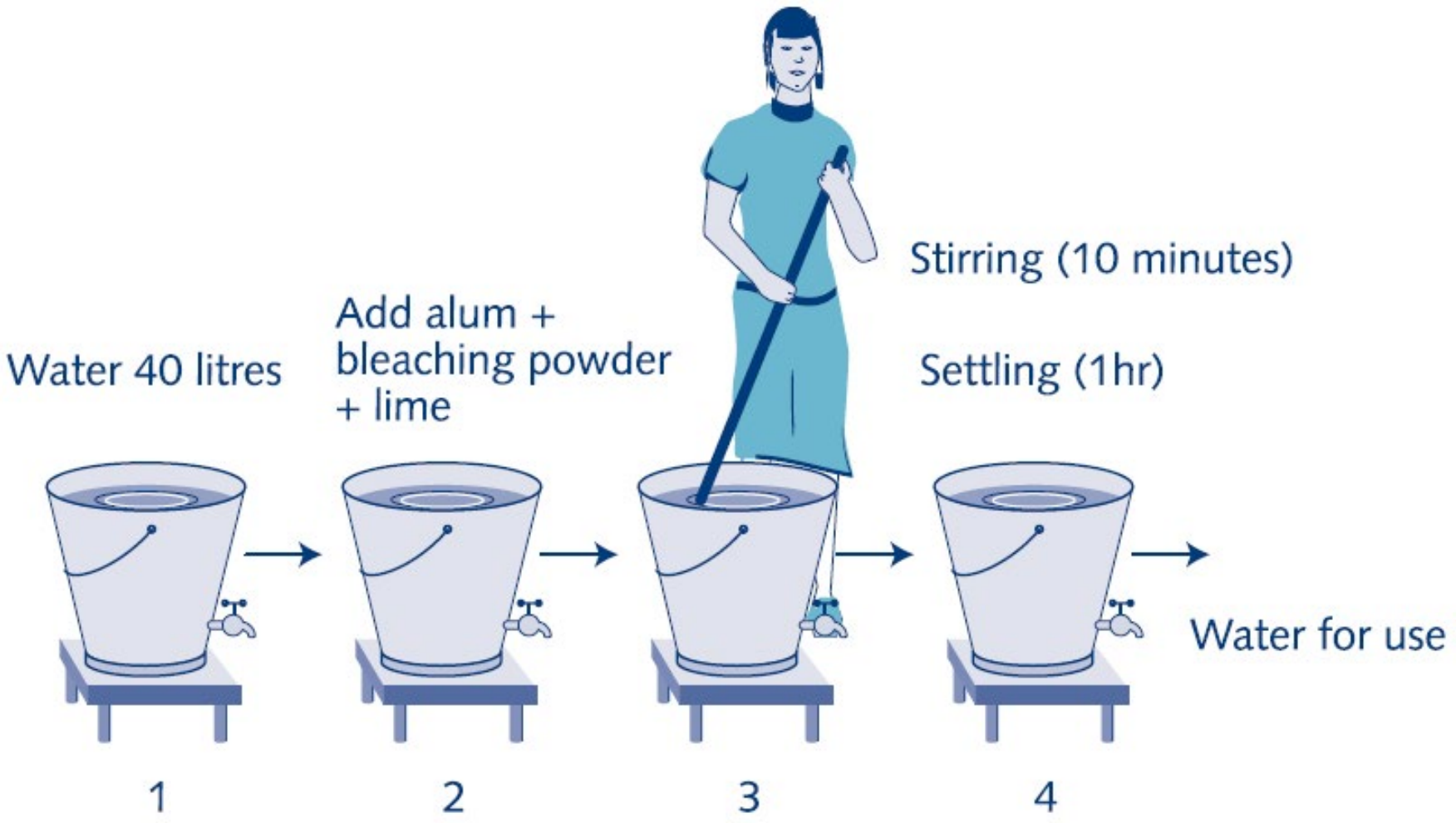


Source: Frencken (1990)

Domestic Defluoridation

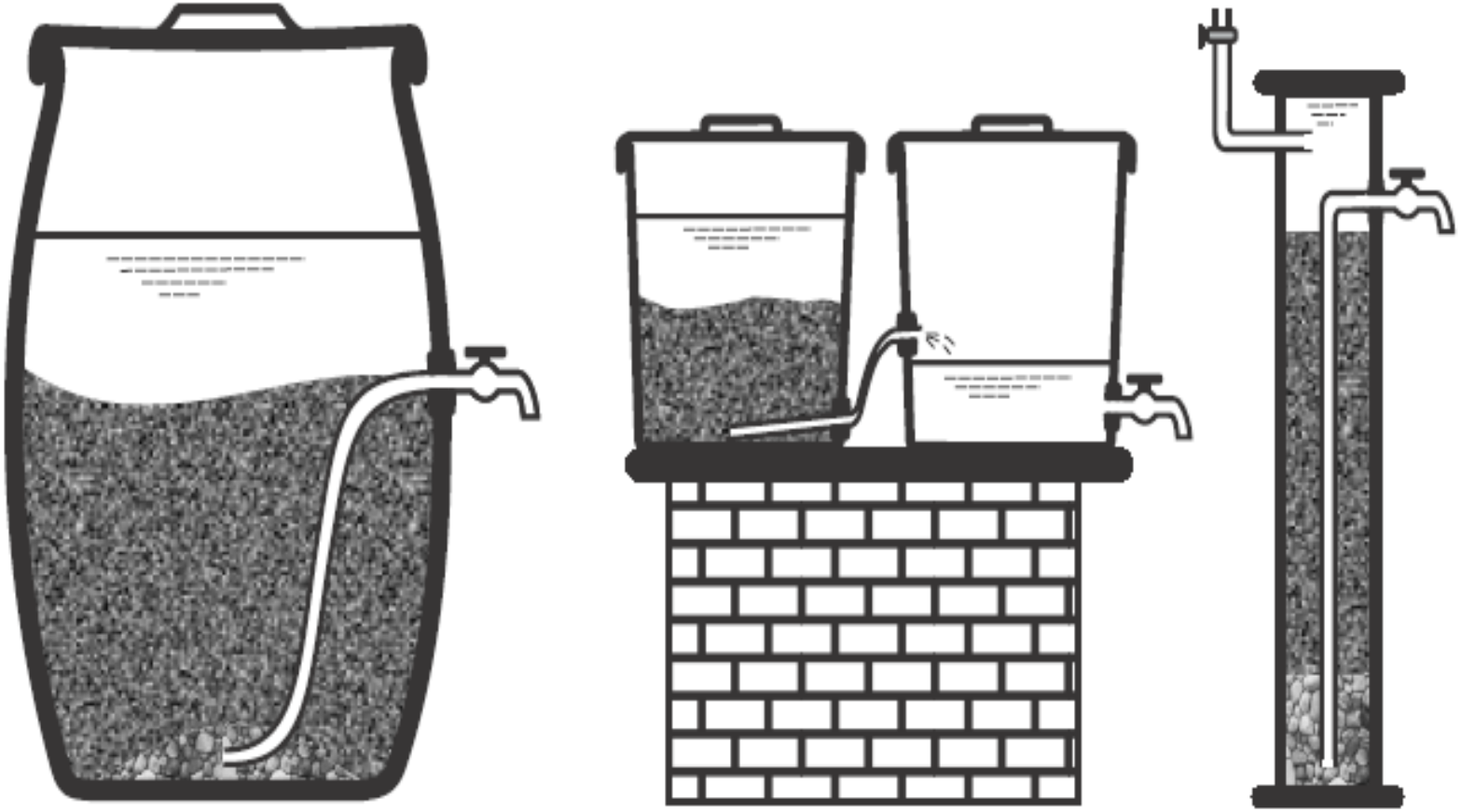
(using Nalgonda Technology)

Source: IRC (2002)



Domestic Defluoridation using Bone Char

Source: WHO (2006)

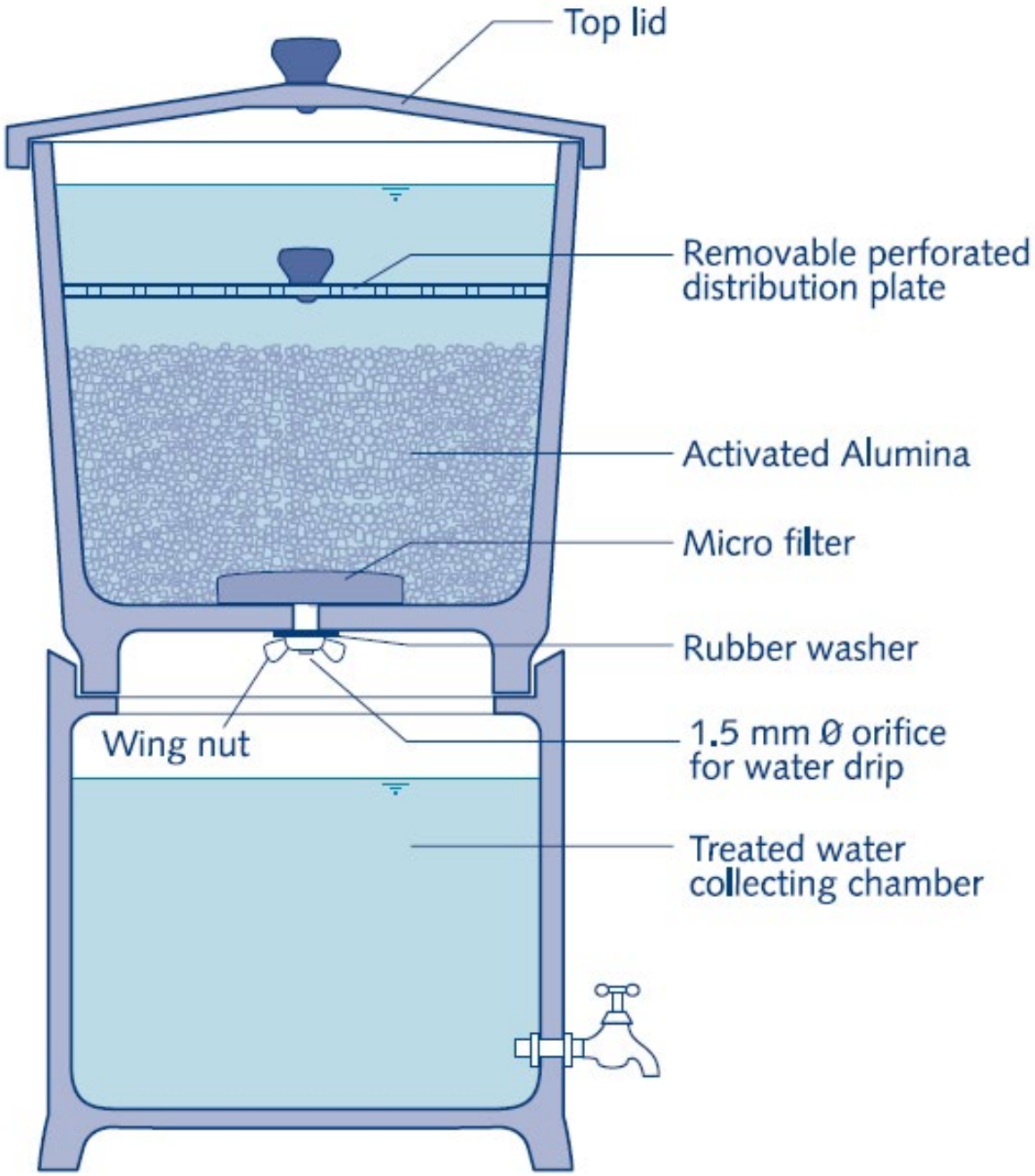


A. Drum

B. Double Bucket

C. Column Filter

Activated Alumina-based domestic defluoridation system



Source: (IRC, 2002)

Arsenic in Groundwater

- Naturally occurring semi-metallic element, widely distributed in the earth's crust
- Arsenic concentration in groundwater: up to 12 g/L
- High arsenic concentration in groundwater – A global problem affecting millions of people
- Arsenic in drinking water: no taste, no smell, not visible
- Most common species:
  As (V) : typically aerobic water
  As (III) : typically anaerobic conditions, low pH
- WHO guideline value for arsenic: 10 µg/L

Problems with Arsenic in Groundwater

- As is carcinogenic to human beings
  - skin cancer
  - internal cancers (lungs, urinary bladder, kidney)
- melanosis - abnormal black-brown skin pigmentation
- de-pigmentation
- (hyper)keratosis (thickening) of palm and sole
- gangrene of the lower extremities
- kidney and liver failures

Arsenic Removal Technologies

- **(Enhanced) coagulation using alum or ferric chloride followed by floc separation (sedimentation / filtration)**
- **Adsorption (activated alumina, ion exchange, granular activated carbon, iron oxide composites, iron oxide coated media)**
- **Lime softening**
- **Filtration through manganese-green sand filter (with $KMnO_4$ addition)**
- **Nanofiltration, Reverse Osmosis**

** **Challenges to apply these technologies at household level. Several POU arsenic removal systems are in use.**

IHE Family Filter for Arsenic Removal

- POU arsenic removal system
- Adsorbent: Iron oxide coated sand
- Average filtration rate: 0.25 m/h
- Media depth : 1 – 1.5 m (depending on water quality)
- Filter size: 150 mm diameter; Production ~ 100 L/day
- Operated for > 18 months in Bangladesh without media replacement

Other POU Arsenic Removal Systems
(used in Bangladesh)

Alcan Filter

(activated alumina)

Shapla Filter

(iron oxide bonded brick chips)

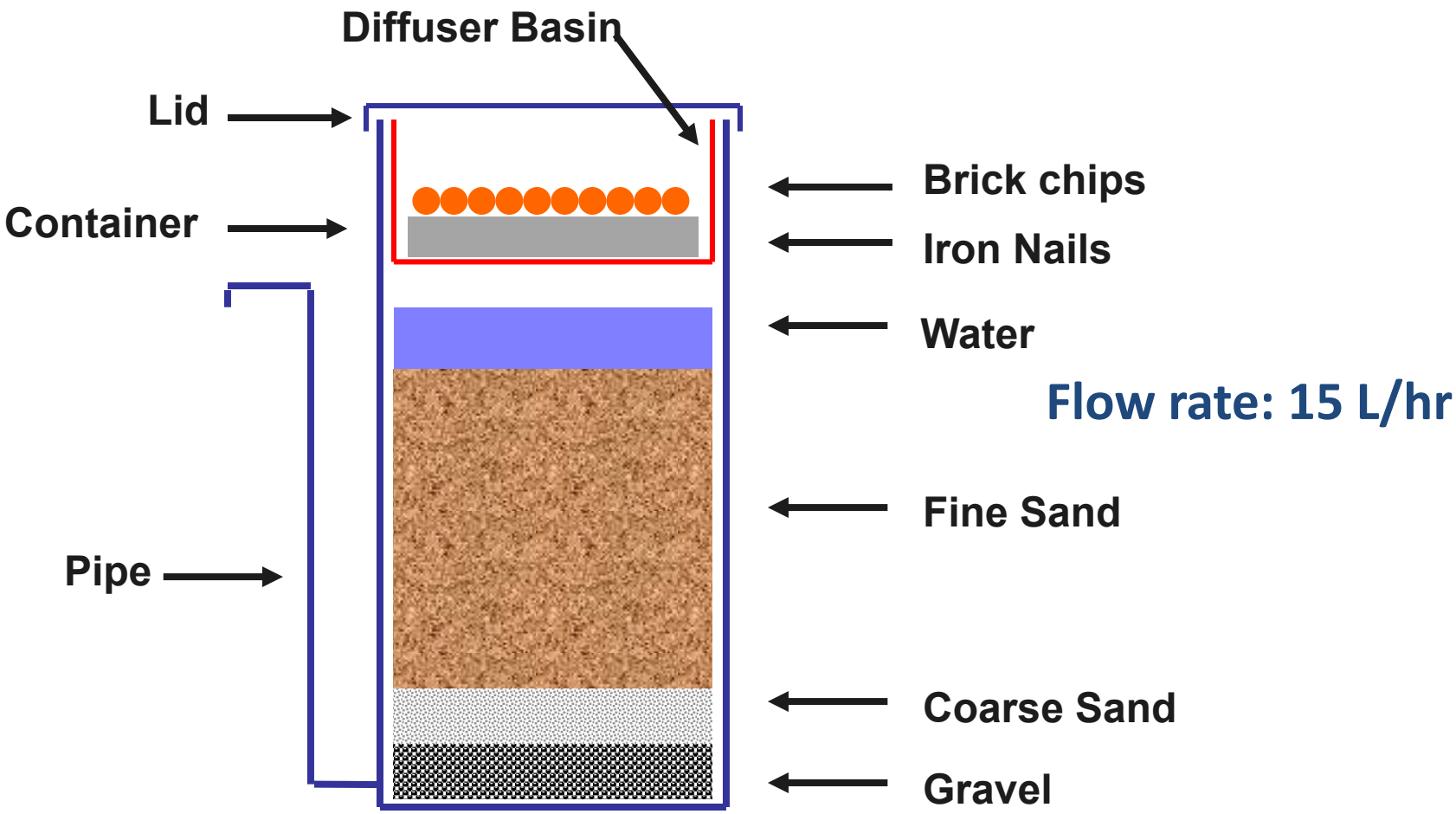
Star Filter

Coagulation with iron chloride + sand filtration

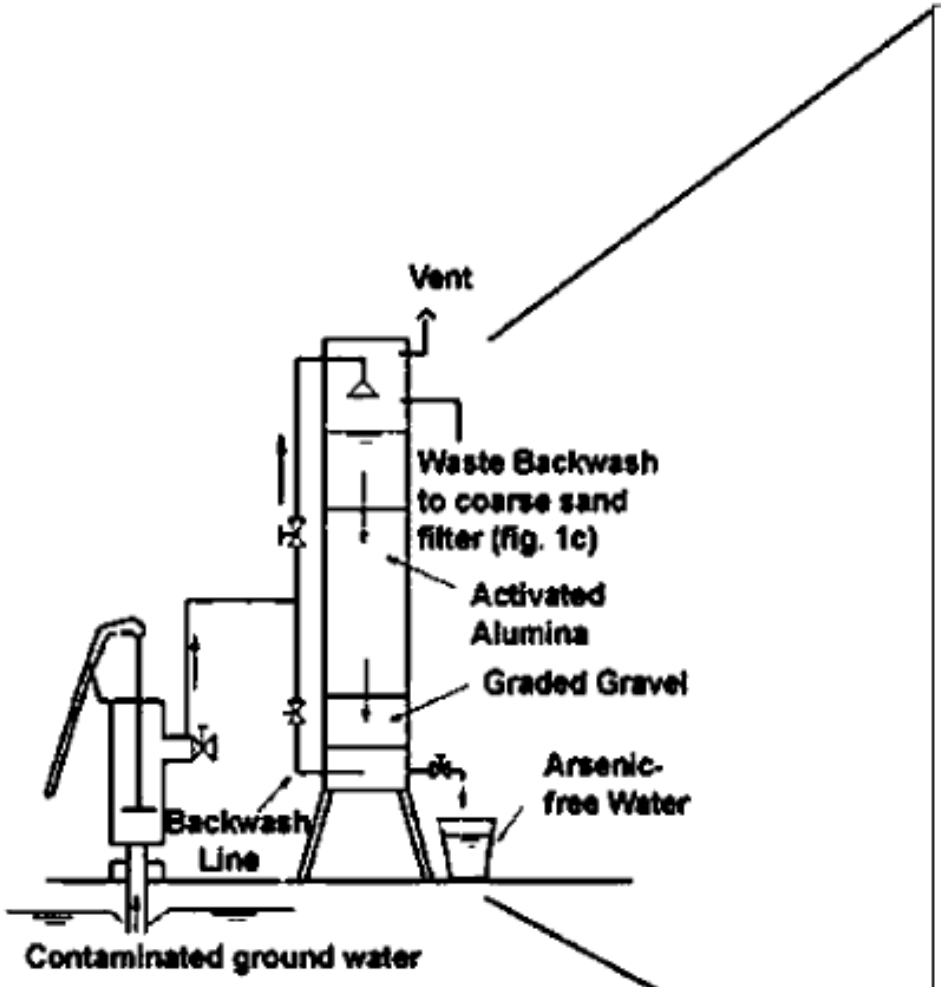
Kanchan™ Arsenic Filter

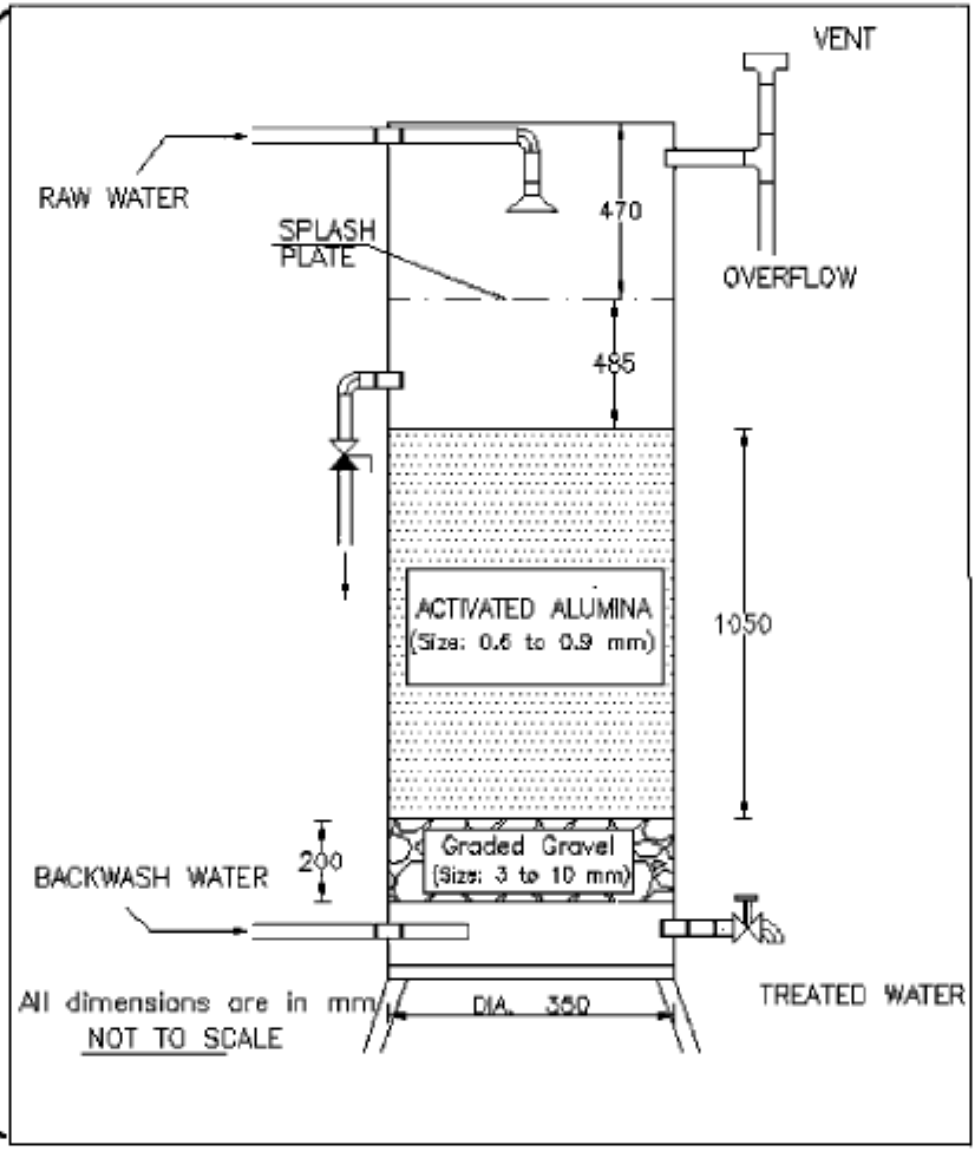
(Arsenic Biosand Filter)

Source: Murcott (2004)



Well-head Arsenic Removal System





Source: Sarkar et al. (2005)

Some remarks on household level water treatment systems in developing countries

- Household water treatment and safe storage is an essential component of a global strategy to provide safe water to all.
- Often household water treatment is cost-effective compared to conventional centralized water supply interventions.
- Several POU treatment systems are in use worldwide to remove different contaminants (mainly for filtration and disinfection).
- Long-term performance of many of these systems is not well-documented.
- No reliable system or indicator to monitor performance of at household level.
- Users are often not aware of O&M requirements - chemical dosing, media replacement, waste disposal etc.
- Some POU treatment systems in use are not robust and generally breakdown after few months of operation.

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Thank you for your attention