Environment and Water

Dr. Md. Rahul Parvez
Lecturer (Community Medicine)
Rajshahi Medical College

Environment

- The term **environment** implies all the **external factors**- living and non-living, material and non-material- which surround man.
- In its modern concept environment includes **not only the water, air and soil** that form our environment but also the **social and economic conditions** under which we live.

Components of environment

- **Physical:** Water, air, soil, housing, wastes, radiation etc.
- **Biological:** Plant and animal life including bacteria, viruses, insects, rodents and animals
- **Social:** Customs, culture, habits, income, occupation, religion etc.

Safe and wholesome water

- Water intended for human consumption should be both **safe and wholesome.** This has been defined as water that is-
  a. free from **pathogenic agents**
  b. free from **harmful chemical substances**
  c. **pleasant to taste** i.e. free from colour and odour
  d. **usable** for domestic purposes
- Water is called **polluted or contaminated** when it does not fulfil the above criteria.

Uses of water

- **Domestic use:** Drinking, cooking, washing, bathing etc.
- **Public purposes:** Cleaning streets, swimming pools, public fountains, fire protection and public parks.
- **Industrial purposes:** Processing and cooling
- **Agricultural purpose:** Irrigation and washing of crops
- **Power production** from hydropower and steam power
- **Carrying away waste** from all manner of establishments and institutions

Sources of water supply

- **Rain:** Rain water is the **purest** water in nature.
- **Surface water**
  - ✓ Impounding reservoirs
  - ✓ Rivers and streams
  - ✓ Tanks, ponds and lakes
- **Ground water**
  - ✓ Shallow wells
  - ✓ Deep wells
  - ✓ Springs

Surface water

- Surface water **originates** from **rain water**.
- Impounding reservoirs are **artificial lakes** constructed usually of earthwork or masonry in which large quantities of surface water is stored.
- The area draining into the reservoir is called **"catchment area"**.
- Reservoir **ranks next to rain water** in purity.

Ground water

- It is the **cheapest and most practical means** of providing water.
- It is **superior to surface water**, because ground water itself provides an effective filtering medium.
- **Advantages**:
  - ✓ Likely to be free from pathogenic agents
  - ✓ Usually requires no treatment
  - ✓ Supply is likely to be certain even during dry season
  - ✓ Less subject to contamination

Shallow wells vs deep wells

	Shallow wells	Deep wells
Definition	Taps water from above the first impervious layer	Taps water from below the first impervious layer
Chemical quality	Moderately hard	Much hard
Bacteriological quality	Often grossly contaminated	Tapes purer water
Yield	Usually goes drier in summer	Provides a constant supply

Sanitary well

- **Location:** Not less than **15m or 50 feet** from sources of contamination
- **Lining:** Built of bricks or stone set in cement up to a depth of at least **6 m or 20 feet**
- **Parapet wall:** At least **70-75 cm/28 inch** above the ground
- **Platform:** At least **1 m or 3 feet** in all ground
- **Drain:** Pucca drain
- **Covering:** Top should be covered with a cement concrete
- **Hand-pump:** Hand pump for lifting water
- **Quality:** Acceptable standards of safe and wholesome water

Tubewells

- Tubewells are **cheap** in comparison to other source of water supply.
- Tubewells are the **largest individual source** of water supply in the rural areas.
- Tubewell consists of a pipe sunk into the water-bearing stratum and fitted with a strainer at the bottom, and a hand pump at the top.
- Area within **15 m** of the tube well must be **free from pollution**

Sources of impurities of water

- **Substances received at source:** Depends on the nature of soil; water of chalky soil contains excess of calcium
- **Impurities obtained during transit from source to reservoir:** e.g. rivers, canals etc. are liable to be polluted by sewage, waste water and industrial sources
- **Impurities during storage:** e.g. from containers
- **Impurities during distribution:** e.g. from distribution pipes or from distributors

Water pollution vs Water contamination

Water pollution	Water contamination
Turbidity present	Turbidity present or absent
Presence of pathogen is doubtful	Presence of pathogen is definite
Suspended solid and BOD determine pollution	Microscopy culture determine contamination

Water-borne diseases: Biological

Viral	Hepatitis A & E, poliomyelitis, rotaviral diarrhoea
Bacterial	Typhoid and paratyphoid fever, cholera, bacillary dysentery
Protozoal	Amoebiasis, giardiasis
Helminthic	Roundworm, threadworm, hydatid disease
Leptospiral	Weil's disease
Snail	Schistosomiasis
Cyclops	Guinea worm, fish tapeworm

Water-related diseases: Chemical

Chemical	Health effects
Excessive magnesium sulphate or chloride	Bowel irritation; Diarrhoea
Brackish water from wells	Dyspepsia
Lead containing water	Plumbism
Excess zinc	Constipation
Excess iron	Dyspepsia and constipation
Excess fluorine	Fluorosis
Fluorine <1ppm	Dental caries

Water-related diseases

- **Dental health:** Fluoride in drinking water more than 1gm/litre cause mottling of the dental enamel.
- **Cyanosis in infants:** High nitrate content of water causes methaemoglobinaemia
- **Cardiovascular diseases:** Hardness of water appears to have beneficial effects against CVD

Purification of water on a large scale

- The components of purification of water at a large scale comprises one or more of the following measures:
  - **Storage**
  - **Filtration**
  - **Disinfection**
    i. Chlorination
    ii. Ozonation
    iii. Membrane process

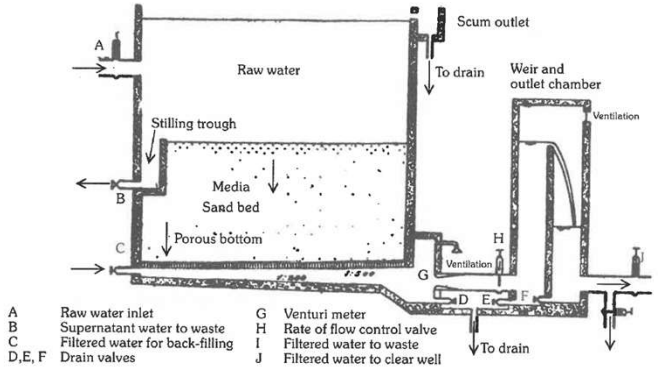
Purification of water: Storage

- This is **natural** purification process.
- A very considerable amount of purification takes place.
- It is described from 3 point of view:
  - **Physical:** About 90% of suspended impurities settle down in 24 hours by gravity.
  - **Chemical:** The aerobic bacteria oxidize the organic matter present in the water with the aid of dissolved oxygen. As a result, free ammonia is reduced and a rise in nitrates occurs.
  - **Biological:** There is 90% drop in bacterial count in the first 5-7 days while river water is stored.

Purification of water: Filtration

- **Two types** of filters are used:
  a. **Slow sand filters or biological filters**
  b. **Rapid sand filters or mechanical filters:** It is of 2 types-
     i. **Gravity type:** Paterson's filter
     ii. **Pressure type:** Candy's filter

Purification of water: Slow sand filters



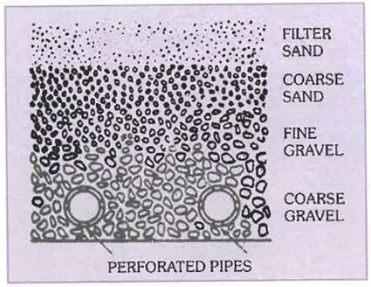
Purification of water: Slow sand filters

- **Elements** of a slow sand filters:
  - **Supernatant (raw) water**: It is 1-1.5 meter in depth above the sand bed.
  - **A bed of graded sand**
  - **An under-drainage system**
  - **A system of filter control valves:** Venturi meter is an important component which measures the bed resistance or "loss of head".
- The first 3 elements (raw water, sand bed and under-drainage system) are **contained in filter box.**

Purification of water: Slow sand filters

Sand bed

- **Most important** part of the filter.
- Thickness is **about 1 meter**.
- Supported by a layer of **graded gravel, 30-40 cm** deep.
- **Purification processes-** mechanical straining, sedimentation, adsorption, oxidation and bacterial action.



Purification of water: Slow sand filters

Vital layer:

- When the filter is newly laid, it acts merely as a mechanical strainer, and cannot **truly be considered as 'biological'**.
- But very soon, the surface of the sand bed gets covered with a slimy growth known as **"Schmutzdecke", vital layer, zoogleal layer or biological layer**.
- The layer is **slimy and gelatinous** and consists of **threadlike algae** including plankton, diatoms and bacteria.

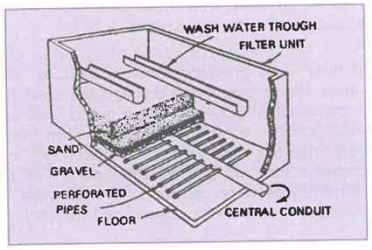
Purification of water: Slow sand filters

Vital layer:

- It may **take several days** to develop and extends for **2-3 cm** into the top portion of sand bed.
- It is **the heart** of the slow sand filter.
- It removes organic matter, holds back bacteria and oxidizes ammoniacal nitrogen into nitrates and yielding a bacteria-free water.
- Until the vital layer is fully formed, the first few days **filtrate is usually run to waste**.

Purification of water: Rapid sand filters

- The following steps are involved in purification of water by rapid sand filters:
  - **Coagulation**
  - **Rapid mixing**
  - **Flocculation**
  - **Sedimentation**
  - **Filtration**



Purification of water: Rapid sand filters

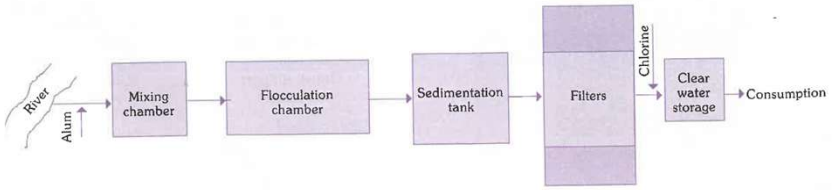


Fig: Flow diagram of a rapid sand filtration plant

Rapid sand filters vs Slow sand filters

	Rapid sand filter	Slow sand filter
Space	Occupies very little area	Occupies large area
Rate of filtration	200 m.g.a.d.	2-3 m.g.a.d.
Effective size of sand	0.4-0.7 mm	0.2-0.3 mm
Preliminary treatment	Coagulation and sedimentation	Plain sedimentation
Washing	By back-washing	By scraping the sand bed
Operation	Highly skilled	Less skilled
Loss of head allowed	6-8 feet	4 feet
Removal of turbidity	Good	Good
Removal of color	Good	Fair
Removal of bacteria	98-99%	99.9-99.9%

Purification of water: Chlorination

- In water works practice, the term **disinfection** is synonymous with **chlorination**.
- Chlorine kills **pathogenic bacteria** but not spores and certain viruses (e.g. polio, viral hepatitis) except in high dose.
- When chlorine is added to water, it forms hydrochloric and hypochlorous acid.

$$H_2O + Cl_2 \rightarrow HCl + HOCl$$
$$HOCl \rightarrow H + OCl$$

- **Hypochlorous acid is the most effective form** of chlorine for water disinfection.

Purification of water: Chlorination

- The **chlorine demand** of water is the difference between the amount of chlorine added to the water, and the amount of residual chlorine remaining at the end of a specific period of contact at a given temperature and pH of the water.
- The presence of free residual chlorine for a **contact period of at least 1 hour** is essential to kill bacteria and viruses.
- The recommended minimum concentration of free residual chlorine is **0.5mg/L for 1 hour.**
- **Methods of chlorination:** Chlorine gas; Chloramine; Perchloron

Purification of water on a small scale

- **Household purification of water:**
  - **Boiling:** Rolling boil for 10-20 minutes is most effective.
  - **Chemical disinfection:** Bleaching powder, Chlorine solution, High test hypochlorite or perchloron, Chlorine tablets, Iodine, Potassium permanganate
  - **Filtration:** Pasteur Chamberland filter, Berkefeld filter, Katadyn filter
  - **Ultraviolet irradiation**
  - **Multi-stage reverse osmosis purification of water**
- **Disinfection of wells**

Disinfection of wells: Steps

- Find the **volume of water** in a well: $\frac{\pi d^2 h}{4} \times 1000$
- Find the **amount of bleaching powder** required for disinfection
- **Dissolve bleaching powder** in water
- **Delivery of chlorine solution** into the well
- **Contact period:** One hour is allowed
- **Orthotolidine arsenite test:** To test the free residual chlorine after one hour contact. It the residual chlorine level is less than 0.5mg/L, the chlorination procedure should be repeated.

Water quality: criteria and standards

- The guidelines for drinking water quality recommended by WHO comprises:
  - **Acceptability aspects**
  - **Microbiological aspects**
  - **Chemical aspects**
  - **Radiological aspects**

Acceptability aspects

Colour	15 TCU	Iron	0.3 mg/L
Taste and odour	Acceptable	Manganese	0.1 mg/L
Temperature	Acceptable	Sodium	100 mg/L
Turbidity	1 NTU	Sulphate	250 mg/L
Aluminium	0.2 mg/L	TDS	1000 mg/L
Ammonia	1.5 mg/L	Zinc	4 mg/L
Chloride	250 mg/L	Hydrogen sulfide	0.05 mg/L
Copper	1 mg/L		

Microbiological aspects

- **Bacteriological indicators:**
  - **Coliform organisms: E. coli, Klebsiella aerogens**
  - **Faecal streptococci**
  - **Clostridium perfringens**
- **Virological aspects:** Acceptable drinking water should be free from any viruses.
- **Biological aspects:** Should be free from all protozoa causing diseases in human.

Microbiological aspects

All water intended for drinking E. Coli or thermotolerant coliform bacteria	Must not detectable in any 100 ml sample
Treated water entering the distribution system E. Coli or thermotolerant coliform bacteria	Must not detectable in any 100 ml sample
Total coliform bacteria	Must not detectable in any 100 ml sample
Treated water in the distribution system E. Coli or thermotolerant coliform bacteria	Must not detectable in any 100 ml sample
Total coliform bacteria	Must not detectable in any 100 ml sample

Hardness of water

- **Hardness** may be defined as the **soap destroying power** of water.
- The hardness in water is caused mainly by **four dissolved compounds**: Calcium bicarbonates; Magnesium bicarbonate; Calcium sulphate and Magnesium sulphate
- Hardness is classified as **carbonate and non-carbonate** hardness.
- **Carbonate or temporary hardness** is due to the presence of calcium and magnesium bicarbonates.
- **Non-carbonate or permanent hardness** is due to the presence of calcium and magnesium sulphates, chlorides and nitrates.

Classification of hardness in water

- Hardness in water is expressed as **milli-equivalent per litre**.
- **1 mEq/L** of hardness producing ion is equal to **50 mg $CaCO_3$.**

Classification	Level of hardness (mEq./L)
Soft water	< 1 mEq/L (<50 mg/L)
Moderately hard water	1-3 mEq/L (50-150 mg/L)
Hard water	3-6 mEq/L (150-300 mg/L)
Very hard water	> 6 mEq/L (>300 mg/L)

Removal of hardness of water

- Methods of removal of temporary hardness
  - **Boiling**
  - **Addition of lime**
  - **Addition of sodium bicarbonates**
  - **Permutit process**
- Methods of removal of permanent hardness
  - **Addition of sodium bicarbonates**
  - **Base exchange process**

References

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