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TREATMENT OF HOUSEHOLD DRINKING WATER FOR THE REMOVAL OF FAECAL BACTERIA CAUSING WATER BORNE DISEASES IN RURAL COMMUNITIES

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Highlights of Presentation

1. Brief background

2. Introduction

3. The impact of contaminated water sources on public Health

   - Sources of microbial contamination of water
   - Water-borne pathogens

4. Household drinking water treatment

5. Sustainability of household drinking water treatment in rural communities

6. Conclusion

Introduction

•Water is an essential elixir for all living organisms

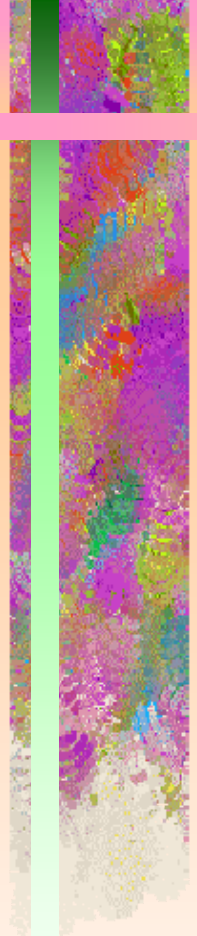
•The quality of water is crucial for general wellness

•Drinking water quality may refer to water that should be consumed in any desired quantity without any adverse effects on health

• The water should not contain pathogenic organisms and should be free from biological forms that are aesthetically objectionable

•In South Africa, water infrastructures are well developed in urban areas but not in rural areas

•Rural communities rely on river, stream and pond water sources, which are devoid of treatment for their water needs



Introduction contd

- Rural communities are therefore prone to the devastating effects of water borne diseases and their complications
- Water borne diseases are responsible for a substantial degree of morbidity and mortality across different age groups worldwide
- Methods of rural water purification for households should therefore be vigorously encouraged and sustained
- This paper will therefore highlight different household water treatment methods

The impact of contaminated water sources on public health

Sources of microbial contamination of water

1. *Human Faecal Waste/Infectious organisms*

- A drop of faecal matter may contain millions of microorganisms, some of which are aetiological agents of diseases

- Sewage or waste water is not supposed to be released untreated to the environment

- Poor microbiological quality of effluents from waste water treatment plants may contribute to surface water pollution

- In rural areas, occurrence of pollution by untreated sewage is very high due to lack of proper treatment facilities.

2. *Agricultural and Animal Waste*

- Animal waste harbours several potentially pathogenic microbes

- Nutrients from manure and fertilizers encourage the growth of plants and algae in water

- At death, microbes decompose them and consume oxygen dissolved in water during decomposition

- This leads to a drop in oxygen level in water to the extent that oxygen dependent animals may die (eutrophication).

3. Thermal pollution

• Water drawn from lakes, rivers and oceans are often used as a coolant in factories and power plants and usually returned to the source warmer than when it was taken.

• Small temperature changes in a body of water can scare away resident organisms and attract others e.g. thermophiles

Water borne pathogens

- The potential for the spread of water borne diseases arise when water is polluted with faecal matter.
- Water borne diseases are typically caused by enteric pathogens
- These pathogens include species of *Salmonalla*, *Shigella*, *Campylobacter*, and *Escherichia coli*, as well as *Vibrio cholerae*
- Other pathogens include parasites such as *Giardia* and *Cryptosporidium*, and viruses such as rotaviruses

Household Drinking Water Treatment

- Water treatment is one of the trumpcards of science and technology
- Water treatment transforms raw surface and ground water into safe drinking water
- There are mainly two types of processes:

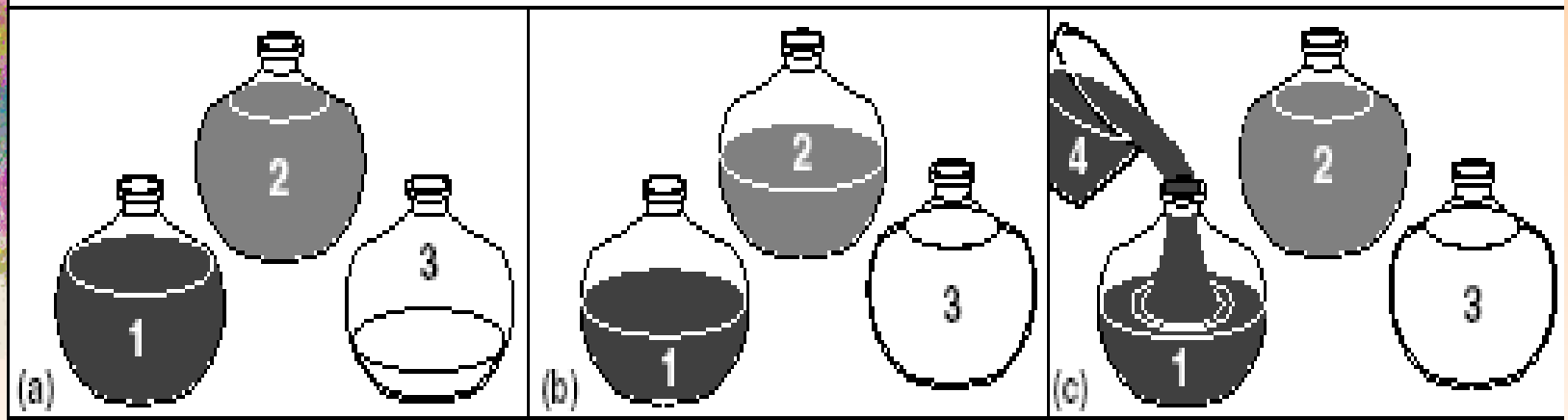
1. Physical removal of solids (mainly minerals and organic particulate matter and micro-organisms)

2. Chemical disinfection (inactivates and kills microorganisms)

- Water treatment equipment and methods are not however 100% effective in the removal of contaminants but are designed to reduce contamination to acceptable levels

Physical process 1: Storage and settlement

The Three-Pot Treatment System



Drinking-water: Always take from pot 3. This water has been stored for at least two days, and the quality has improved. Periodically this pot will be washed out and may be sterilized by scalding with boiling water.

Each day when new water is brought to the house:

(a) Slowly pour water stored in Pot 2 into Pot 3, wash out Pot 2.
(b) Slowly pour water stored in Pot 1 into Pot 2, wash out Pot 1.
(c) Pour water collected from the source (Bucket 4) into Pot 1. You may wish to strain it through a clean cloth.

Using a flexible pipe to siphon water from one pot to another disturbs the sediment less than pouring.

Physical process 2: Boiling

- Bring the water to a rolling boil for ten minutes
- Reaching 100°C for a few moment will kill most pathogens
- It uses up fuel
- Affect the taste
- Vigorously shaking the water after cooling will improve the taste.

Physical process 3: Filtration

- *Treatment of household water by filtration*

• Filtration processes include adsorption

• Filters can remove suspended solids, pathogens, certain chemicals, tastes and odours

• Different methods of filtration have been identified:

a. Slow Sand Filtration

1. Simple Slow Sand Filter

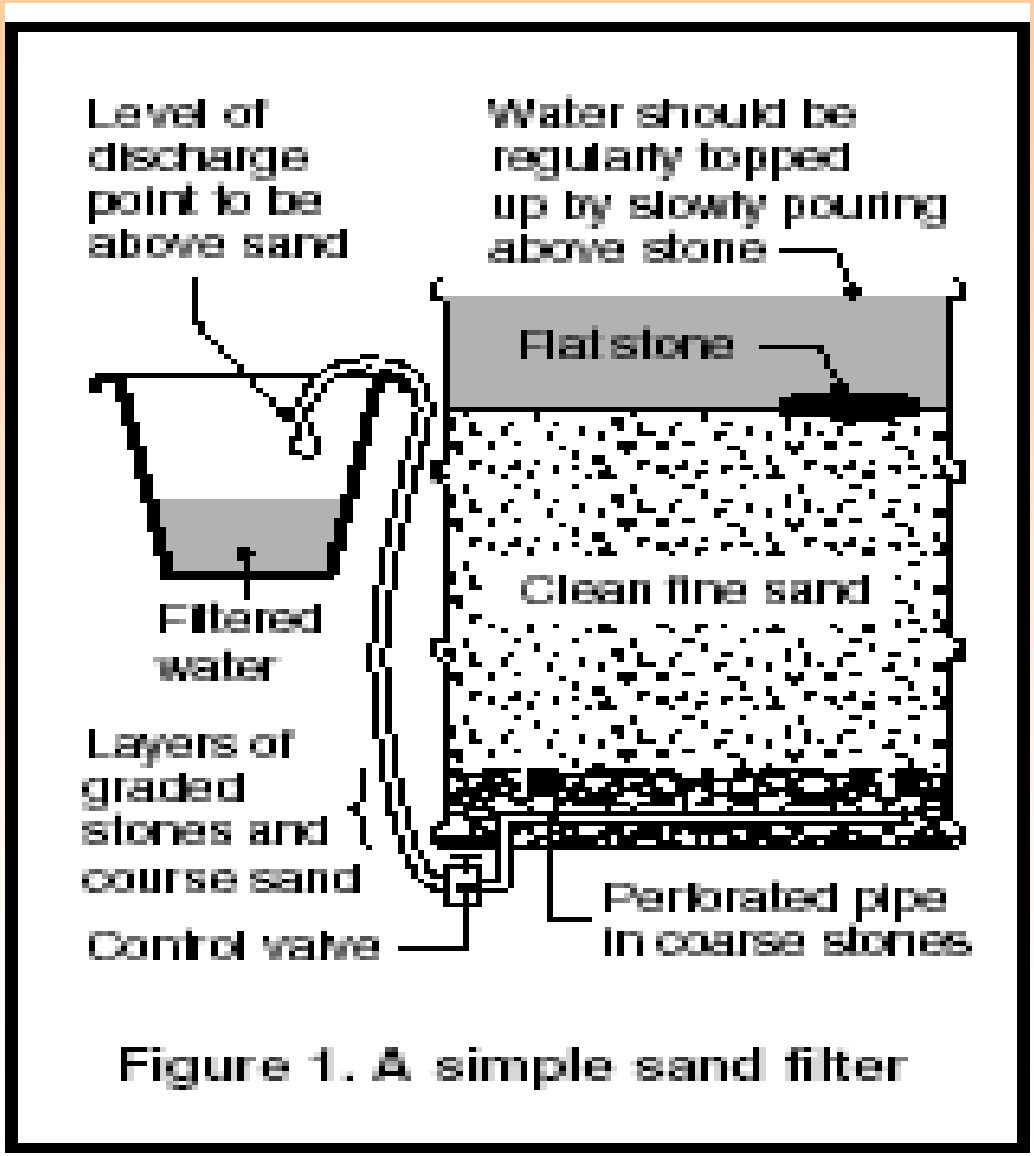


Figure 1. A simple sand filter

2. Slow Sand Filter with control

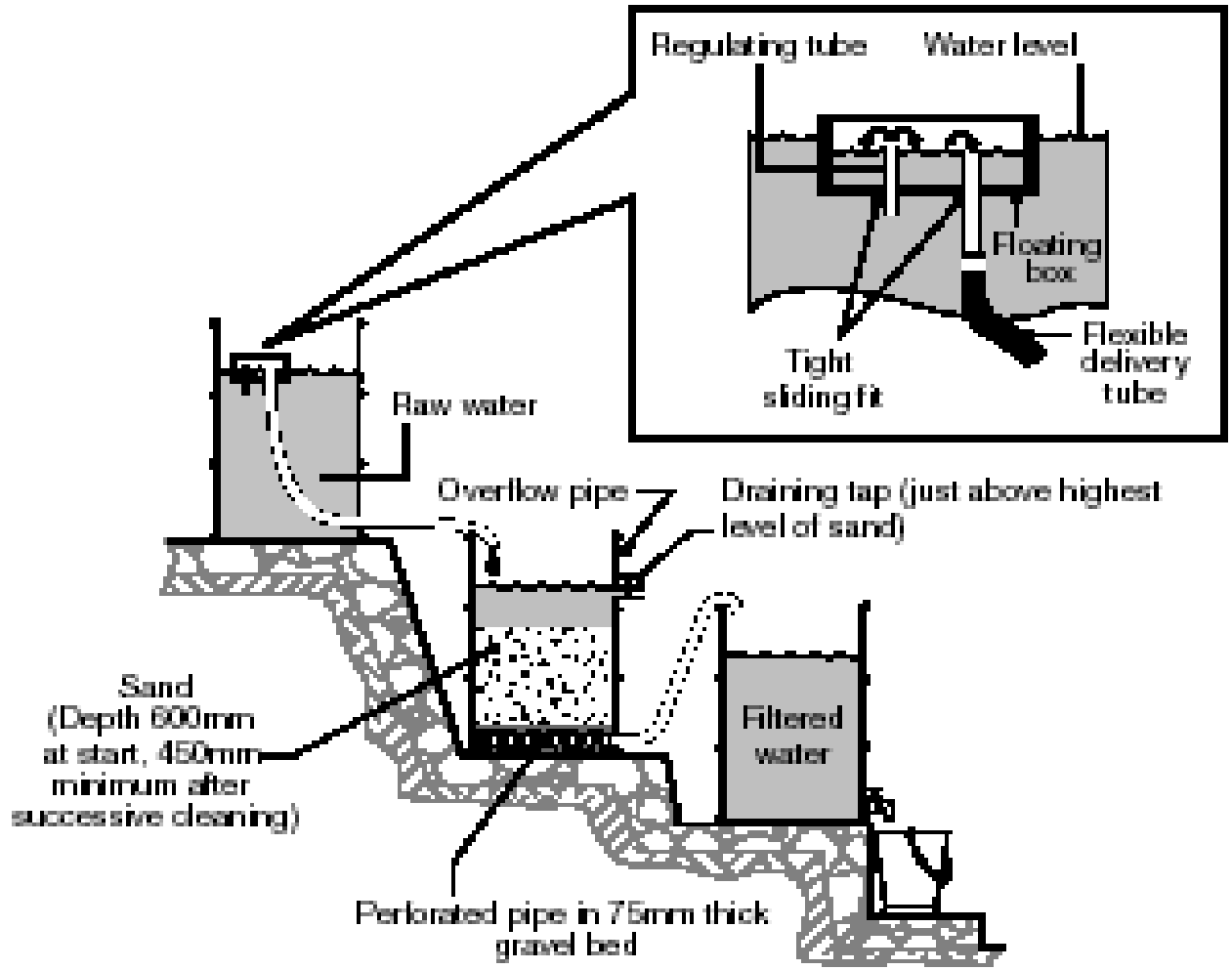


Figure 2. Slow sand filter with flow control (IRC, 1988)

- This method of treatment renders the water free from bacteria, worms and other organisms
- It generally improves the physical, chemical and bacteriological quality of raw water
- This is simple to construct and easy to operate and maintain
- The cost is low and affordable
- The disadvantage is that it can only be used for waters with low turbidity
- Very turbid waters will clog the system with build-up of sediments
- In addition, the Schmutzdecke has to be removed every 70-100 days and a new layer placed on the filter
- Another disadvantage is that the treatment water flows into a separate container, which predisposes to recontamination
- The method is also very slow and thus time consuming to collect treated water for a large household

b) Rapid Sand Filtration (RSF)

- This uses coarser sand than the sand used in the slow sand filtration method
- Rate of flow in this method is quicker
- Schmutzdecke is not formed
- Two types of RSF exist - Downflow filter and Upflow filter
- Both types require backwashing for cleaning
- RSF reduces turbidities and enteric bacteria by about 90%
- May be too technologically advanced for use in rural communities
- The treatment by RSF can be conducted as follows

    a) Bucket filters
    b) Roughing filters
    c) Fibre fabric and membrane filters

Rapid Sand Filter 1

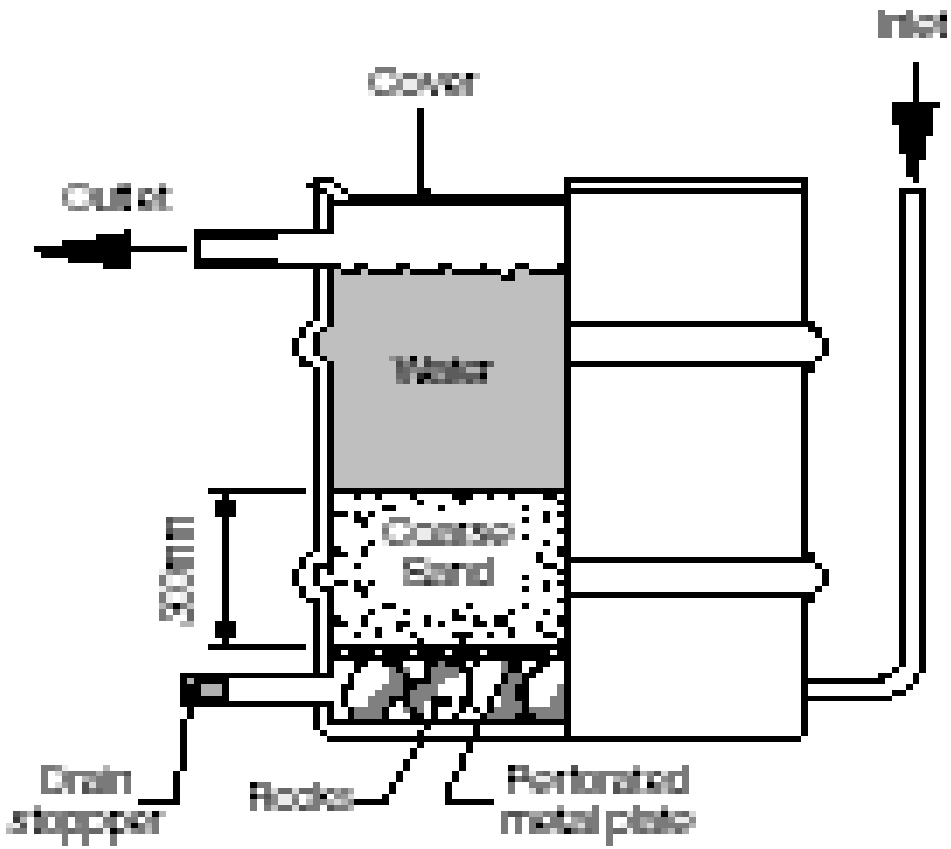


Figure 3. A simple upflow rapid sand filter (Heber, 1985)

Rapid Sand Filter 2

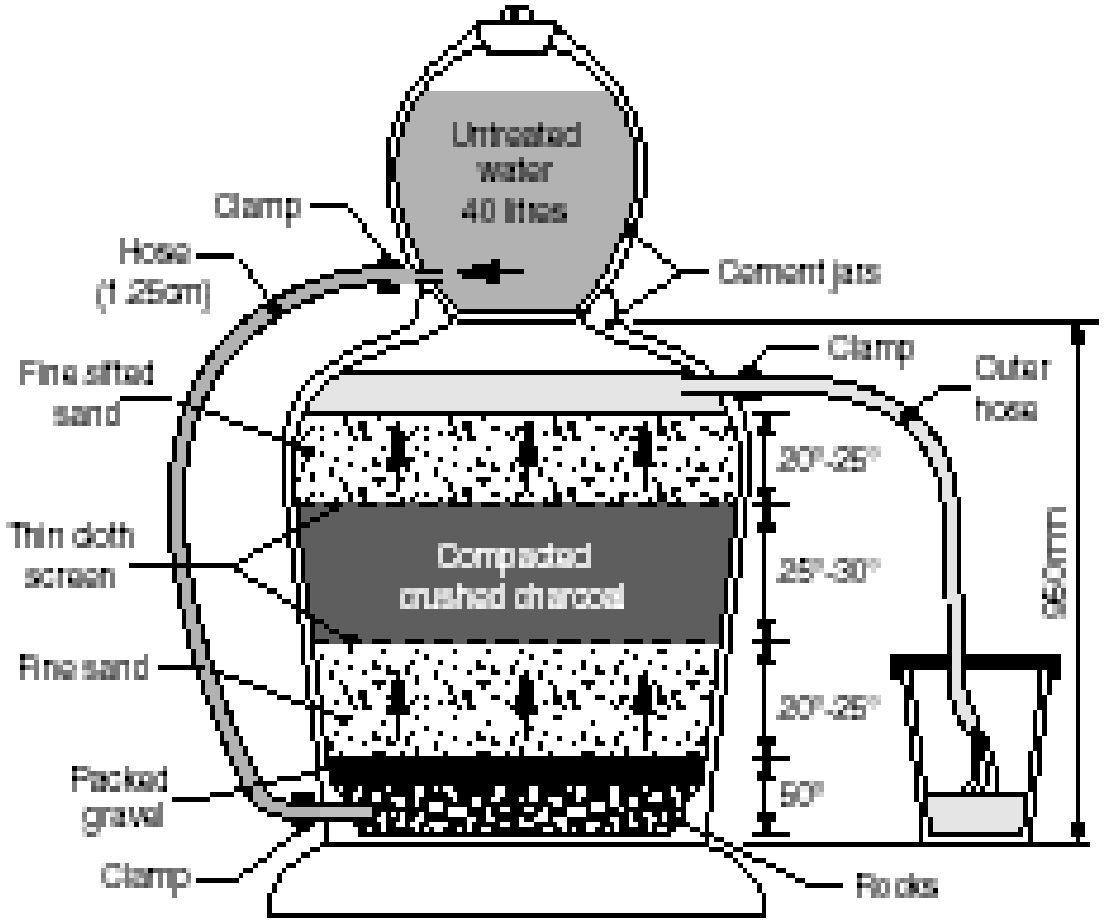


Figure 4. The Unicef upflow sand filter

c) Activated Carbon Filtration (AC filtration)

- This is effective for the removal of organic chemical contaminants from water including some pesticide residues

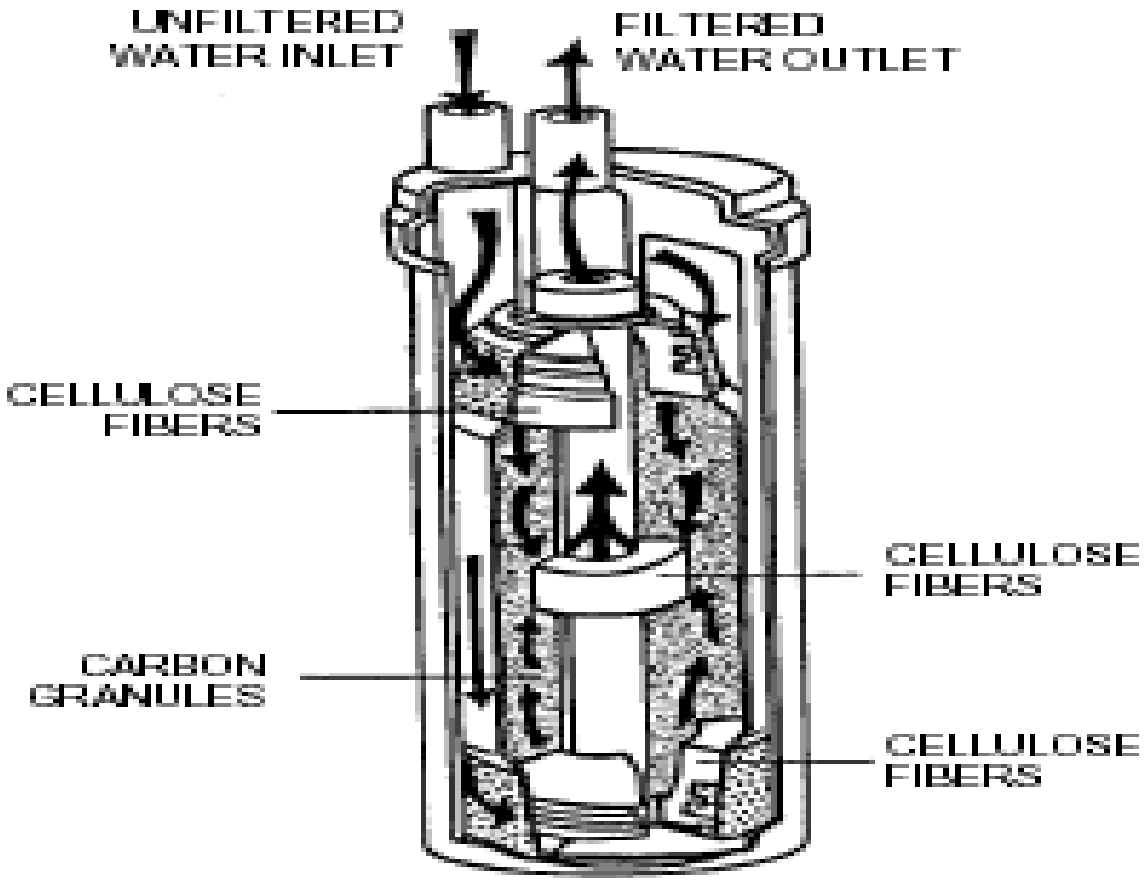
- Organic chemicals consist of two basic elements - carbon and hydrogen and treat general taste and odours problems

- AC filtration also removes chlorine residue

- AC filters do not remove microbes, sodium, fluorides, nitrates and hardness

- Filter devices are available in several sizes from small units that can fit in the kitchen to large under-sink units designed to treat up to 1500 gallons before filter change

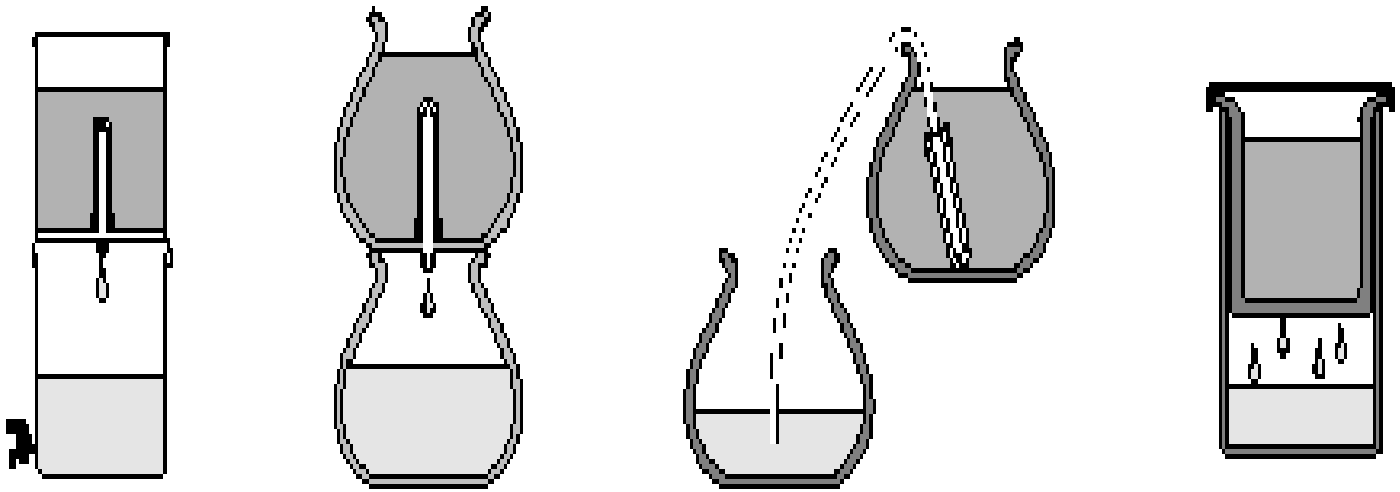
Activated Carbon Filter



Activated Charcoal Filter. Water passes between inner and outer cylinders, then through cellulose fibers

Other Filtration systems:

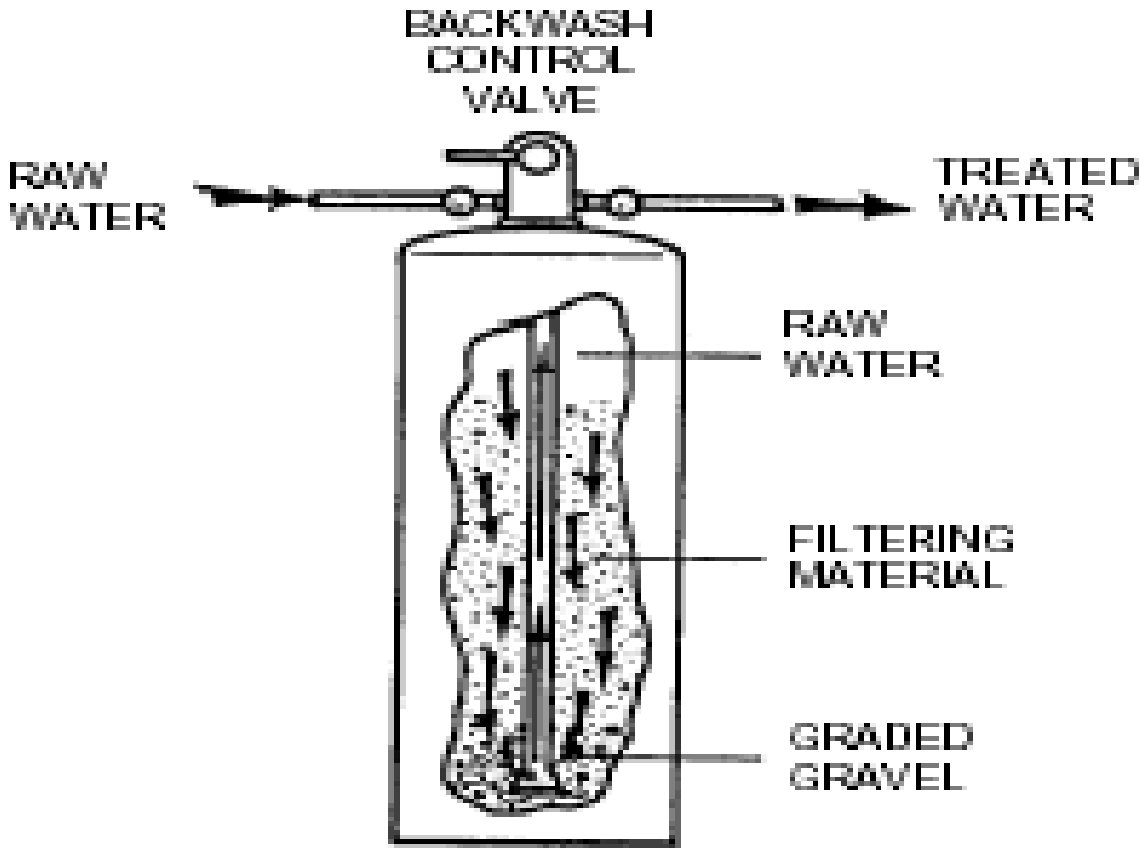
1. Ceramic filters



(a) Manufactured unit (b) Candle with jars (c) Using candle with siphon (d) Porous jar

Figure 5. Ceramic filters

2. Iron removal equipment



Iron filter, backwash type. The unit can be used for removal of iron, sulfur, sediment, tastes and odors, depending upon the filtering material used in the tank.

3. Reverse osmosis

·A reverse osmosis unit substantially removes most suspended and dissolved matter from water

·Contaminants are removed by forcing water through a membrane having microscopic holes that allow water molecules to pass but not larger compounds

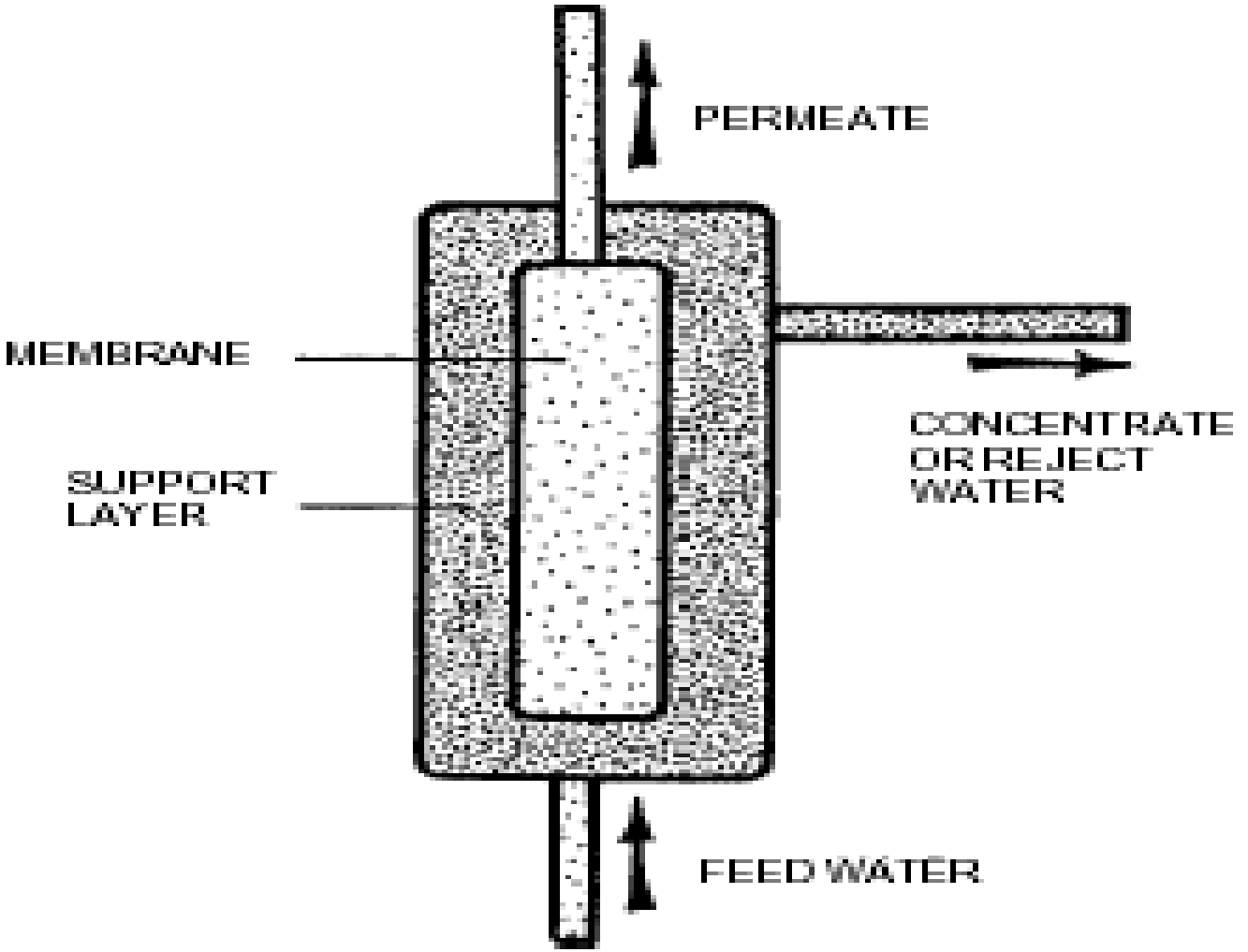
·Do not remove 100% of most chemicals

·Waste large amounts of water

·Develop problems from precipitate build up

·Mechanical and /or activated carbon filters may be installed before the reverse osmosis unit to reduce turbidity and improve taste and odour

Reverse Osmosis Unit



The reverse osmosis process.

d) **Distillation**

• Distillation units boil water to create steam which is condensed as purified water

•Most impurities remain in the heating chamber and must be removed periodically

•Distillation process removes virtually all impurities from water

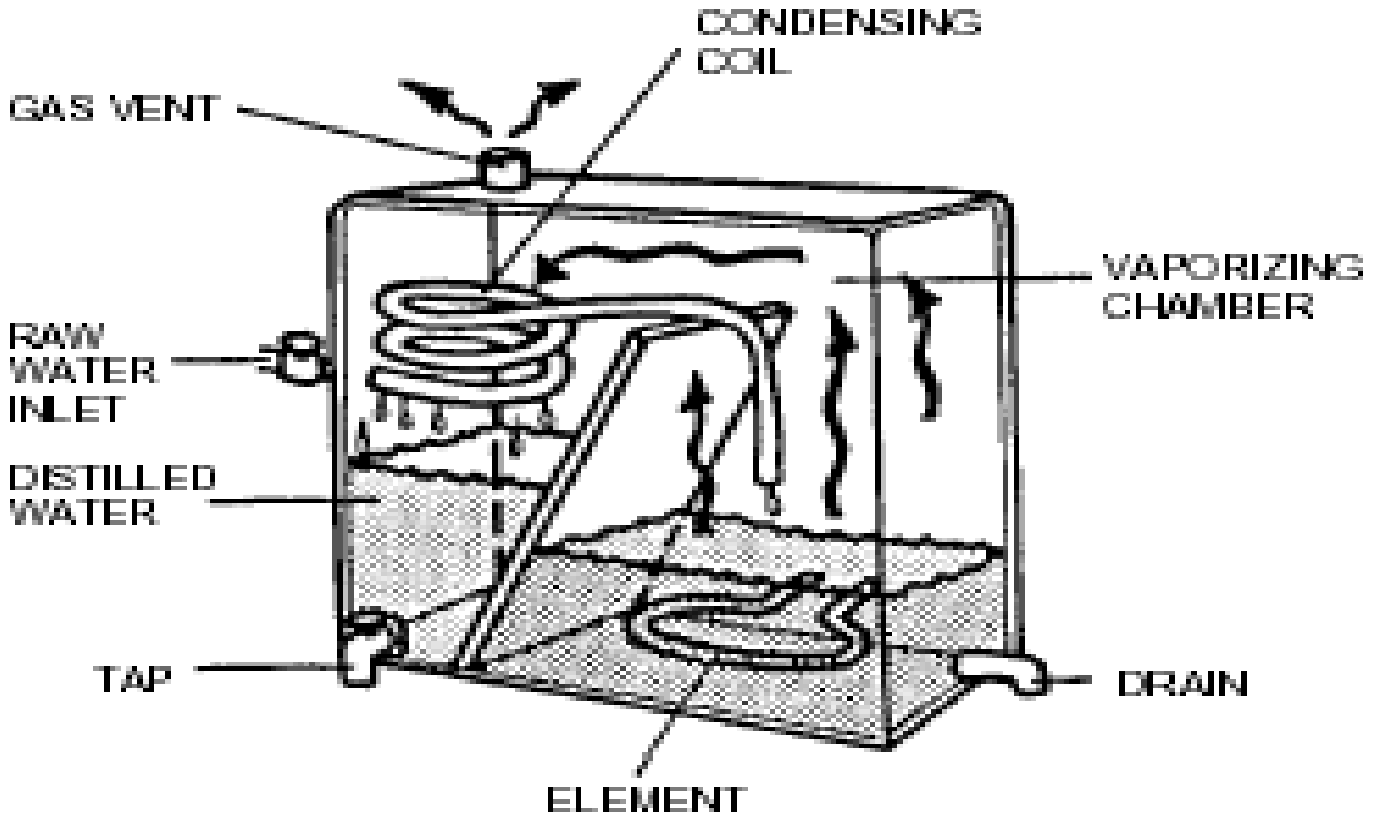
• Distillers are used to remove nitrates, bacteria, sodium hardness (dissolved solids)
organic compounds, heavy metals

• Distillers remove about 99% of the impurities from the original water

•Removal of minerals may produce water that can have a bland taste

•Distillers are also expensive to operate

Distillation Unit

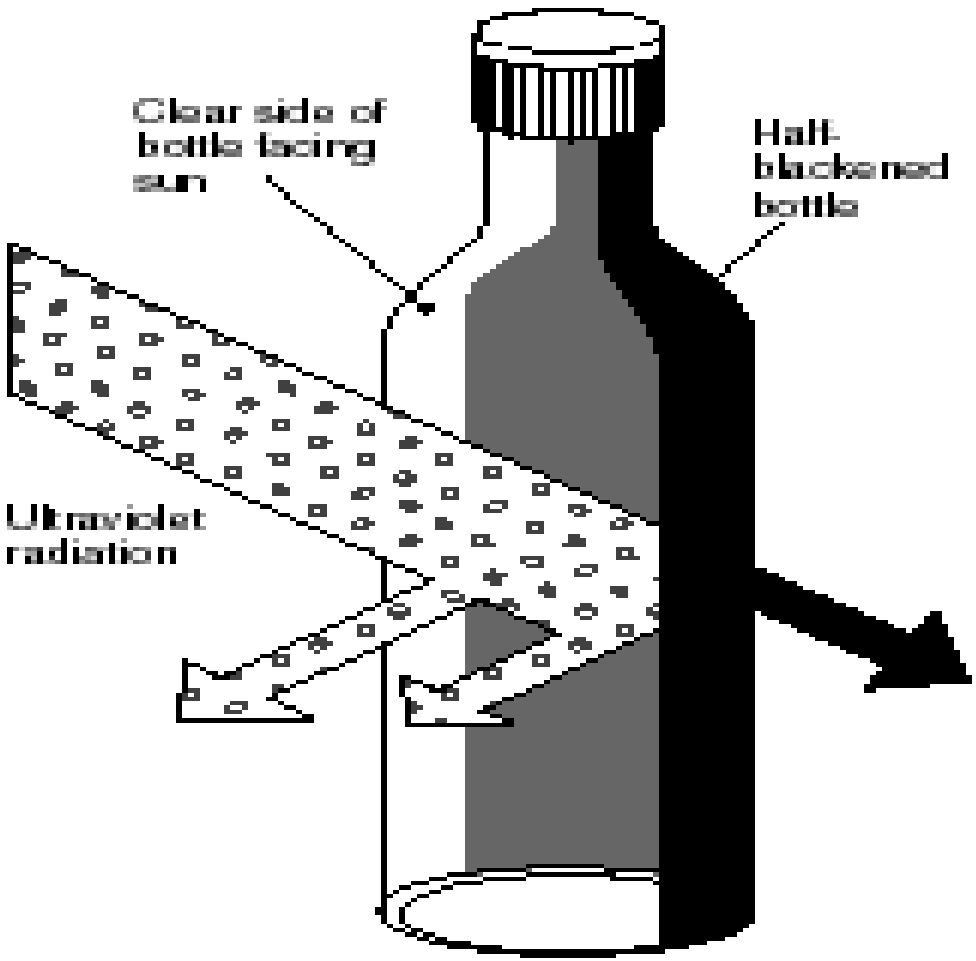


Distiller, rectangular cart style.

e) Solar disinfection: Ultraviolet Radiation (UV radiation)

- UV radiation can be obtained from the sun or generated by mercury arc lamps
- UV radiation kills bacteria by damaging genetic materials
- It thus inactivates and kills many pathogens including viruses, cysts and spores that are present in water
- The disadvantage of this method is the lack of residual protection and this may imply a high risk of recontamination during storage
- Irradiated organisms can sometimes repair and reverse the destructive effects of UV through a process called photoreactivation
- It does not provide for taste and colour control

Solar Disinfection Unit



The SODIS system

Other treatment devices

1. Water softener:

- Water softeners contain a zeolite mineral in the resin that Replaces water hardness minerals with sodium on an ion-exchange basis.
- Improves cleaning action of soaps, detergents
- Prevent scale deposits in pipes
- Periodic backwashing and regeneration required

2. Neutralizer

- Treats corrosive or acidic water
- May increase sodium or water hardness

CHEMICAL DISINFECTION

• Disinfection is a chemical process aimed at controlling potential pathogens by killing or inactivating them. Two methods can be discussed:

a) **Chlorination**

- Chlorine is the most widely used of all disinfectants

- Can be applied in water in one of three forms:

(i) elemental chlorine which is available as a gas

(ii) hypochlorite solution (bleach)

(iii) dry calcium hypochlorite

- Chlorine is effective against a wide array of pathogens

- Residual chlorine prevents water sources against recontamination and reduces biofilm regrowth

- Chlorine is easy to apply, control and monitor, and it is cost effective

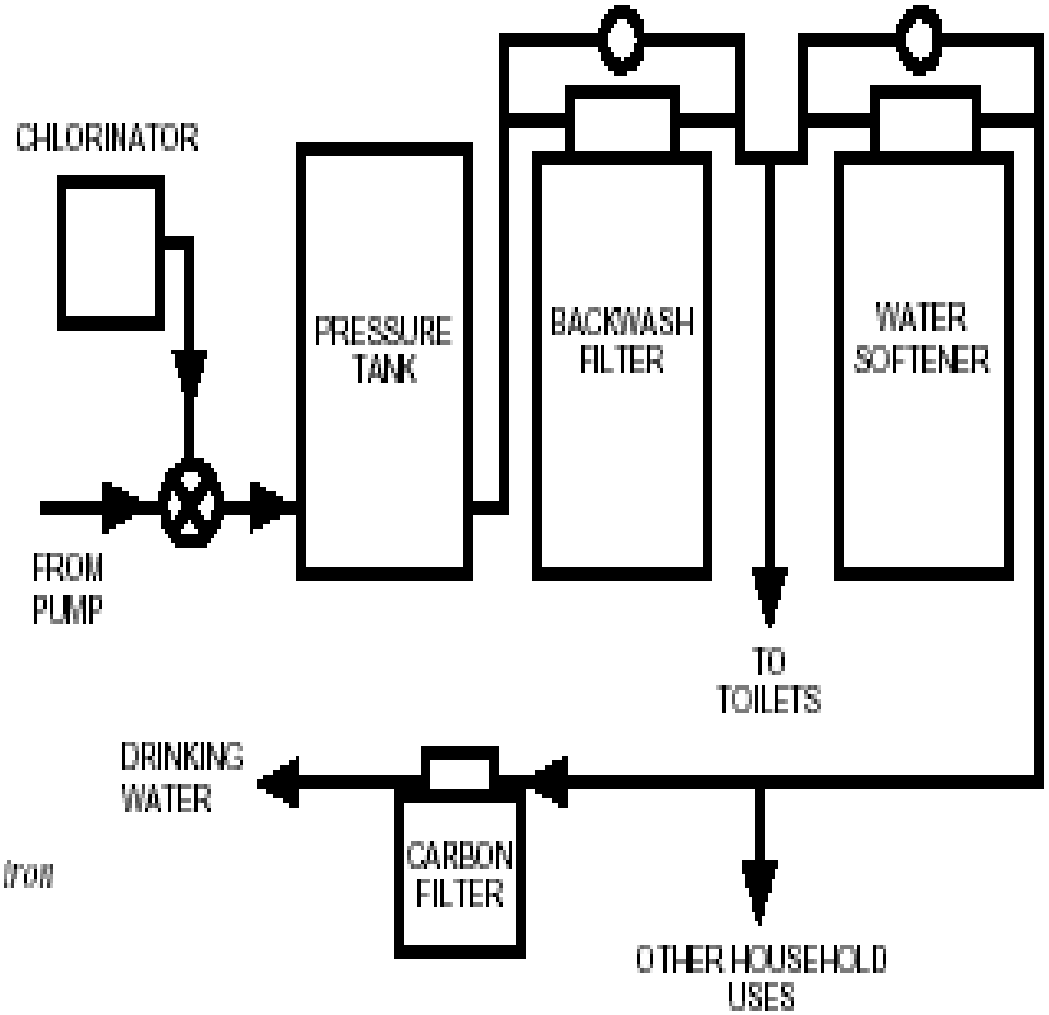
- The disadvantage is that by-products are formed when chlorine is added to water, and this may have some health implications

- The by-products include trihalo-methanes and hydrocarbons

- Chlorine is not effective against parasites or cysts

- Chlorination in combination with filtration is usually effective

Household installation with chlorination



Installation when chlorination is used for iron removal and water is softened.

Ozone Disinfection

- Ozone is effective against *Cryptosporidium* at high concentrations

- When ozone comes into contact with bacteria, viruses, the extra O atom breaks them down directly by oxidation

- Ozone does not produce any protective residue (risk of recontamination)

- It produces brominated by-products like bromate and brominated organics

- Ozone breaks down complex organic matter and the smaller compounds could encourage microbial growth during storage

- The cost of ozone is high

SUSTAINABILITY OF A HOUSEHOLD DRINKING WATER TREATMENT IN RURAL COMMUNITIES

- Affordability
- Maintainability
- Acceptability
- Educational programmes

CONCLUSION

- Treatment of household drinking water, if effectively undertaken, will reduce cases of water-borne diseases in rural communities

- The choice of any of the methods will depend on ease of operation, affordability and maintenance cost

- Sustained educational programmes on the significance of treating household drinking water and the need to maintain good personal hygiene are *sine qua non* for meaningful socio-economic development and improved health care delivery