Dept. of Public Health Dentistry

WATER AND ENVIRONMENT

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POTABLE WATER

- **DEFINITION**: Water that is
  - Free from **P**athogenic agents
  - Free from harmful **C**hemical substance
  - Free from **C**olor & odor
  - Useful for all **D**omestic needs.
- **Quantity needed**
  - 50 liters to 200 liters/head/day
  - Drinking water-2lt/ day
  - Domestic needs: 150-200 ltrs /head/ day
  - It depends on the Climatic conditions, availability, customs, habits etc.
  - Shallow wells & step wells unsatisfactory at most places.

- **Uses of water:**

  Domestic

  Public

  Industrial

  Agricultural

  Power production

  Carrying away waste

- **Sources:**

  Rain, Surface water, rivers, streams, reservoirs, ground water (springs, wells) Sea water

NORMS OF POTABILITY

Tests	Standards	Max. permissible limits (dom.)
PHYSICAL	Turbidity (units)	<5 NTU (Nephelometric Turbidity Units)
	Color (units)	<15 True color
	Taste, odour	-
BIOLOGICAL	Coliforms	10
	E. Coli, streptococcal, cl.perfringes	0

CHEMICAL	pH	6.6-8
	Total solids	< 600 mg/ltr
	Hardness ($CaCO_3$ Eq)	(50-150 mg/L)
	Chloride	250(mg/lt)
	Sulphate	250(mg/lt)
	Nitrate	45(mg/lt)
	Fluoride	1.5(mg/lt)

- Depletion of dissolved Oxygen in water supplies can encourage microbial reduction of Nitrates to nitrite & Sulphate to Sulphide.

- Drinking water should be free from any virus, Protozoa, Helminthes and free living organisms which are infectious to man.

- **Problem Village :** A village where no source of safe water is available within a distance of 1.6km **OR** where is available at a depth of more than 15 mtr **OR** water source has excess salinity, iron, fluorides, and other toxic materials **OR** where water is exposed to the risk of cholera or guinea worm.

Purification of Water

1. Large Scale
   - Storage
   - Filtration
     - Biological / Slow sand filters
     - Mechanical / Rapid sand filters
   - Chlorination
2. Small Scale

   Boiling

   Chemical Disinfection

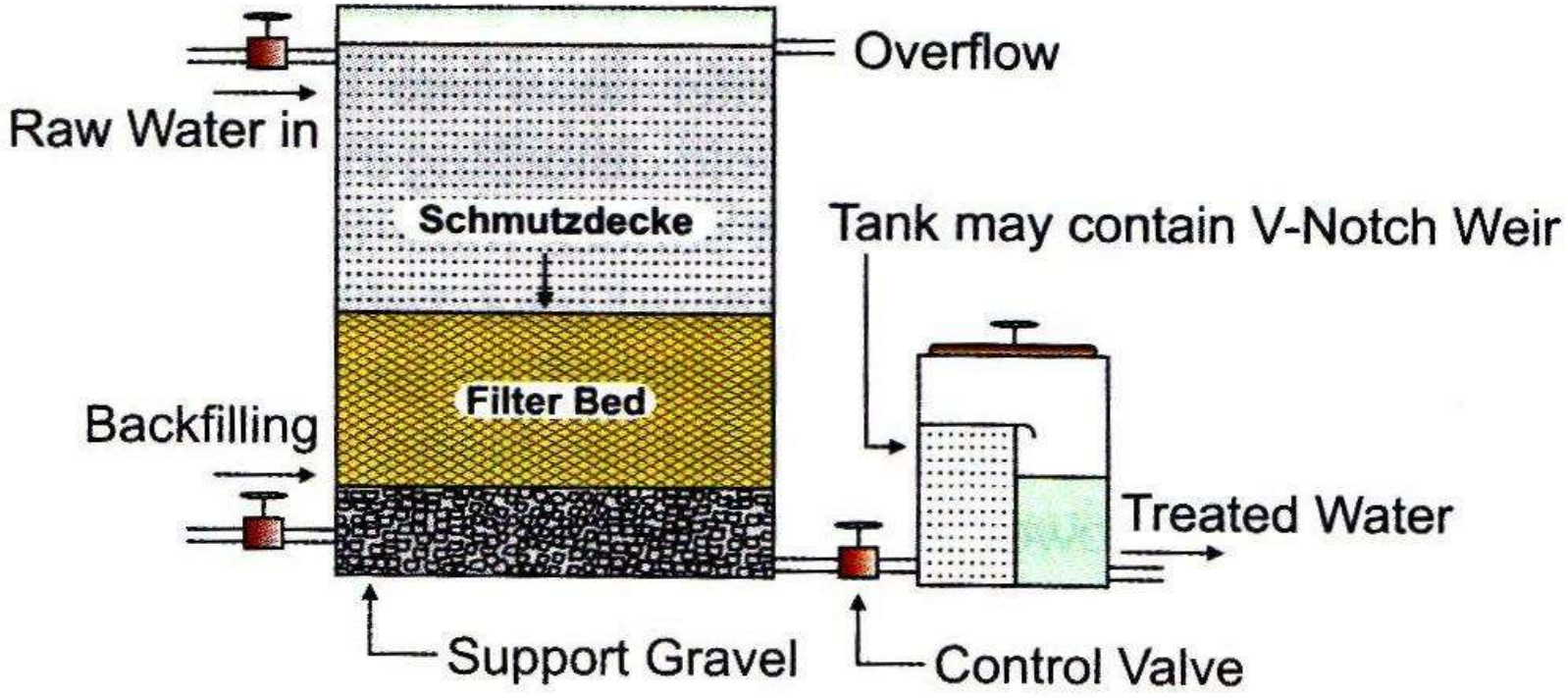
   Filtration

Storage

- **Physical Action :** About 90% of suspended impurities settle down in 24 hrs by gravity
- **Chemical** : The aerobic bacteria oxidize the organic matter present in the water that reduces free ammonia & increases Nitrates
- **Biological** : Pathogenic organisms gradually die out. If stored for long time, there may be algae growth which imparts bad smell & color

Biological / Slow sand filter

1st used-scotland-1804, london, famous worldwide in 19th century



Slow sand filter (Sketch)

Vital Layer- 1-1.5 mtr
Sand Bed- 1.2 mtr
Gravel Support – 0.3 mtr

- **Suparnatant water** : it should flow in the upper tank region without disturbing schmutzdecke
  - The water in this compartment must have sufficient depth of 1-1.5 mtr so as to provide constant head of water to overcome the resistance of filter bed
  - Waiting period is 3-12 hrs for the raw water which helps it to undergo partial purification by sedimentation, oxidation, and particle agglomeration.

A bed of graded Sand : the effective diameter of sand grain should be 0.2-0.3 mm & is supported by graded gravel 30-40 cms deep which also prevents the fine grains being carried into the drainage pipes.

-Rate of filtration = 0.1-0.4 m^3/hour/$m^2$of sand bed surface

Vital Layer

- The Slimy growth covering the surface of the sand bed is known as “Schmutzdecke”, Vital layer, zoogleal layer, or biological layer
  - It consists of threadlike algae, plankton, diatoms and bacteria.
  - It may take several days for the vital layer to form fully & when formed it extends for 2-3cm into the top portion of the sand bed. Formation of the vital layer is known as **“RIPENING”** of the filter.
  - The Vital layer is the heart of the filter. It removes Organic matter, holds back bacteria and oxidizes ammoniacal nitrogen into nitrates and helps in purifying the water.
  - Until the vital layer is fully formed, the first few days filtrate is usually run to waste.

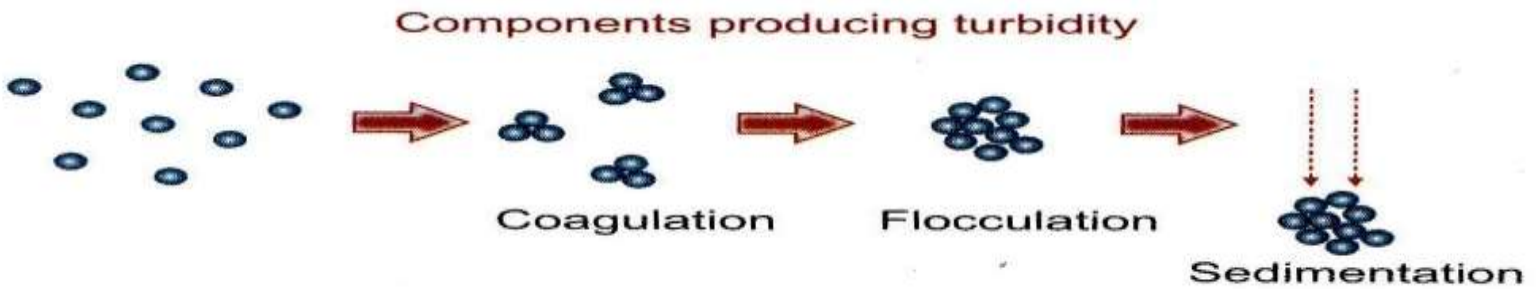
- **An under drainage system** : It consists of perforated pipes through which filtered water is collected and it supports the filter medium above.
- **A system of filter control valve** : The outlet pipe system is equipped with valves & venturi meter, which helps to maintain a constant rate of filtration.
  - Venturi mtr measures loss of head, if >1.3 mtr, stop filtration

- As filtration proceeds, the suspended impurities and bacteria clog the filters resulting in their reduced efficiency called **“LOSS OF HEAD”**
- **Filter cleaning** : When the bed resistance increases to such an extent that the regulating valve has to be kept fully open, it is time to clean the filter bed.
  - The supernatant water is then drained off and the sand bed is cleaned by scrapping off the top portion of the sand layer to a depth of 1-2 cm.
  - After 20-30 scrapings, the thickness of the sand bed will have reduced and a new bed is constructed.

Mechanical / Rapid Sand filters

1st in USA-1885

1. **Coagulation** : The raw water is treated with chemical coagulant such as alum.
2. **Rapid mixing** : violent agitation in Mixing Chamber for a few minutes to allow quick and thorough dissemination of alum throughout the bulk of the water.
3. **Flocculation** : Slow and gentle stirring in Flocculation Chamber for 30 min. to form thick, copious, white flocculent precipitate of aluminium hydroxide.
4. **Sedimentation** : coagulated water is kept in sedimentation tank for 2-6 hrs where flocculent precipitate with impurities & bacteria settle down.
5. **Filtration** : the partly purified water is then subjected to rapid sand filtration.



Process of coagulation, flocculation, and sedimentation

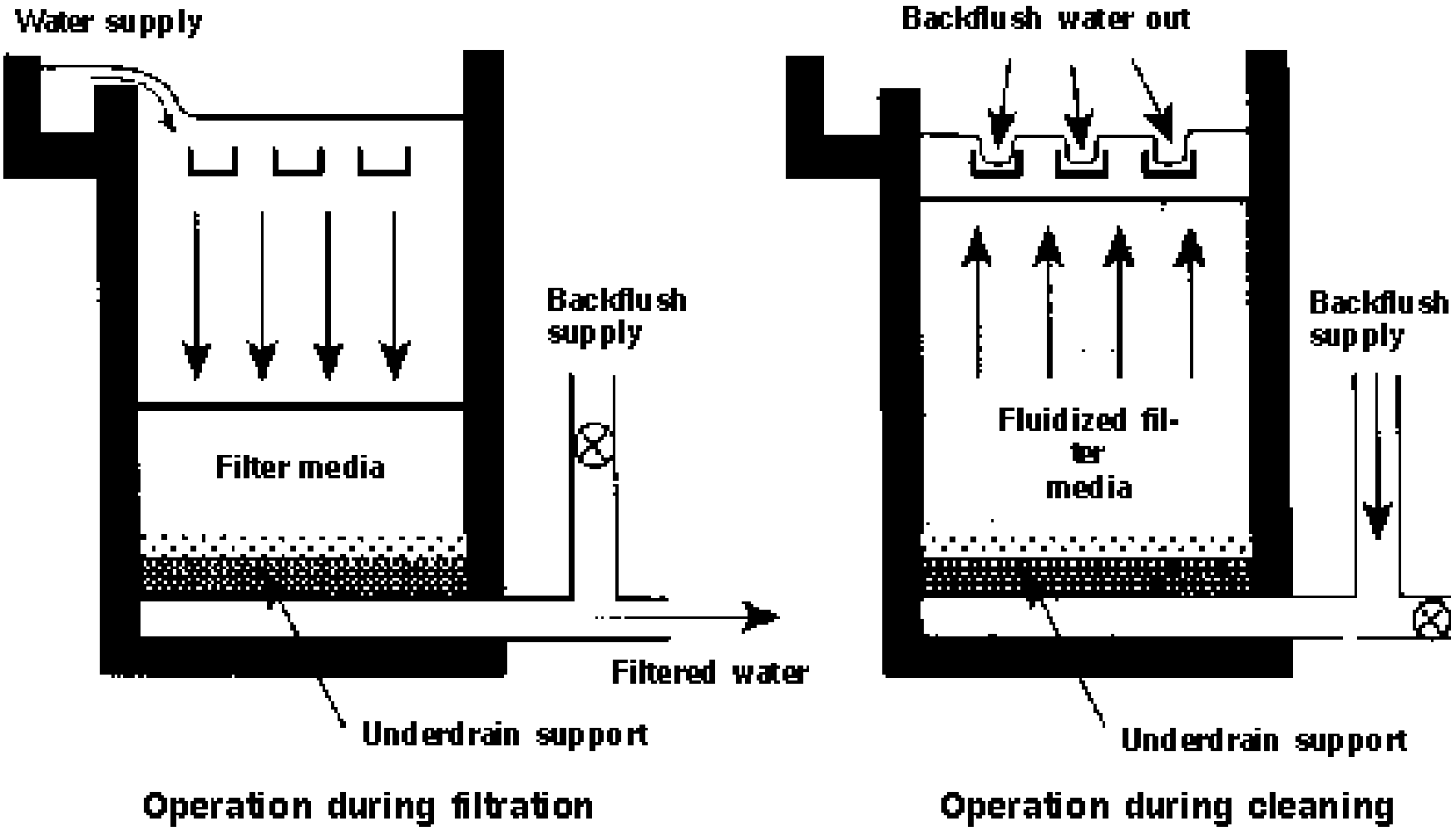


Figure 2. Cross-section of a rapid sand filter.

- **Filter Bed** :
  - It is a bed of sand(size-0.4 to 0.7 mm)of 1mtr thickness & surface of 80-90 m^2
  - Below the send bed, layer of graded gravel of 0.3-0.4 mtr and the under drainage pipe system carries the filtered water away.
  - Filtration removes the remaining alum floc not removed by sedimentation.
  - Rate of filtration = 5-15m^3/hour/$m^2$of sand bed surface
  - As filtration proceeds, the suspended impurities and bacteria clog the filters resulting in their reduced efficiency called “LOSS OF HEAD”

- **Back Washing** : Rapid sand filters need frequent washing daily/weekly depending upon the loss of head.
  - Washing is accompanied by reversing the flow of water through the sand bed , called “BACK Washing”
  - It helps in dislodging the impurities and cleaning up the sand bed.
  - Washing is stopped when the wash water is sufficiently clean.
  - The whole process of washing takes about 15 min.

Final process:

river → Alum →Mixing chamber →Flocculation chamber →Sedimentation tank → filters → Chlorine→ clear water storage → consumption

Differences between RSF and SSF	Rapid sand filter	Slow sand filter
1. Space	Little	Large area
2. Rate of filtr	5-15 $m^3/hr/m^2$ surface area	0.1-0.4 $m^3/hr/m^2$ surface area
3. Prelim. Treat	Chemical coagulation +sedi	Plain sedimentation
1. Washing	Back-washing	Scraping bed
2. Operation	High skill	Less skill
3. Removal of turbidity	Good	Good
4. Color removal	Good	Fair
5. Bacteria removal	98-99%	99.9%

CHLORINATION

- Chlorination is a supplement, not a substitute to sand filtration.
- **Mechanism of Action:**
  - Chlorine kills pathogenic bacteria, but it has no effect on spores and certain viruses except in high doses.
  - It destroys taste & odour producing constituents, controls algae and slime organisms & aids coagulation.
  - $H20 + Cl2 \rightarrow HCl + HOCl$ (hypochlorus acid)
  - $HOCl \rightarrow H + OCl$ (hypochlorite ions)
  - The disinfecting action of chlorine is mainly due to hypochlorus acid & to a small extent by ions.

Principle of CHLORINATION

- The water to be chlorinated should be clear and free from turbidity.
- The “Chlorine Demand’ of water should be estimed.
- **Chlorine demand** is the difference between the amount of chlorine added to a sample of water and the amount of chlorine remaining at the end of a specified period (Approax 60 min.)at the given Temp & pH of water.
- It is the amount of Cl used up in destroying bacteria and oxidizing all organic and ammoniacal substances.

- **Break point chlorination**: the addition of Cl to water to a point at which free residual Cl begins to appear is called break point chlorination

- After 60 min of Chlorination, 0.5 mg/ltr free **residual Cl** should be present to provide margin of safety against subsequent microbial contamination which may occur during storage and distribution.

- Cl demand+free residual Cl(0.5mg/l)=correct dose of Cl

- **Superchlorination**: it comprises of the addition of large doses of chlorine to the water and removal of excess of chlorine by dechlorination. This method is used for heavily polluted river water.

Methods of Chlorination

1. **Cl gas** : 1st choice because economical, quick in action, efficient and easy to apply. But irritant to eyes & poisonous.

2. **Chloramines** : loose compounds of Cl & ammonia. Less tendency to produce chlorinous taste and gives a more persistent type of residual Cl.

3. **Perchloron** : also called high taste hypochlorite and is Ca compound.

Small scale purification of water
HOUSEHOLD PURIFCATION

- 1) BOILING
  - rolling boil for 5-10 min
  - It kills all bacteria, spore, cyst & ova.
  - It also removes temporary hardness.
  - preferable to store in the same vessel in which it was boiled

2) Chemical disinfectants:

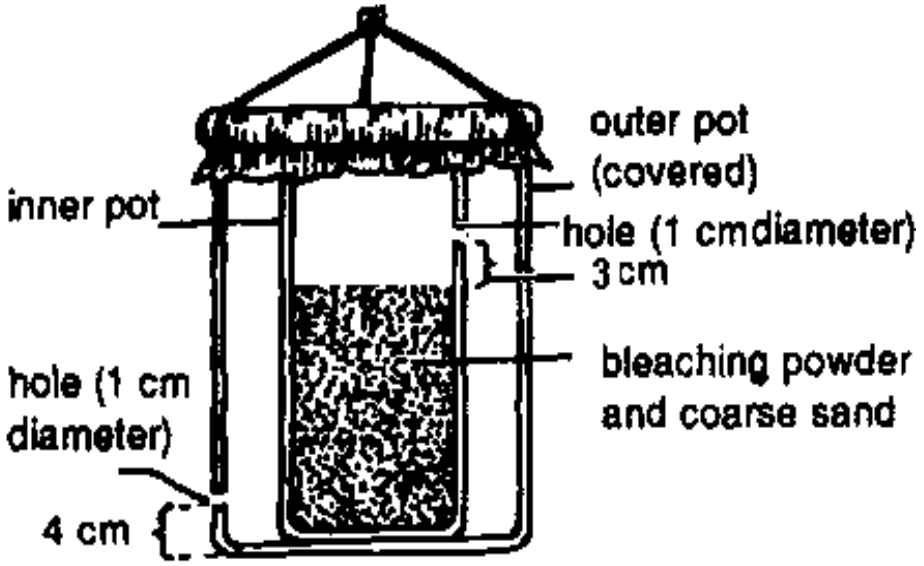
- Bleaching powder is white amorphous powder containing 33% of available Cl
- Chlorine solution- 4kg powder in 20 ltr water = 5% sol for wells
- Chlorine tabs-travelers and in emergencies

  -0.5gm tablet/ 20 ltr water
- Iodine- contact time of 20-30min needed. interferes with thyroid function→ to be used carefully
- Potassium permanganate- lacks anti-virus action

3) Filtration-candle filters (only bacteria)

Disinfection of Wells

- Main source of water supply in rural area
- Effective & economic method is by bleaching powder.
- **The Double Pot Method**
  - Devised by National Environment Engineering research institute (NEERI), Nagpur, India.



  - Uses 2 cylindrical pots, 1 placed inside the other.
  - The inside height & diameter of outer pot are 30cm & 25cm respectively
  - A 1cm diameter hole is placed in each pot. In the inner pot, hole is near the upper rim & in outer pot hole is 4cms above bottom.

- 1kg bleaching powder is mixed with 2kg of coarse sand, slightly moistened with water & the inner pot is filled with this mixture up to 3cms below the hole
- The inner pot is introduced into outer pot & outer pot is covered with polyethylene foil.
- The double pot is lowered into the well by means of a rope & immersed 1 m below water level to prevent damage by buckets used for drawing water.
- This method is used satisfactorily for 2-3 weeks in a well containing about 4500 ltrs of water.

COMPOSTING

- It is a method of combined disposal of refuse (solid waste-street, market, kitchen garbage) and sludge/ night soil
- Natural process-organic matter →bacterial action→ COMPOST, relatively stable humus-like material, considerable manurial value
- Heat produced→60^0 C over several days →destroys eggs and larvae of flies and pathogens→ no or few diseases producing microbes
- Good soil builder, small amounts of plant nutrients like nitrates and phosphates

METHODS OF COMPOSTING

- **1) BANGLORE (Anaerobic, Hot fermentation) method**- Developed by Indian council of agricultural research at the Indian institute of science, Bangalore.

  -satisfactory anaerobic method of waste disposal for small town wastes and night soil.

  -deep trenches(3 ft) are dug →refuse layered first → night soil→ alternate layering done till heap rises 1ft above the ground with refuse as the top layer →covered with earth

  - in 7 days, bacterial action generates too much heat (60^oC)→ decomposes the heap and kill all microbes in 2-3 wk

  - after **4-6 months**, resulting manure is well decomposed, odorless, high quality manure

- **2) MECHANICAL COMPOSTING (Aerobic)**

  - in this aerobic method, large scale production of compost using machines in developed countries like Swtz, Germany

  -refuse is first cleared of matter which is likely to interfere with grinding →pulverization to reduce particle size →mixing with sewage, sludge or night soil in mixing machine and incubated. Temp., moisture, pH, certain C-N ratio are maintained. →after **4-6 wks**. Compost is ready

  - Govt of India is considering the installation of these plants for big cities.

Question Asked….

1. What is problem village? (1)
2. Composting (5)
3. What is Zoogleal Layer? (1)
4. Def- Potable water (1)
5. Slow Sand Filtration (5)

THANK YOU