Community Medicine	HIV/AIDS, Syphilis	1	145	Describe HIV/AIDS considering Risk groups, pathology, Diagnosis, treatment, and Prevention
			146	Describe Syphilis in terms of causative agent, incubation period, transmission, manifestation, diagnosis treatment and prevention.
	Chlamydia, Genital warts, Gonorrhea		147	Describe Chlamydia in terms of etiology, transmission, symptoms, treatment, and prevention.
			148	Describe Genital warts in terms of causes, transmission, symptoms, treatment, and prevention.
			149	Describe Gonorrhea in terms of causes, transmission, symptoms, treatment, and prevention.
	Human Papiloma virus,		150	Describe Human Papiloma Virus (HPV) in terms of causes, types, transmission, symptoms, screening, and prevention.

Community medicine	Environmental health: Introduction	1	109	Explain the importance of environmental health
			110	Define and classify environmental degradation
	Water pollution	1	111	Define water pollution and describe its importance for health

			112	Describe the different types of water pollution as simple biodegradable, complex biodegradable and complex non-degradable
	Water quality management	4	113	Explain the importance and daily requirements of water.
			114	Describe the qualities and criteria of different sources of water including surface water, ground well, shallow well, deep well.
			115	Classify different methods of purification of water
			116	Describe natural methods of purification of water
			117	Describe physical methods.
			118	Describe chemical methods.
			119	Describe filtration methods both small scale and large scale
			120	Describe purification of water in special circumstances
			121	Enumerate different water quality parameters
			122	Describe physical parameters
			123	Describe different chemical parameters and its interpretation.
			124	Explain the permissible limits of chemical parameters.

Safe & Wholesome Water - Water that is **[P-P.C.O.D]**

- **P**leasant to taste
- ***Free from Pathogenic agents***
- ***Free from harmful Chemical*** substances
- F***ree from Odor & Color***
- ***Usable for Domestic purpose***

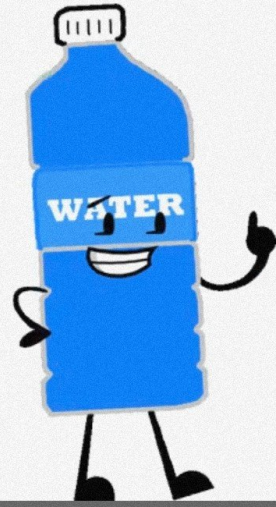
❖ Water is said to be **Polluted** or **Contaminated** if it does not fulfill the above criteria

❖ ***Daily requirement of water to meet needs for Domestic purposes***

- ***Rural- 40 - 60 liter per capita / day*** ***(55 Liter / capita / day)***
- ***Urban- 150 - 200 liter per capita / day***

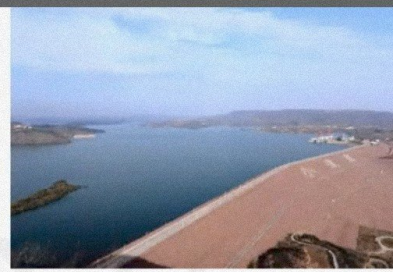
❖ ***Physiological requirement of water***

- ***Adult male – 3.7 liter***
- ***12-year girl – 2.1 liter***



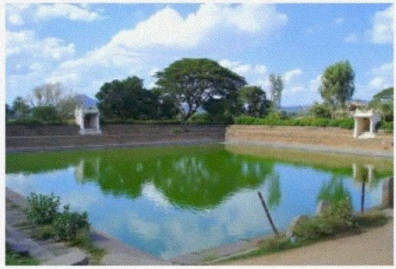
Sources of Water

1. Rain water



2. Surface water

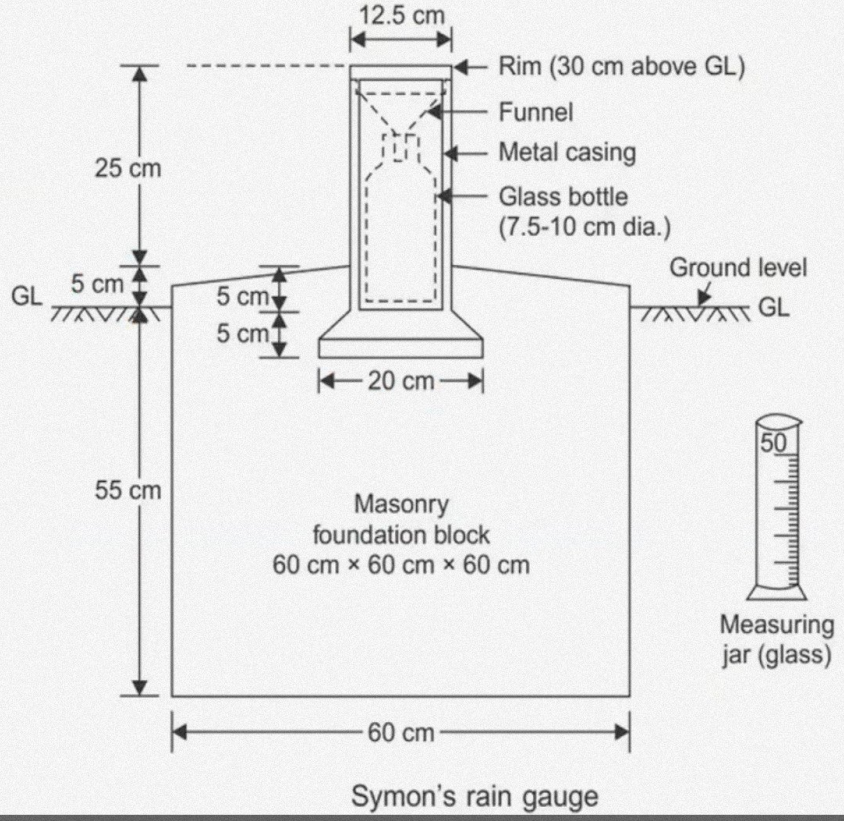
   i. *Impounding reservoirs*
   ii. *Rivers & Streams*
   iii. *Tanks,* Ponds & Lakes



3. Ground water

   i. *Shallow well*
   ii. Deep well
   iii. Springs

1. **Rain** – (Gibraltar)
   - ***Purest source of water***
   - **Very soft** water
   - ❖ ***Symon's rain gauge – widely used in India***



Symon's rain gauge

2. ***Surface water*** – **(**Mumbai, Chennai, Nagpur)

i. ***Impounding reservoirs***

- **Artificial lakes**
- ***Next to rain water in purity***
- ❖ ***Catchment area*** ***– areas from which water is drained to these reservoirs***

ii. ***Rivers & Streams*** **- (**Delhi, Kolkata, Allahabad**)**

- **Grossly polluted** water, so without treatment it is unfit for drinking

iii. ***Tanks,*** **Ponds & Lakes**

Water Pollution – caused by different kinds of Water impurities

1. **Natural impurities-** Comprises of
    i. **Dissolved gasses** - **Nitrogen, Carbon dioxide, Hydrogen sulphide**
    ii. **Dissolved minerals** - salts of **Calcium, Magnesium, Sodium**
    iii. **Suspended impurities** - **Clay, Silt, Sand & Mud**
    iv. **Microscopic organisms**

2. **Water pollution caused by human activities**
    i. **Urbanization & Industrialization**
    ii. **Sewage -** Contain **Organic matter & Pathogenic agents**
    iii. **Industrial waste -** Contains toxic agents like **Metal salts**
        - ***Most common cause of pollution of drinking water***
    iv. **Agricultural pollutants** - **Fertilizers & Pesticides**
    v. **Physical pollutants** - **Heat & Radioactive substances**

- Indicators of Water pollution

  i. Total Suspended Solids (TSS)

  ii. Biochemical Oxygen Demand (BOD)

  iii. Concentration of Chlorides, Nitrogen & Phosphorus

- Water Pollution Law –

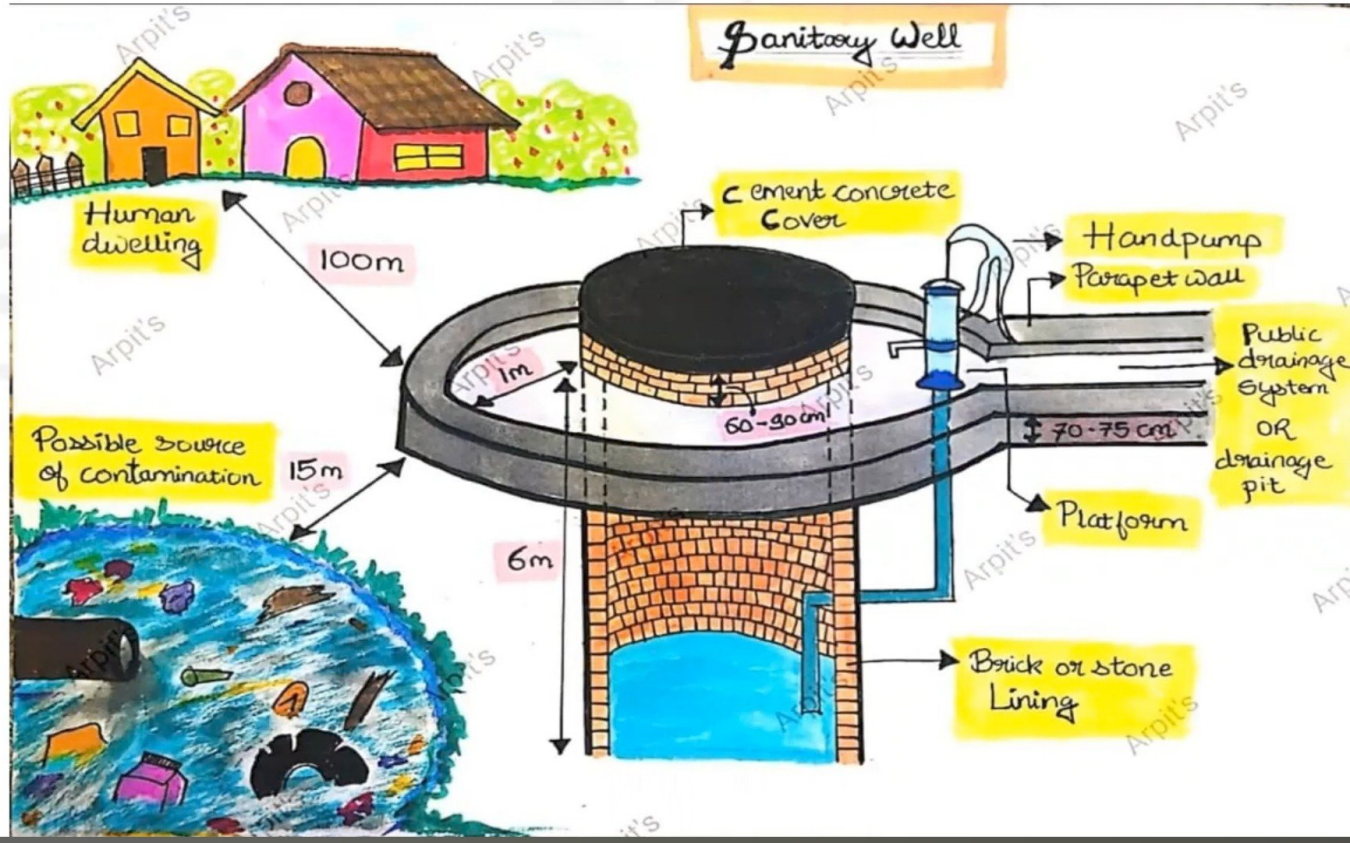
  - Water (Prevention & Control of pollution) Act 1974

Sanitary Well

– one that is **Properly located**, **Well-constructed**, and **Well protected** from possible locations of contamination, so as to ensure supply of **safe water**

- **Points kept into consideration before building Sanitary Well**

1. **Location**
2. **Lining / Stone wall**
3. **Parapet wall**
4. **Platform**
5. **Drain**
6. **Covering**
7. **Hand Pump**

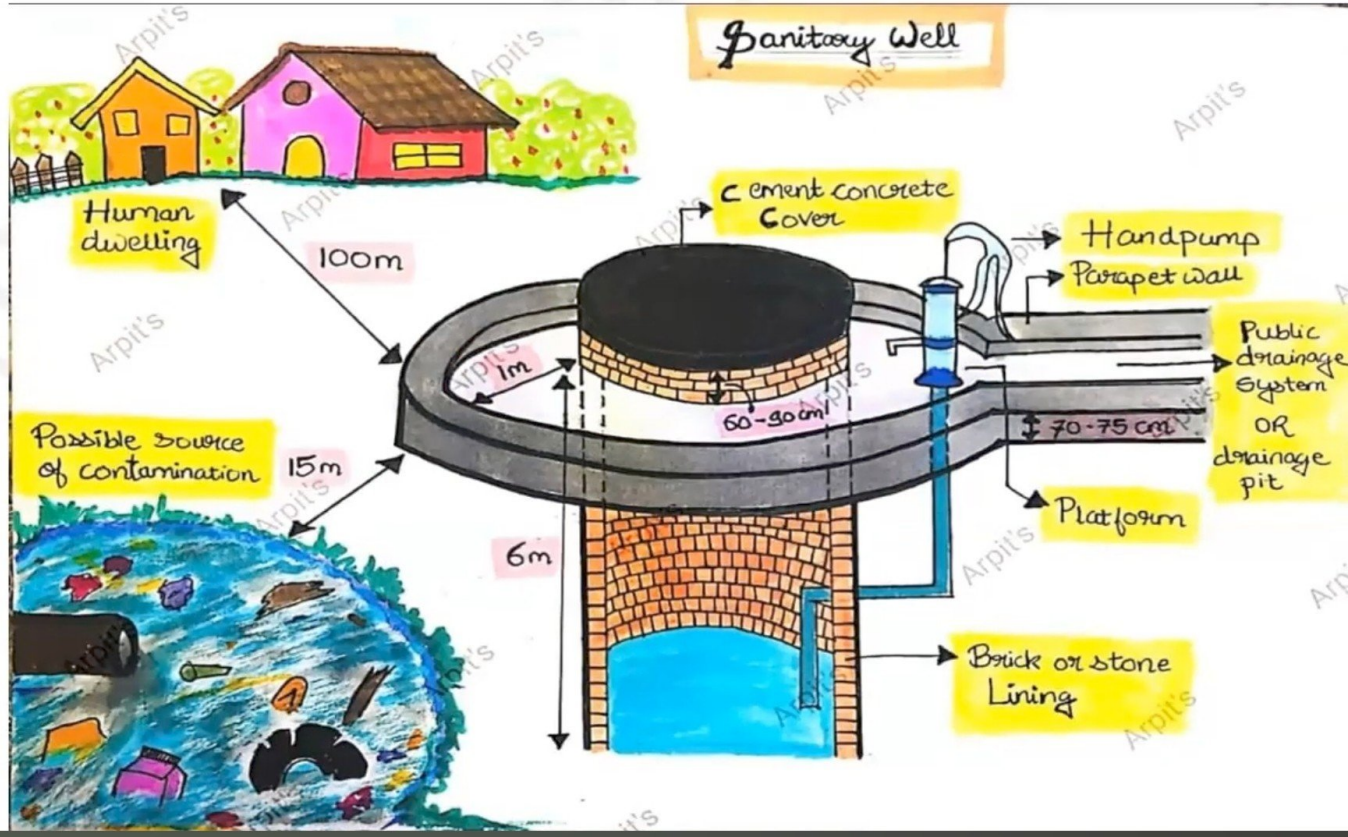


1. Location

- ***100 m / 300 ft distance from Human dwelling***
- ***15 m / 50 feet from likely Source of contamination***
- Should be located at a **higher elevation**

2. Lining / Stone wall

- Built of bricks or stones set in cement upto a ***Depth of at least 6 m / 20 feet***
- Lining should be carried **1 m / 3 feet above** the ground



3. Parapet wall

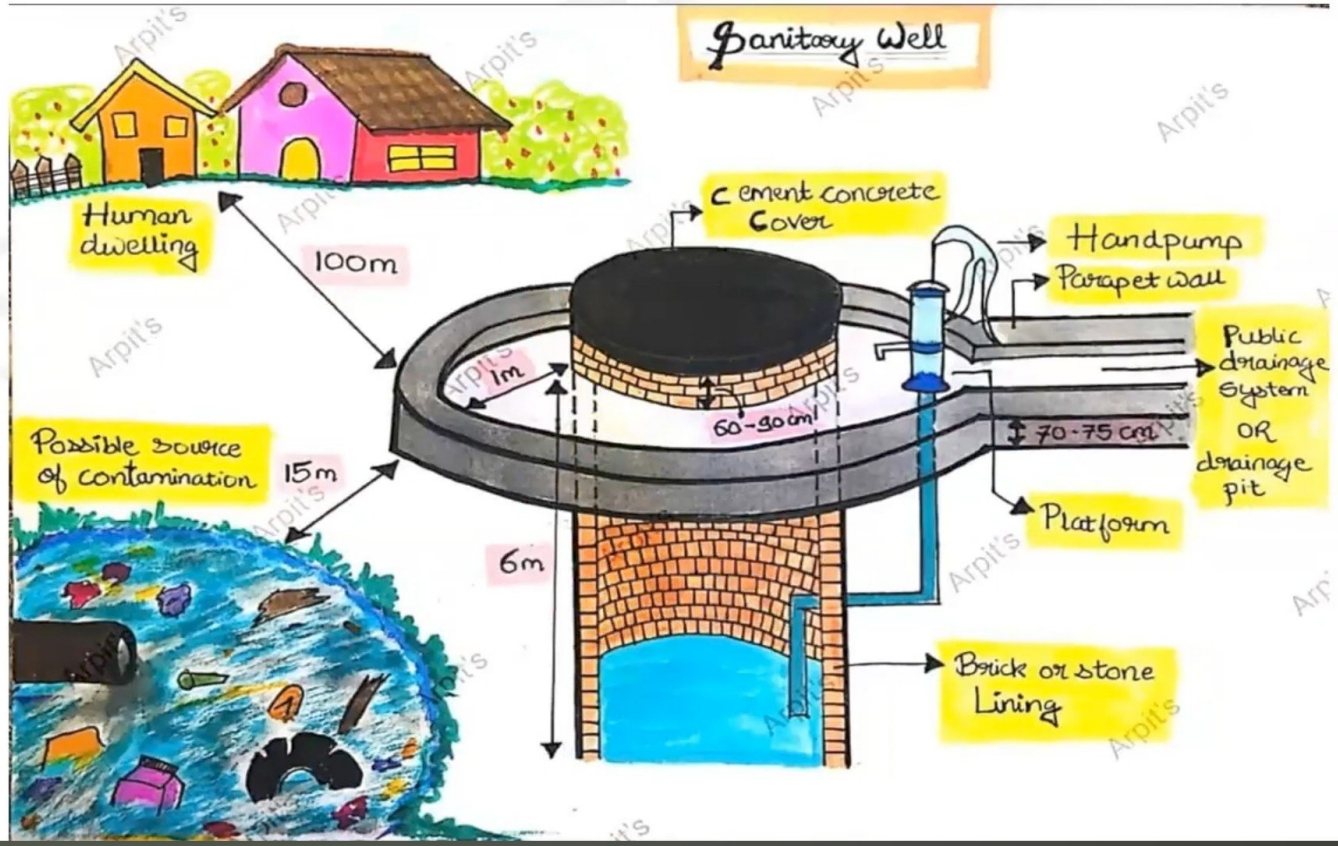
- Up to height of at least ***70 – 75 cm / 28 inches above the ground***

4. Platform

- ***At least 1 m / 3 feet in all direction***
- Gentle **slope outwards** towards a drain

5. Drain

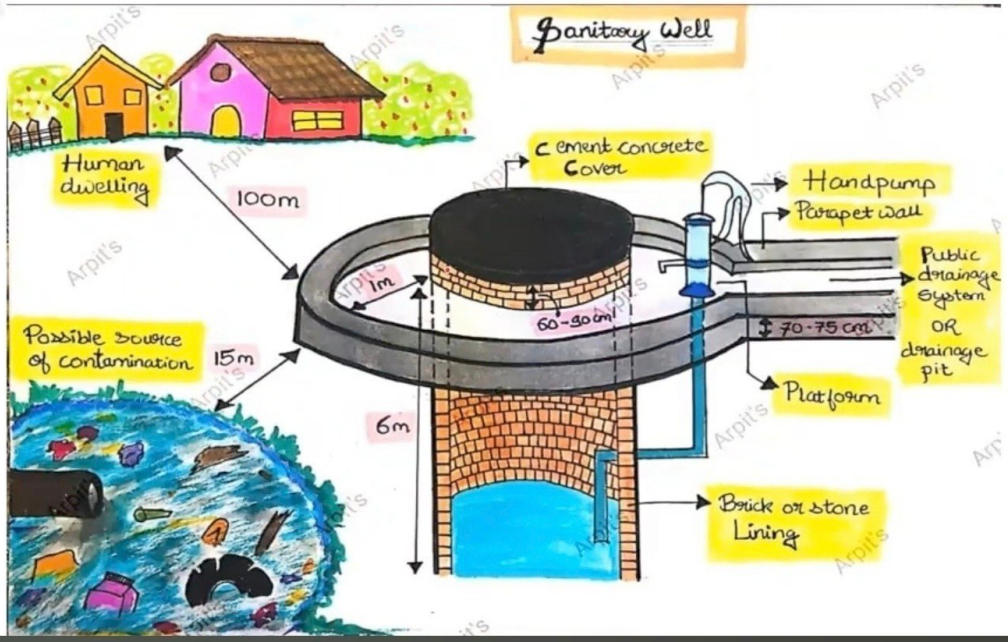
- **Pucca drain** to carry off spilled water to a public drain



5 - Sanitary Well

platform

parapet wall



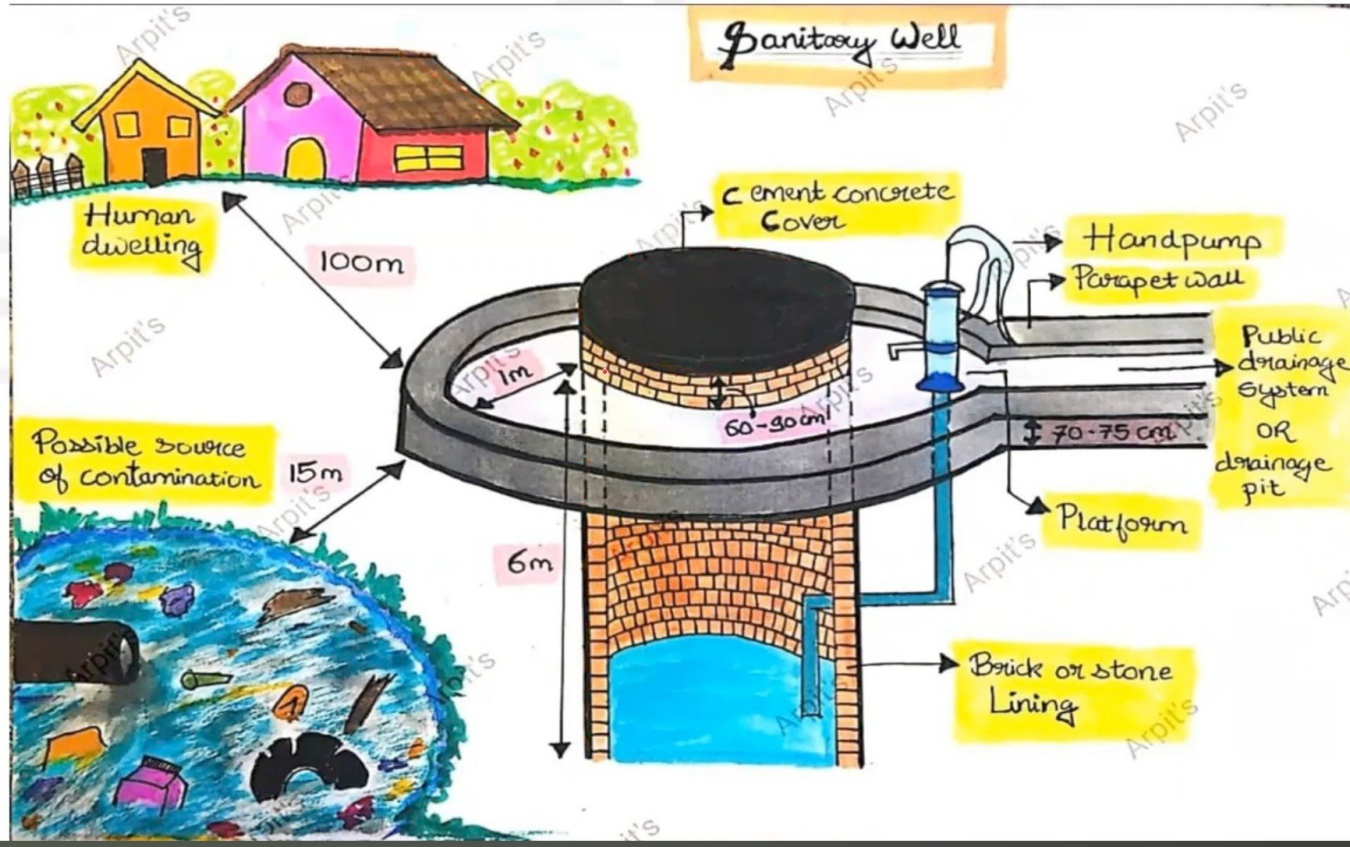
6. Covering

- Top of the well should be closed by a **cement concrete Cover**

7. Hand Pump

- Well should be equipped with **Hand pump**

for lifting the water in a sanitary manner



7 - Diseases of Water

Diseases of Water

1. Water Borne diseases
    - i. Viral
    - ii. Bacterial
    - iii. Protozoal
    - iv. Helminthic
    - v. Leptospiral

2. ***Water Washed diseases***

3. Water Based diseases

4. ***Water Related diseases*** (Water Breeding Disease)

5. Others
    - Heavy metals, Dyes, Bleaching agents, Solvents etc.
    - Fluoride
    - Hardness of water

1. Water Borne diseases

- Occur due to **drinking contaminated water**
- Transmitted by **Faeco - Oral route**
- **Example-**

  i. **Viral**- ***Hepatitis A*** & E

  ii. **Bacterial**- ***Typhoid*** & Paratyphoid fever, ***Cholera***

  iii. **Protozoal**- Amoebiasis, Giardiasis

  iv. **Helminthic** – Roundworm, Threadworm

  v. **Leptospiral** – Weil's disease

[w.A.t.E.r]

2. *Water Washed diseases*

- Infection of **outer body surface** due to improper hygiene & inadequate use of water
- **Example-** ***Scabies, Trachoma***, Typhus, ***Conjunctivitis***, ***Shigellosis*** etc.

3. Water Based diseases

- Infection transmitted through an **Aquatic invertebrate**
- **Example-** Shistosomiasis, Dracunculiasis (Guinea worm disease)

4. *Water Related diseases* (Water Breeding Disease)

- Infections spread by **insects that depends on water**
- **Example**- Malaria, Filariasis, Dengue, ***Yellow fever***, Onchocerciasis etc.

5. Others

- **Heavy metals, Dyes, Bleaching agents, Solvents** etc.
- **Fluoride - 1mg/L Protect** against **Dental Caries** but **high-level cause mottling of Dental Enamel**
- **Hardness of water -** is beneficial against **CVD**

8 - Purification of Water

Purification of Water

I. Purification of water on Large Scale

1. Storage

2. Filtration

3. Disinfection

II. Purification of water on Small Scale

1. Household purification of water

2. Disinfection of Well

I. Purification of water on Large Scale

1. **Storage**
   - i. **Physical** - 90% of the suspended impurities settle down by **gravity**
   - ii. **Chemical** - **Aerobic bacteria** oxidizes organic matter, which reduces free Ammonia into Nitrates
   - iii. ***Biological – when river water is stored properly, bacteria count drops 90% in first 5 -7 days***

2. **Filtration** - 99% bacteria are removed, apart from other impurities
   - i. **Slow Sand filter** or ***Biological Filters***
   - ii. ***Rapid Sand filter*** or **Mechanical Filters**

3. ***Disinfection***
   - i. ***Chlorination***
   - ii. ***Ozonation***
   - iii. **Membrane process**
     - a. **High pressure process**
       - I. **Reverse Osmosis**
       - II. **Nanofiltration**
     - b. **Low pressure process**
       - I. **Ultrafiltration**
       - II. **Microfiltration**

II. Purification of water on Small Scale

1. Household purification of water

i. Boiling

ii. Chemical disinfection

a. Bleaching powder / Chlorinated lime / $CaCl_2$

b. Chlorine solution,

c. High Test Hypochlorite (H.T.H) (Perchloron)

d. Chlorine tablet (Halazone)

e. Iodine

f. Potassium Permanganate

iii. *Filtration (Ceramic filters)*

a. *Pasteur Chamberland filter*

b. *Berkefeld filter*

c. *Katadyn filter*

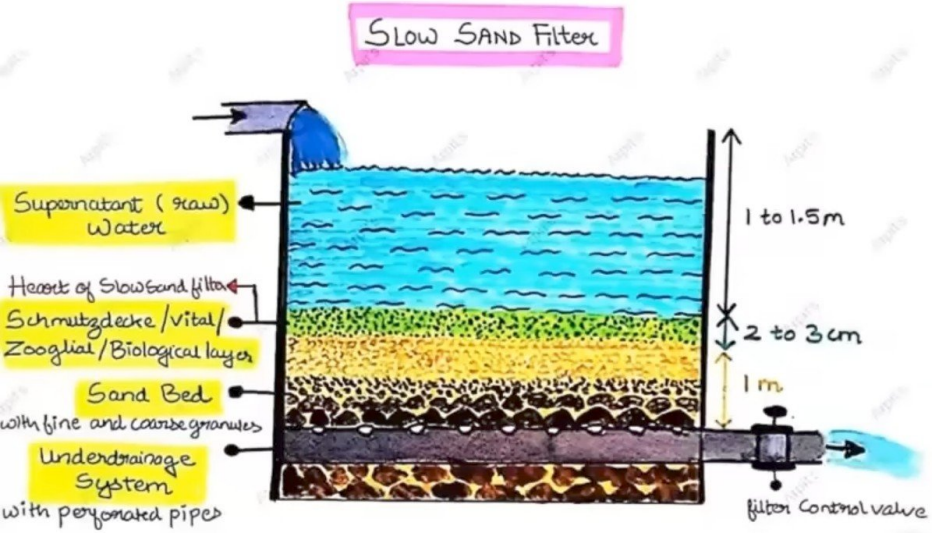
a. *Ultraviolet Filtration*

i. *Multistage Reverse Osmosis*

2. Disinfection of Well

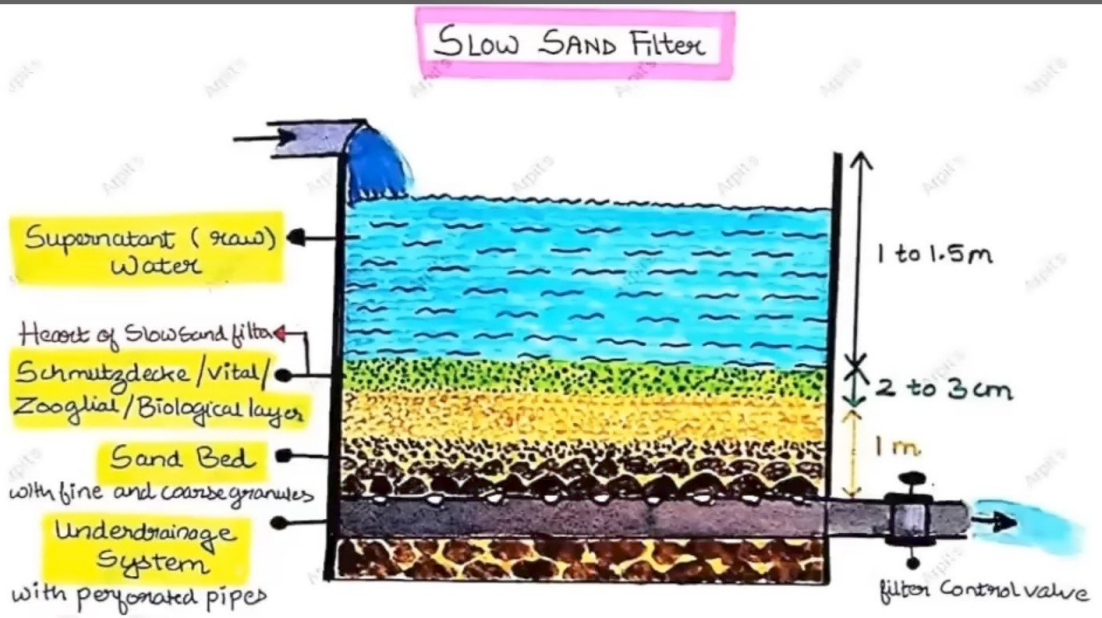
❖ Double Pot Method

8.1 - Slow Sand Filter

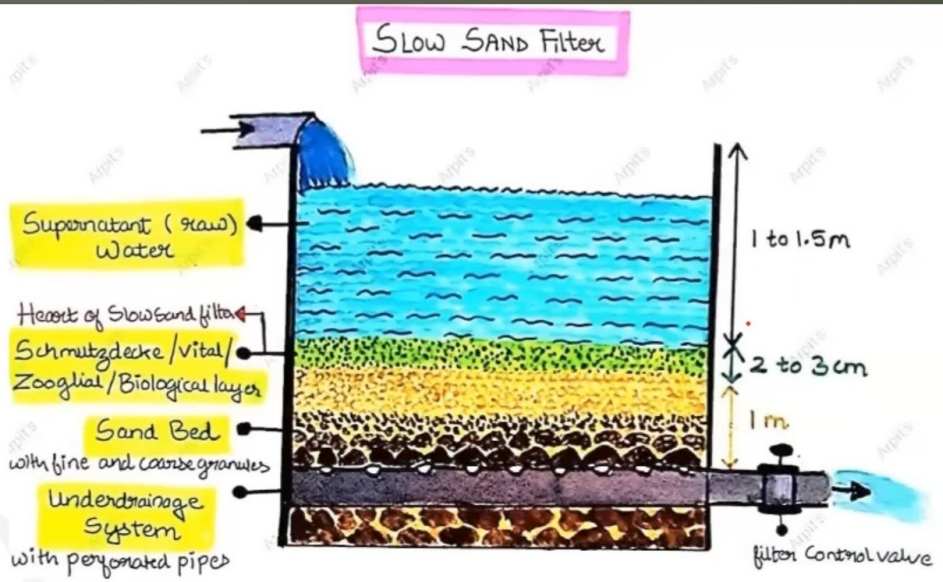


Slow Sand Filter / Biological Filter

1. Supernatant (Raw) Water
2. Sand Bed
3. Under Drainage System
4. Filter Controls



1. Supernatant (Raw) Water

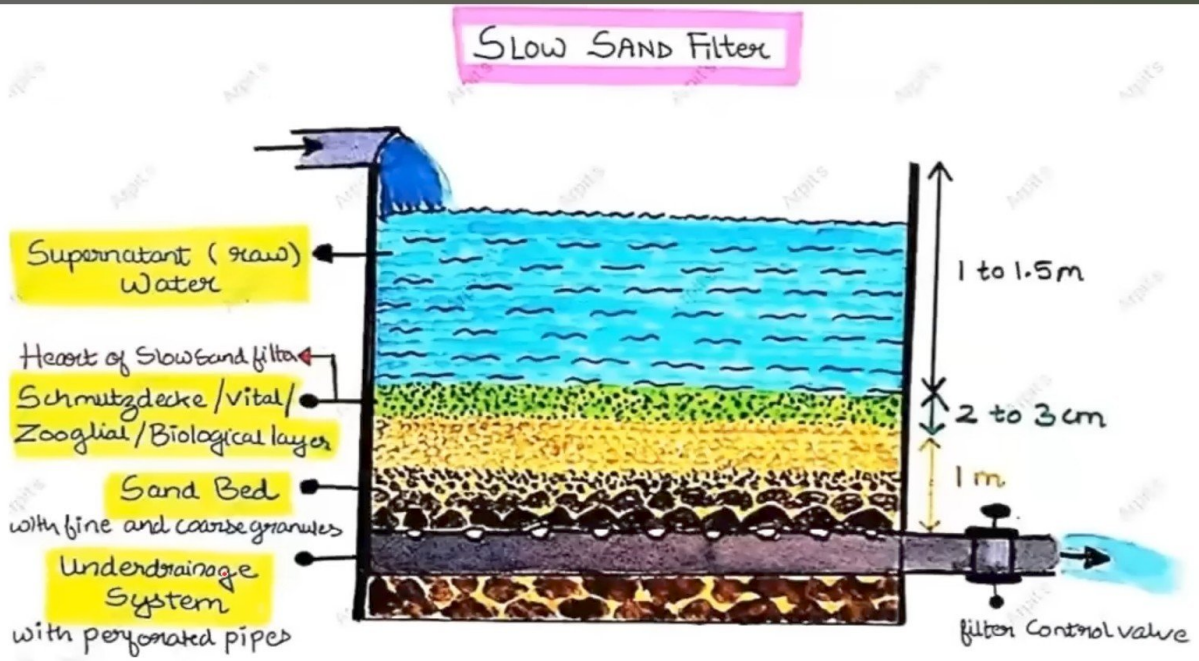


- **Depth** - **1.5 m**
- **Provides constant head of water** to promote downward flow of water
- **Also provides waiting period** of **3 - 12 hours** which helps to undergo purification by sedimentation & oxidation

2. Sand Bed

- **Thickness – 1 m**
- ***Sand grains diameter - 0.3 mm***
- **Supported by** layer of graded gravel
- ***Rate of filtration- 0.1- 0.4 m^3/hour/per square meter***

of sand bed surface



❖ ***Vital Layer***- Surface of filter get covered with a slimy growth known as ***Schmutzdecke/*** **Vital/** ***Zoogleal/*** **Biological Layer**

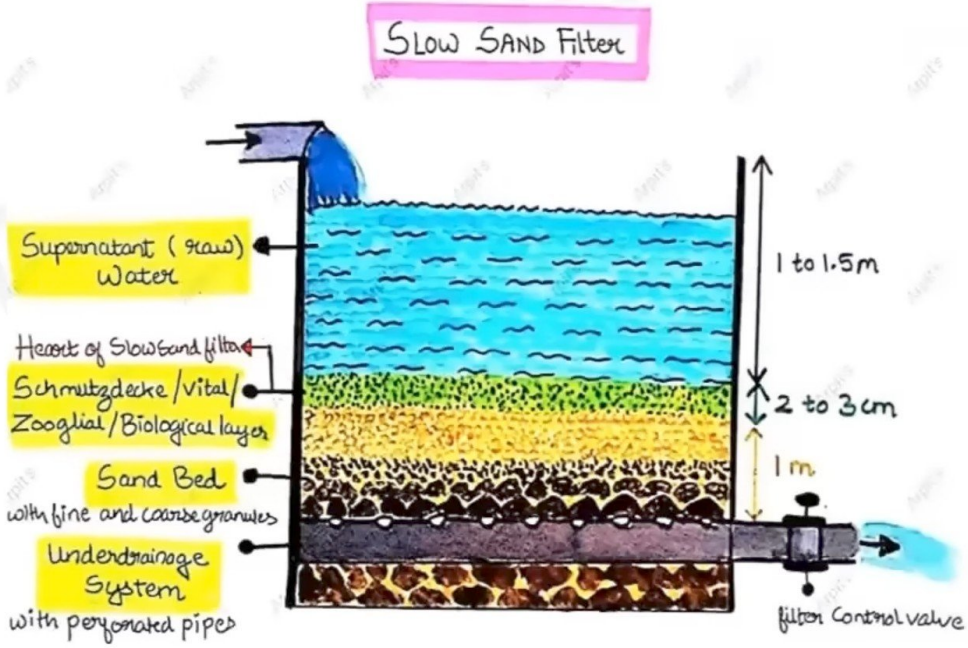
- **Extends** - **3 cm** into the ***top portion of sand bed.***
- **Slimy gelatinous layer** ***consist of thread like*** ***Algae, Bacteria, Planktons*** & ***Diatoms*** **[All Backup Plans Die]**
- ***Heart of slow sand filter*** - Filtered water can be used only after formation of vital layer (k/a **Ripening of the filter)**
- Removes **organic matter** & oxidizes ammoniacal **nitrogen into nitrates**

3. Under Drainage System

- **Perforated pipes** which provides an **outlet** for filtered water & **supporting** the filter from below

4. Filter Controls

- Equipped with **valves & devices**, to maintain a **constant rate** of filtration



❖ ***Venturi-Meter***

- ***measure's sand bed Resistance*** **/ Loss of head** (When exceeds **1.3 m**, it is uneconomical to run the filter)

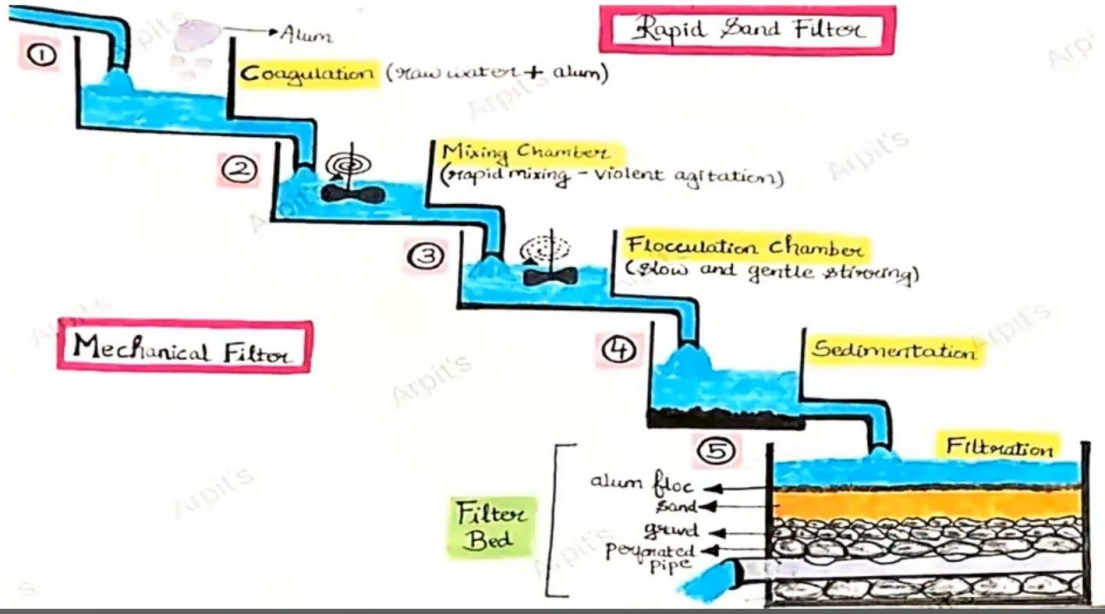
Filter Cleaning

- Supernatant water is cleaned off
- Sand bed is cleaned by **scrapping off** the top portion to the depth of **2 cm**
- After **20 - 30 scrapping**, plant is closed down & new bed is constructed

Advantages

- **Simple & Cheap** to construct
- Physical, chemical & biological quality of filtered water is very high
- ***Removes total bacteria count by 99.9%***

8.2 - Rapid Sand Filter / Mechanical Filter

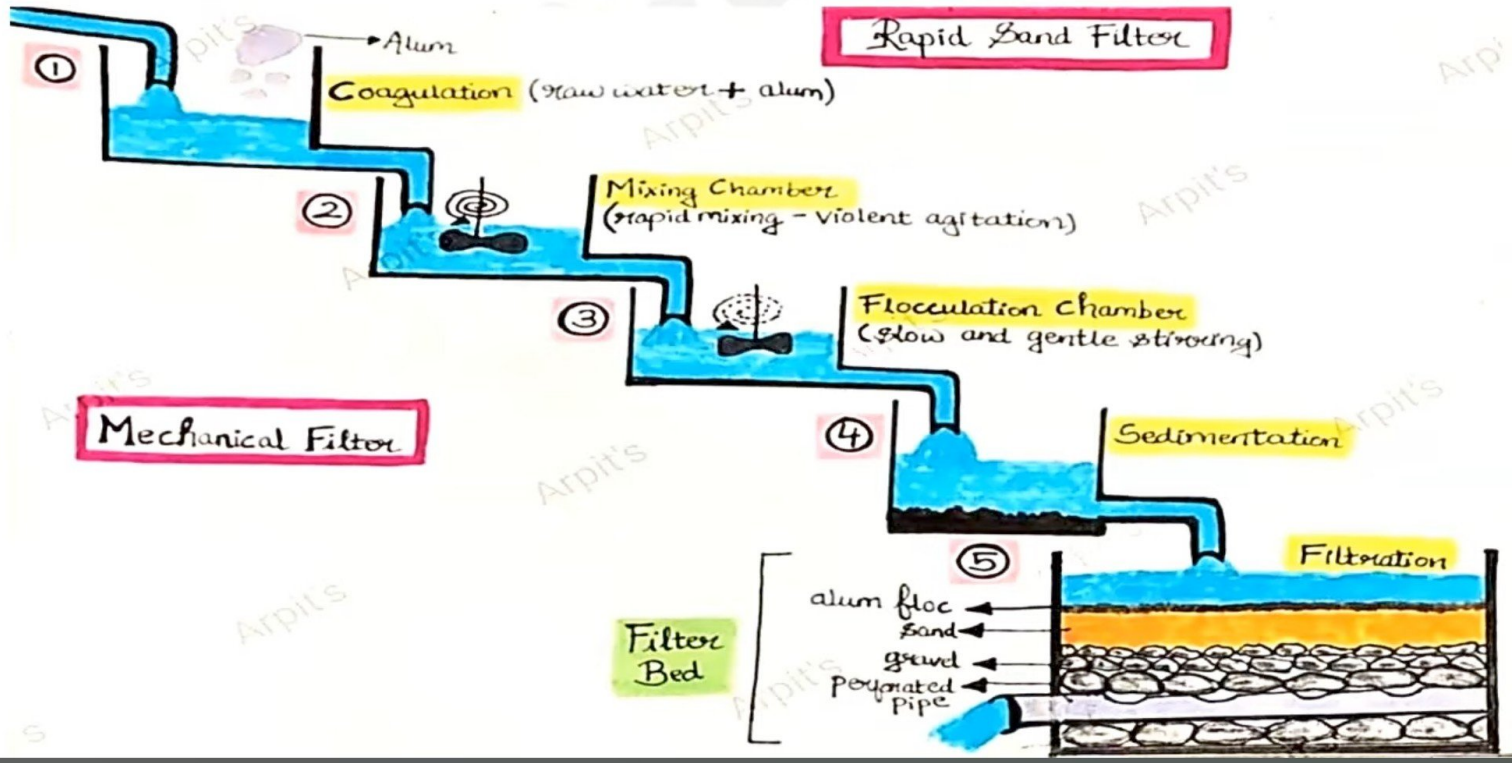


Rapid Sand Filter / Mechanical Filter

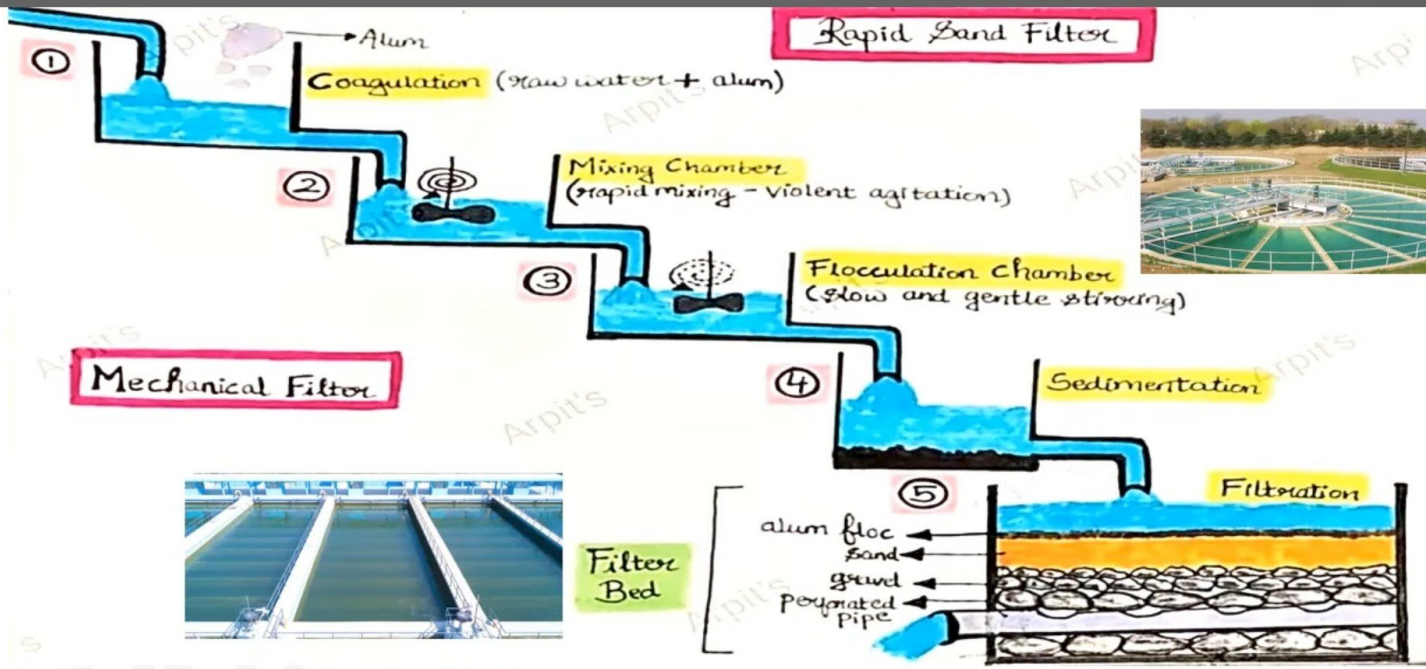
[General Practioner Practi-Ces]

- ***2 types***
  1. ***Gravity type (Paterson's filter)***
  2. ***Pressure type (Candy's filter)***

- **Steps**
  1. Coagulation
  2. Rapid mixing
  3. Flocculation
  4. Sedimentation
  5. Filtration



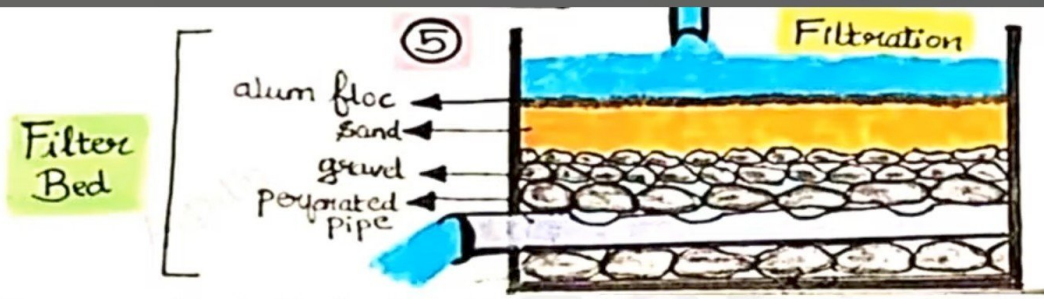
- **Steps**



1. **Coagulation**
   - Raw water treated with **alum**
   - **5 mg / Liter**
2. **Rapid mixing**
   - **Violent agitation** in a mixing chamber
3. **Flocculation**
   - **Slow & gentle stirring** of treated water in flocculation chamber for **30 min**
   - Results in formation of thick, copious, white flocculent precipitate of **Aluminum Hydroxide**
4. **Sedimentation**
   - **6 hours**
   - Flocculent precipitate along with impurities & bacteria, **settles down**
5. **Filtration**
   - **Partly clarified water** is now subjected to rapid sand filtration

   Filter bed - Sand, Gravel, Perforated pipes

❖ **Alum floc** not removed by sedimentation is held back on the sand bed & forms a slimy layer which absorbs bacteria & oxidizes ammonia



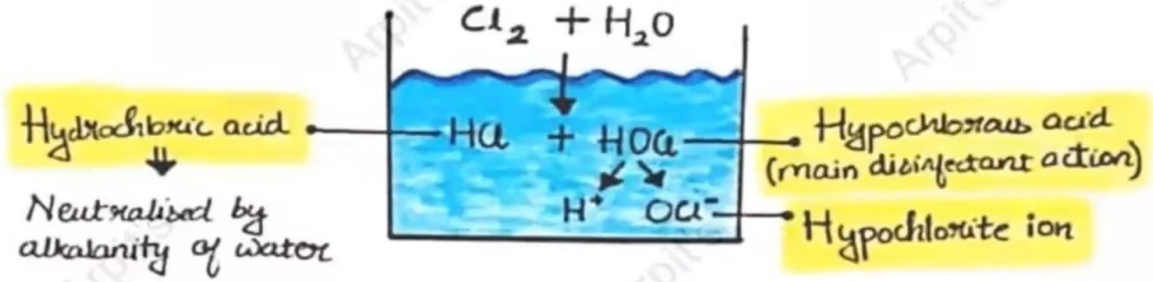
- **Rate of filtration**
  - ***5 m^3/ m^2/hour***
  - ❖ When the loss of head approaches **7 - 8 feet**, filtration is stopped & filters are subjected to backwashing

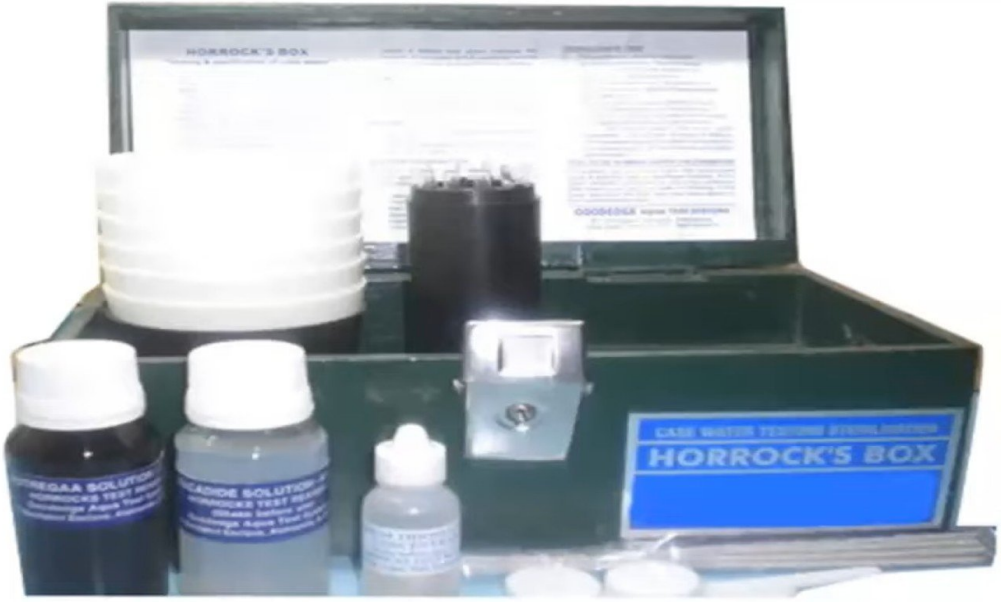
- **Filter cleaning - *Backwashing***
  - **Reversing** the flow of water
  - Sometimes **air** is used

- **Advantages**
  - ***Occupy less space***
  - Filtration is **rapid**
  - Washing is **easy**

	Rapid Sand Filter (Mechanical Filter)	Slow Sand Filter (*Biological Filter*)
1. Space	*Occupy little space*	*Occupy large area*
2. Rate of filtration	*5 m^3/hour/per square meter*	*0.1- 0.4 m^3/hour/per square meter*
3. Size of sand	*0.4 – 0.7 mm*	*0.2 – 0.3 mm*
4. Preliminary treatment	Chemical Coagulation & Sedimentation (i.e., storage)	Plain sedimentation
5. Washing	*Backwashing* – *Requires frequent washing* – *Requires highly skilled workers*	*Scrapping* – *Does NOT require frequent washing* – *Requires less skilled workers*
6. Loss of head allowed	6 – 8 feet	4 feet
7. *Removal of bacteria*	*98 – 99 %*	*99.9 – 99.99 %*
8. Suitable for	Big cities	Small cities
9. *Construction cost*	*Expensive*	*Cheap*
10. *Layer is made of*	Aluminum Hydroxide	*Algae, Bacteria, Planktons & Diatoms*

8.4 - Chlorination





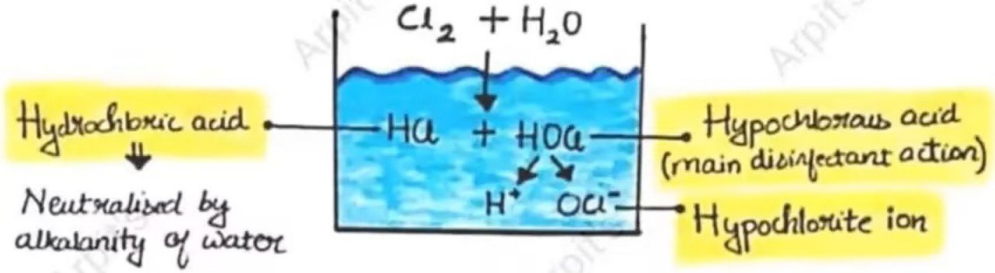
Chlorination

- ***Bactericidal* & moderately *Virucidal* but *NOT* sporicidal**
  - ***Polio virus NOT* sensitive to disinfection by chlorination**
- ***Used for purification of highly polluted water on large scale***

Action of Chlorine

$H_2O + Cl_2 \rightarrow$ HCl (Hydrochloric acid) + HOCl (Hypochlorous acid)

HOCl $\rightarrow$ H^+ (Hydrogen ion) + OCl^- (Hypochlorite ion)



- **Hydrochloric acid** is **neutralized** by alkalinity of water
- ***Disinfection action of chlorine is mainly due to Hypochlorous acid & to a small extent due to Hypochlorite ion***
- ***Chlorine disinfects best when pH of water is 7***
  - **When pH exceeds 8.5** - chlorine is **unreliable** as a disinfectant because 90% of Hypochlorous acid gets ionized to Hydrogen & Hypochlorite ions (most water have pH between 6- 7.5)
- ***Most effective water treatment method in rural areas is chlorination of water***

- **Phases of Chlorination**

Phase I	**Formation** of chloramines
Phase II	**Destruction** of chloramines
Phase III	Appearance of **breakpoint**
Phase IV	Accumulation of **residual chlorine**

- **Methods of Chlorination**
  - **Chlorine gas**
  - **Chloramine**
  - **Perchloron / High Test Hypochlorite (HTH)**

- ***Chlorine demand***
  - ***Amount of chlorine needed to destroy bacteria &***

    to oxidize all organic matter & ammoniacal substances
  - Chlorine demand is the difference between amount of chlorine added to water & amount of residual chlorine remaining at the end of specific period of contact (usually 60 min) at given temperature & pH of water

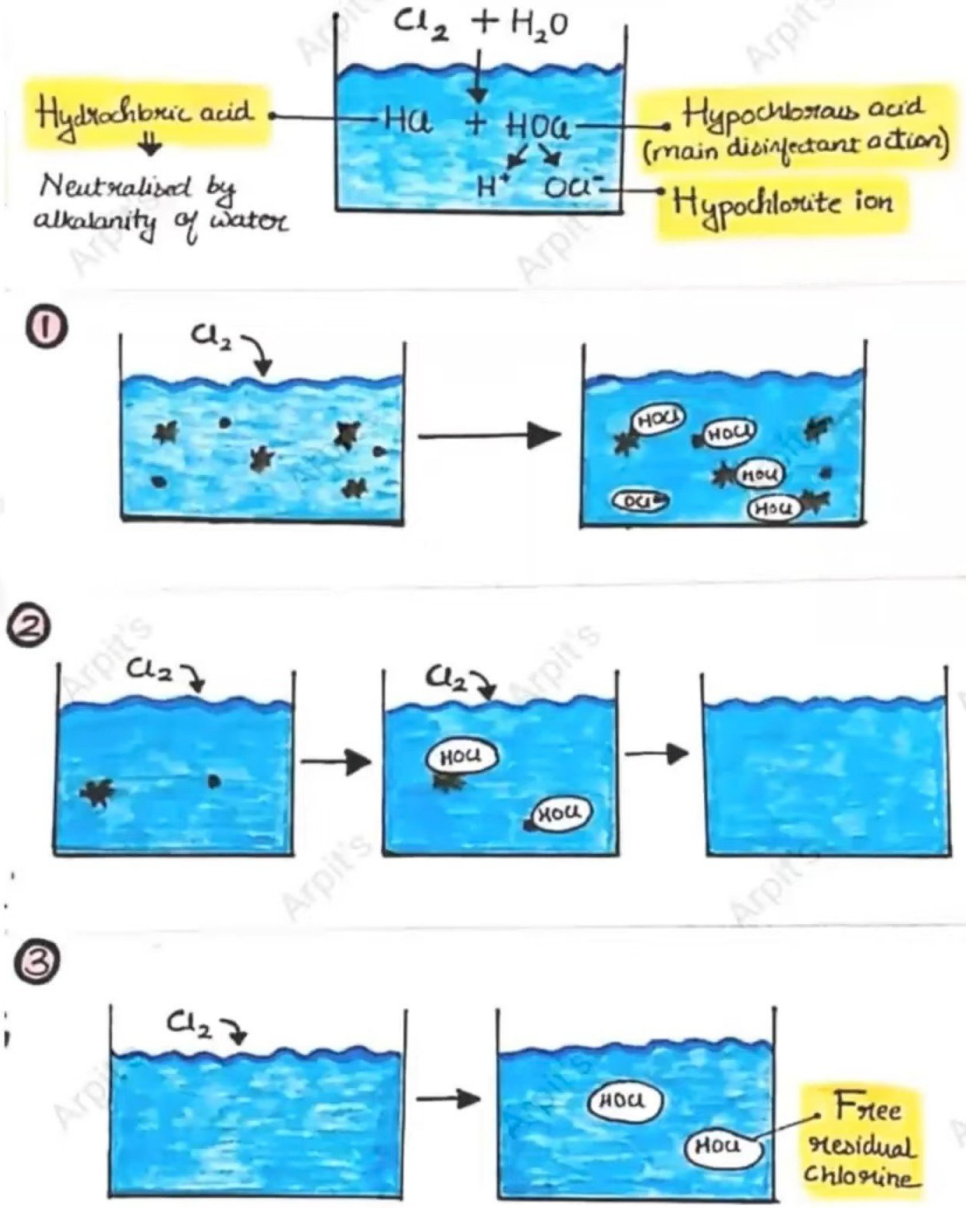
- ***Break point***
  - Point at which chlorine demand of water is **met** &

    if further chlorine is added beyond the break point,

    free residual chlorine (HOCl) begins to appear in water

- **Contact period**
  - Presence of free residual chlorine for a period of ***at least 1 hour***

    is essential to kill bacteria & viruses



- **Free Residual Chlorine**

  - **Recommended level of Free Residual Chlorine in water (*1mg / L = 1ppm*)**

Drinking water		***> 0.5mg / L (after 1 hour)***
Post disaster water bodies		***> 0.7 mg / L***
Swimming pool		***> 1 mg / L***
Post epidemic	***Piped supply***	***0.5 mg / L***
	Wells	**1mg / L**
	Tankers	**2mg / L**

  - **Residual germicidal effect of chlorine**
    - Provides **margin of safety** against microbial contamination, which may occur during **storage or distribution**
    - ***Only chlorine has got the residual germicidal effect whereas UV radiation & Ozone gas DON'T have residual germicidal effect***

❖ Breakpoint Chlorination

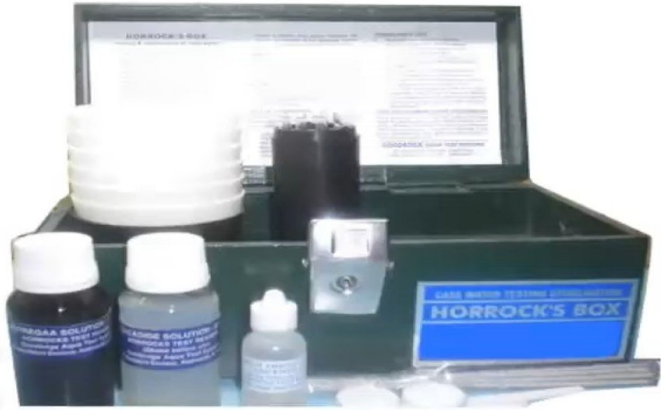
- Addition of chlorine to water **produces chloramines**
- if chlorine dose is increased, a **reduction in residual chlorine** occurs, d/t destruction of Chloramine by added chlorine.
- This causes fall in residual chlorine with further increase in chlorine dose & after a stage, residual chlorine begins to **increase in proportion** to the added dose of chlorine.
- This point at which the residual chlorine appears & when combined chlorine is completely destroyed is breakpoint & dosage is **breakpoint dosage**

❖ Super Chlorination

- ***Super chlorination is followed up with dechlorination***
- It is the addition of **large doses of chlorine** to the water & **removal of excess of chlorine** after disinfection
- This method is ***applicable to heavily polluted waters on large scale***

- **Instruments used in Chlorination**

1. **Horrock's apparatus** - chlorine demand estimation



2. **Chlorinator / Chloramine** - mixing of chlorine

3. **Chloroscope** – measuring residual chlorine

- **Tests for Free Residual Chlorine**

1. Orthotolidine test (OT)

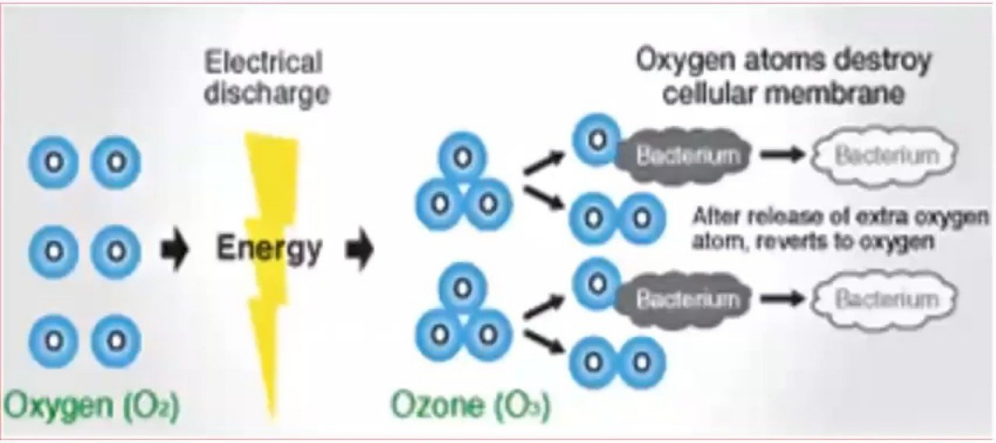
- ***Determines both Free & Combined chlorine in water***
- 0.1 ml reagent (Orthotolidine in 10% HCl) is added to 1 ml of water containing chlorine
- It turns **yellow**, whose color is matched against a **colored disc**
- OT reacts with **free chlorine instantaneously** but more **slowly with combined chlorine**
  - So, it's essential to take reading **within 10 seconds** to estimate free chlorine because color produced **after 15-20 minutes** is due to the action of both free & combined chlorine

2. Orthotolidine Arsenite test (OTA)

- ***For Free & Combined Chlorine separately***
- Errors caused by presence of **Nitrites, Iron & Manganese**

  (as they also give yellow color) are overcome

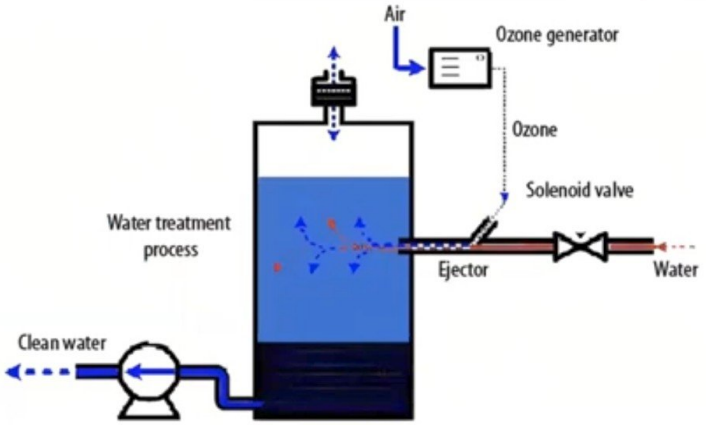
8.5 - Ozonation

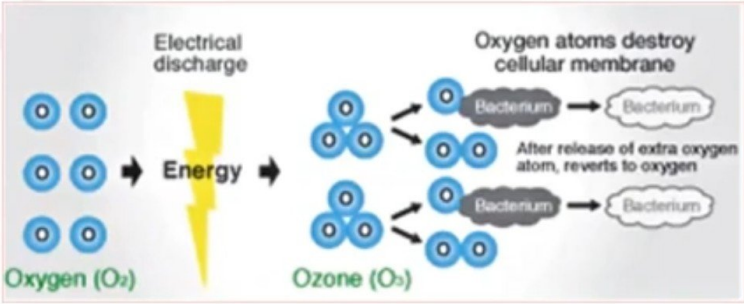


Ozonation

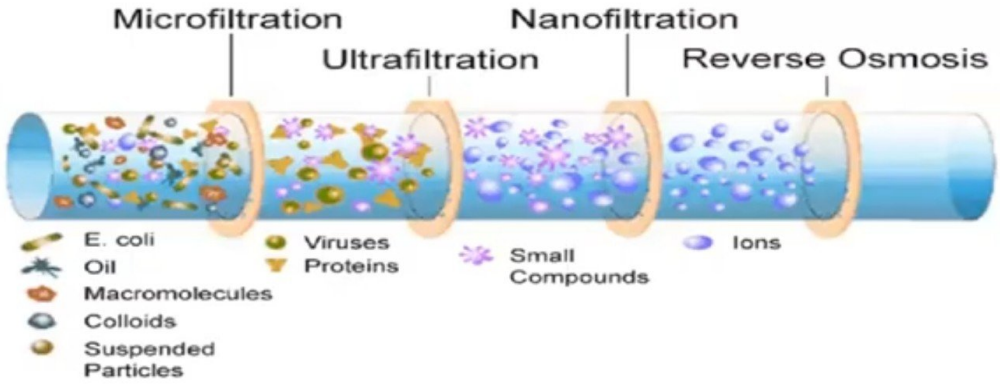
- Ozone gas O_3 is formed by passing **dry air** or **oxygen** through a **high voltage electric field**
  - Resultant **ozone-enriched air** is dosed directly into water
- A residual of about **0.5ml/L** after a contact time of upto **20 min** is typically used
- Normally used with subsequent treatments such as **Biological Filtration**

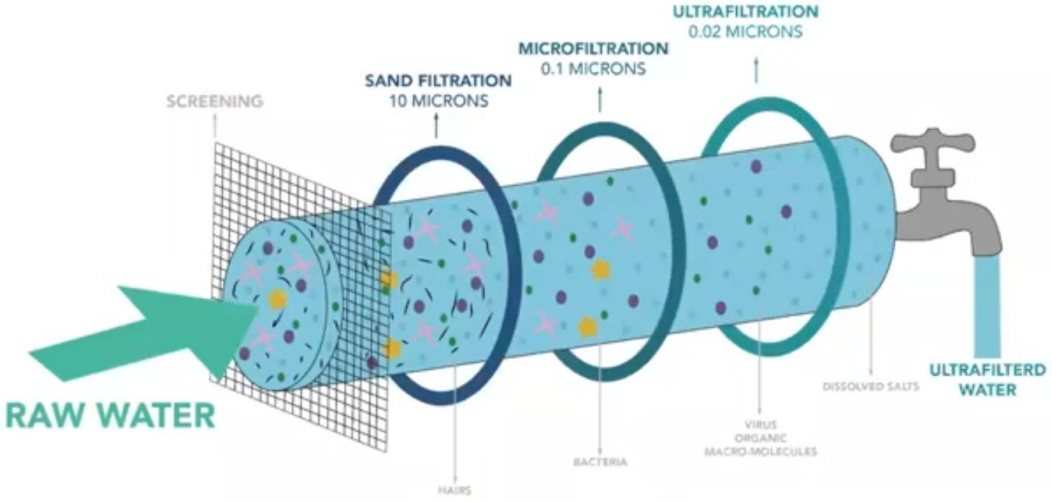
  or **Granular Activated Carbon (GAC)**, to remove biodegradable organics
  - Ozone reacts with **natural organics** to increase their biodegradability
  - Effective for degradation of wide range of **pesticides**
- ***Virucidal*** & **Bactericidal**
- Removes **Odor**, **Taste** & **Color**
- ***No residual effect***





8.6 - Membrane Process





Membrane process

a. ***High pressure process***

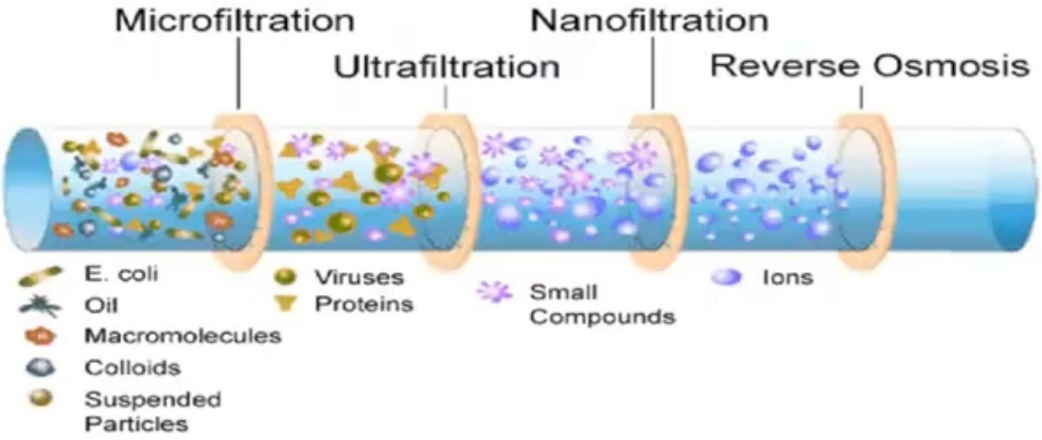
I. ***Reverse Osmosis*** (RO)

II. ***Nanofiltration***

a. ***Lower pressure process***

I. Ultrafiltration

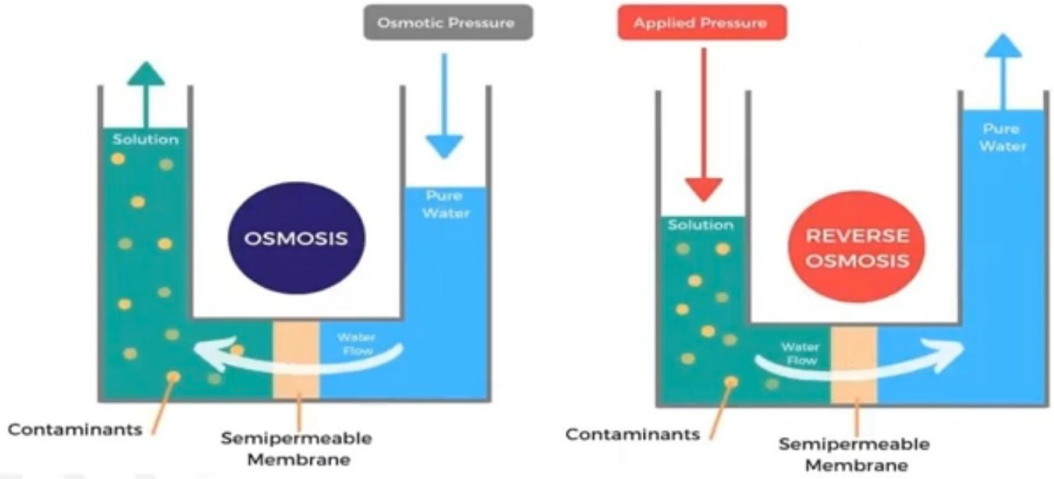
II. ***Microfiltration***

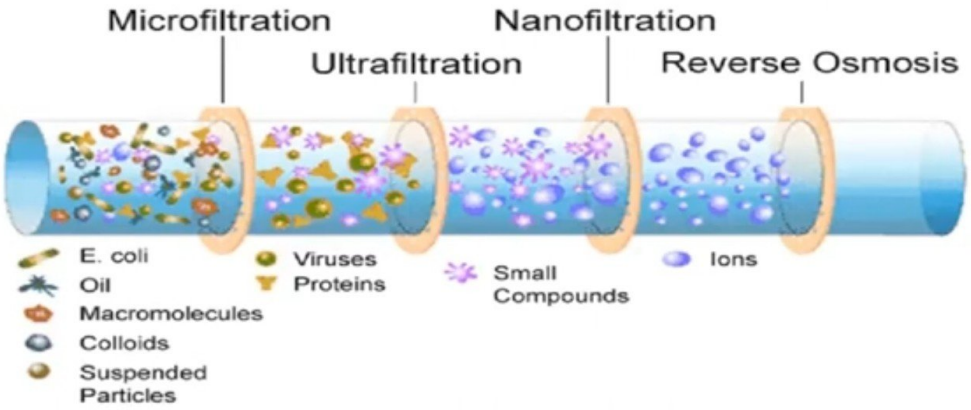


a. High pressure process

I. Reverse Osmosis (RO)

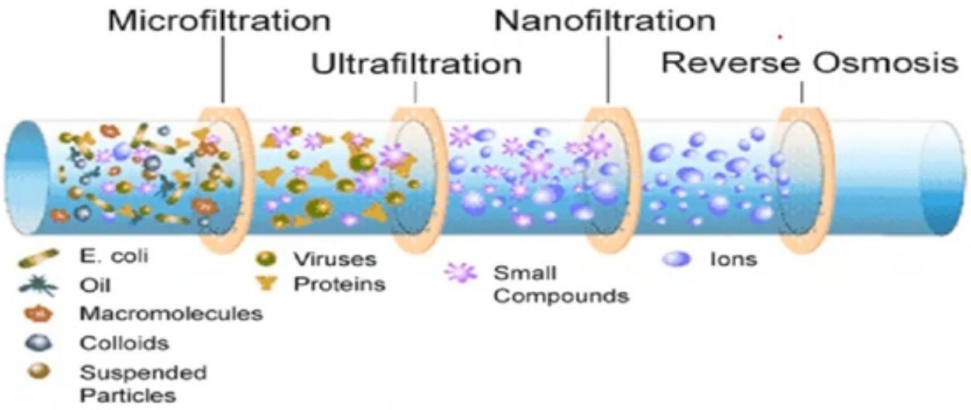
- Force the flow of solvent in opposite direction from the higher to the lower concentration, by increasing the pressure on the higher concentration solution
- **Pressure** - 15 - 50 bar
- **Rejects** - monovalent ions & organics of molecular weight > 50 Daltons
- **Most common application** - desalination of sea water

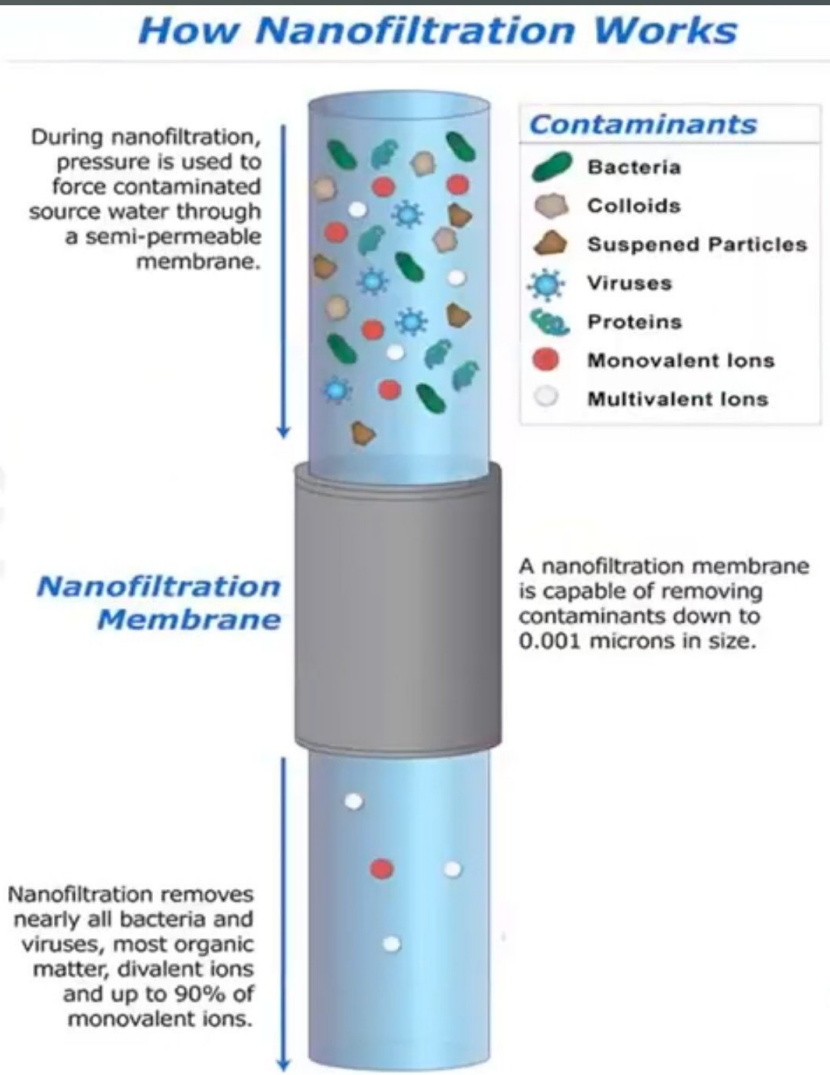




II. Nanofiltration

- Uses membrane with properties **between RO & Ultrafiltration**
- **Pressure** - **5 bar**
- **Rejects** - **divalent ions (Ca, Mg)** & **higher molecular weight** organics
- Effective for removal of **color forming organic compounds**





a. High pressure process

I. Reverse Osmosis (RO)

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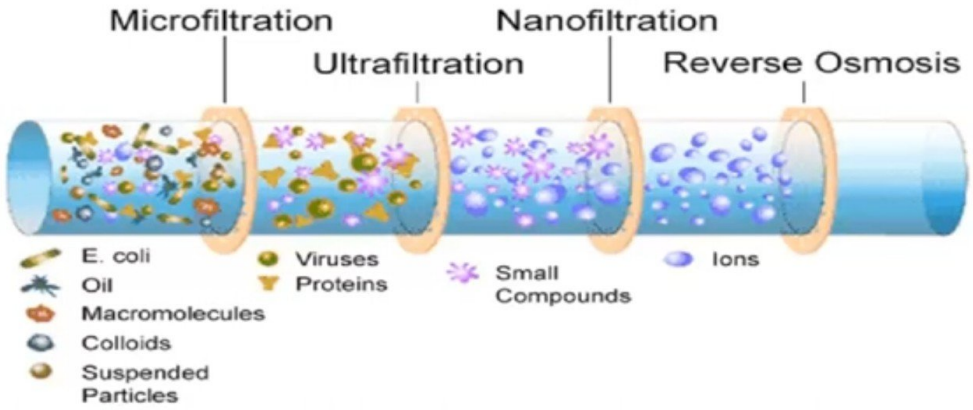
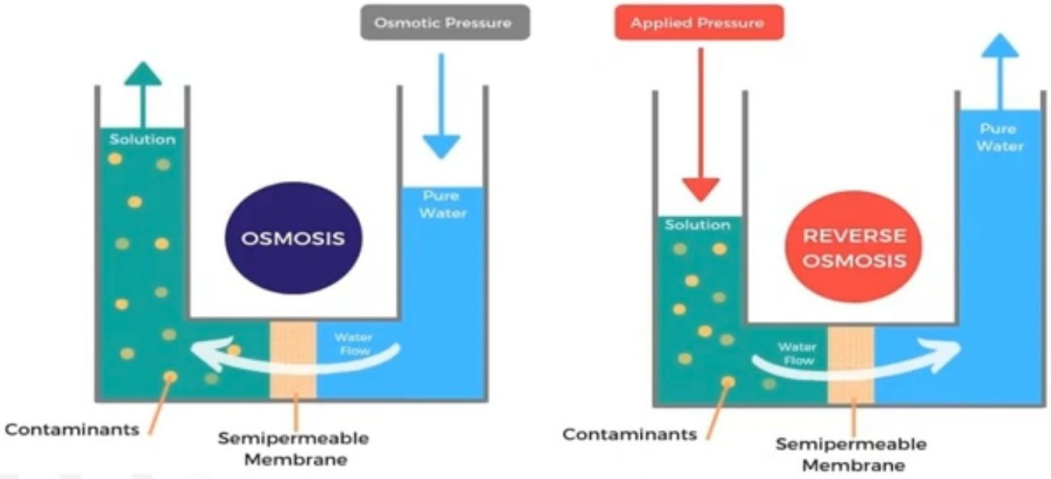




Household purification of water

Household purification of water

1. Boiling

2. Chemical disinfection

   i. *Bleaching powder*/ Chlorinated lime/ $CaOCl_2$

   ii. Chlorine solution

   iii. High Test Hypochlorite – HTH (Perchloron)

   iv. Chlorine tablets

   v. Iodine

   vi. Potassium permanganate

3. Filtration

   i. *Chamberland filter*

   ii. *Berkefeld filter*

   iii. *Katadyn filter*

4. Ultraviolet filtration

5. Multi stage Reverse Osmosis

1. Boiling

- Water must be brought to a rolling boil for **10 to 20 minutes**
- Kills all **bacteria, spores, cysts & ova**
- Also removes **temporary hardness**
- Water should be boiled preferable in the **same container** in which it is to be stored

2. Chemical disinfection

i. *Bleaching powder*/ Chlorinated lime/ $CaOCl_2$

- ***Bleaching powder is widely used in disinfection of wells***
- Contains **33%** of available chlorine
- When mixed with **excess of lime** it retains its strength, this is called **Stabilized Bleach**

ii. Chlorine solution

- **4 kg bleaching powder** mixed with **20 liters** of water
- Gives a **5% solution** of chlorine

iii. High Test Hypochlorite – HTH (Perchloron)

- Contains **60% of available chlorine**

iv. Chlorine tablets

- **Halazone tablets**
- **Single tablet of 0.5 gm** is sufficient to disinfect **20 liters** of water

v. Iodine

- **2 drops of 2% ethanol solution** of iodine will suffice for **1 liter** of clear water
- **High cost** & **thyroid activity** are its major disadvantages

vi. Potassium permanganate

- **Powerful oxidizing agent**, but not a satisfactory agent for disinfecting water

3. Filtration

- ***Ceramic filters NOT used much in India***

i. Chamberland filter

- Candle made up of ***Porcelain***

ii. Berkefeld filter

- Candle made up of ***Infusorial Earth or Kieselguhr***

iii. Katadyn filter

- Surface of filter is coated with ***silver catalyst*** so that bacteria are killed by ***oligodynamic action of silver ions***

4. Ultraviolet filtration

- Involves exposure of film of water **120 mm** thick to **mercury vapor arc lamp**, emitting **ultraviolet radiation** at wavelength of **254 nanometer**

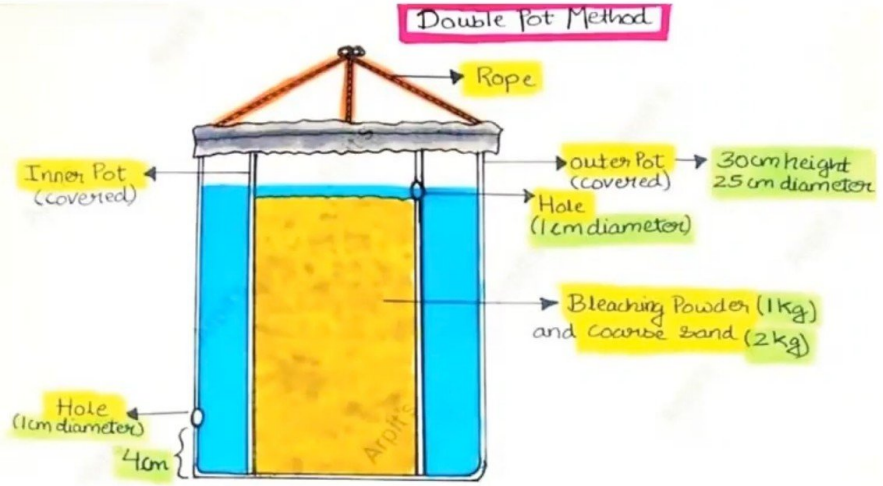
- ***NO residual effect***

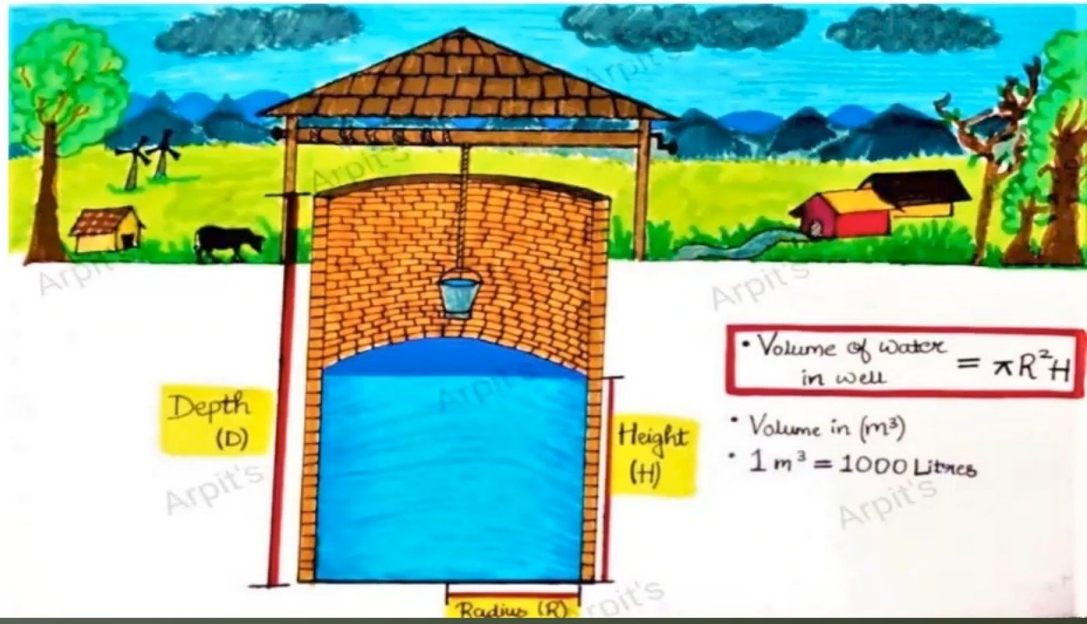
5. Multi stage Reverse Osmosis

- **Clarity cartridge** - removes **suspended particles**

- **RO cartridge** - reduces **TDS, hardness, heavy metals** & eliminate **microorganisms**

8.8 - Disinfection of Well



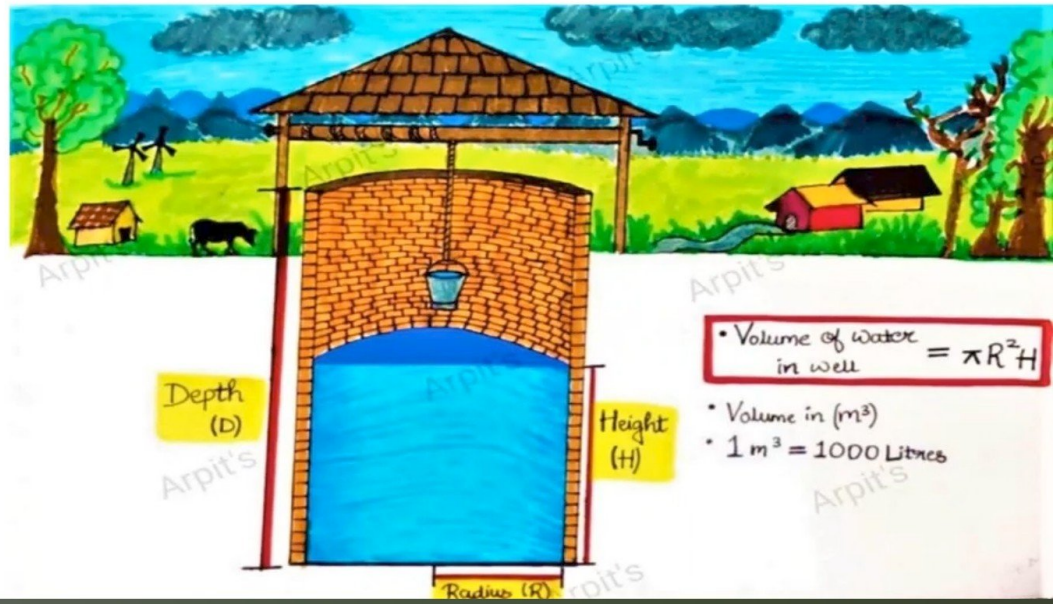


- Volume of water in well $= \pi R^2 H$
- Volume in (m^3)
- $1\ m^3 = 1000$ Litres

Disinfection of Well

Steps of disinfection of well

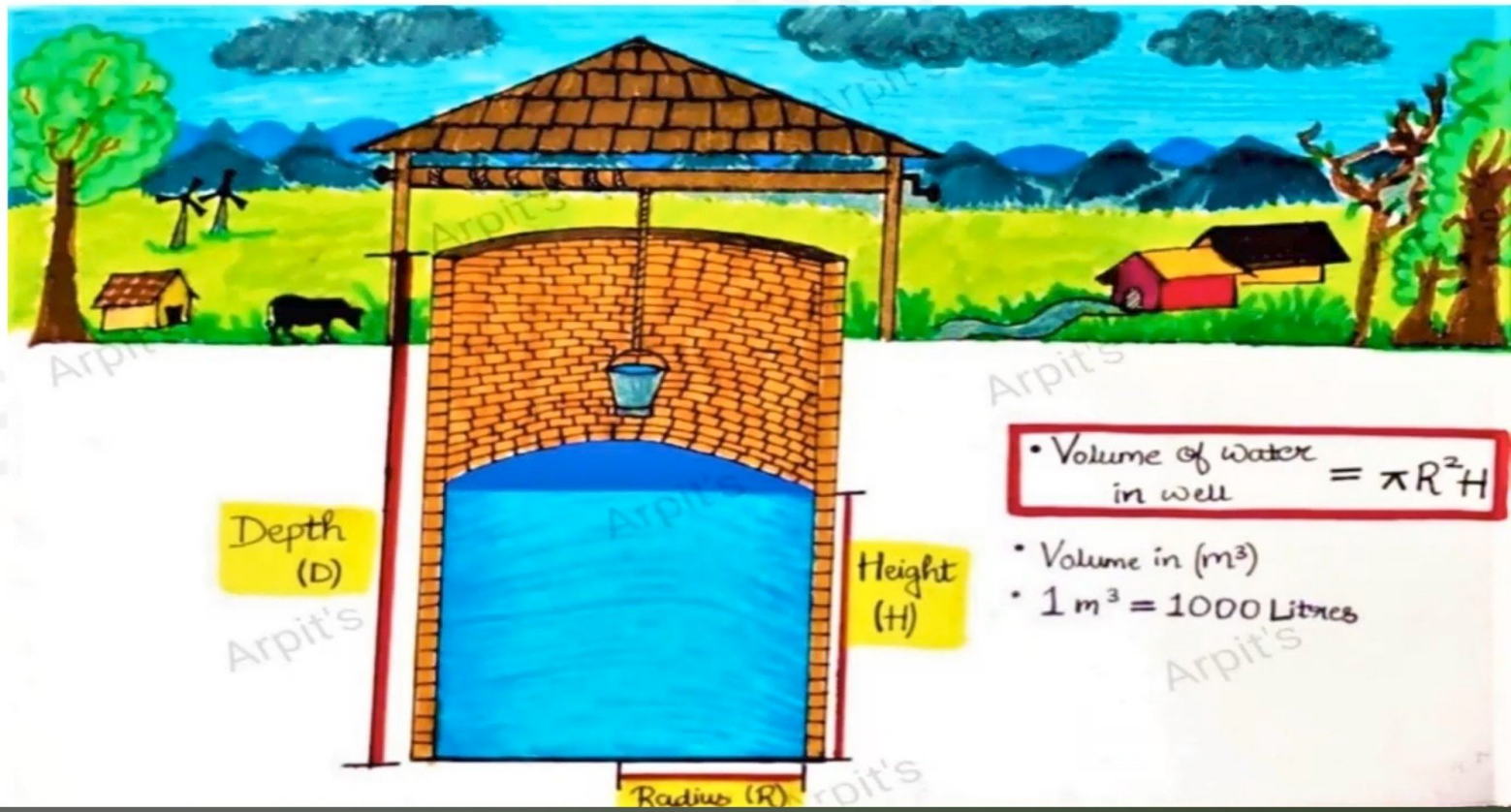
1. **Find volume of water in a well**
2. **Find the amount of bleaching powder**
3. **Dissolve bleaching powder in water**
4. **Delivery of chlorine solution into the well**
5. **Contact period**
6. **Orthotolidine Arsenite test**



1. Find volume of water in a well

Volume = $\pi R^2 H$ (in m^3)

- **1 m^3 = 1000 litres**



2. Find the amount of bleaching powder

- Estimate the **chlorine demand** of well water by **Horrock's Apparatus** & calculate the amount of bleaching powder required to disinfect the well

❖ ***Horrock's Apparatus***

- ***Estimates - chlorine demand of water***
- **Content**- **6 white cups** (200ml), **1 black cup**, **2 metal spoons**, **7 glass stirring rods**
- **Indicator**- **starch iodide** (produce **blue color**)
  - Here development of blue color indicates the presence of **residual chlorine**

Chlorine demand (dose of bleaching powder required) **= n x 2 gm to disinfect 455 litres of water**

(n - number of the **1st cup** which shows blue color change)

3. Dissolve bleaching powder in water

- Required amount of **bleaching powder** is kept in a bucket
- Water is added to make a **thin paste**
- More water is added to fill **¾ of bucket**
- Contents are **stirred** & allowed to **sediment** .
- When lime settles down, the **Supernatant Solution** viz. chlorine solution is **transferred** to another bucket & lime is discarded

4. Delivery of chlorine solution into the well

- Bucket containing chlorine solution is lowered **below the water surface** & well water is **agitated** by moving bucket vertically & horizontally

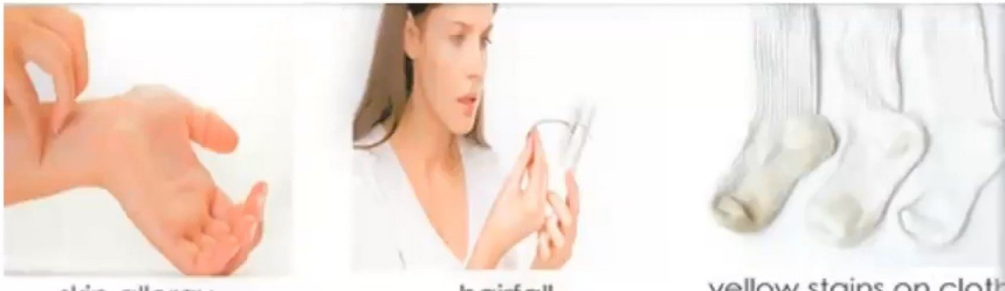
5. Contact period

- Contact period of **1 hour** is allowed before the water is drawn for use

6. Orthotolidine Arsenite test

- To test for free residual chlorine at the end of 1 hour contact, which should be **0.5mg/ L**

8- Hardness of Water



Hardness of Water

Definition - **Soap destroying power** of water

Classification [**CAR** wali **Temporary**, **NON-CAR** wali **Permanent**]

1. **Carbonate hardness**
   - ***Temporary hardness***
   - ***Due to presence of Calcium & Magnesium Bicarbonates***

2. **Non-carbonate hardness**
   - ***Permanent hardness***
   - Due to presence of **Calcium & *Magnesium Sulphates, Chlorides & Nitrates***

Unit

- Expressed in terms of **m Eq/ L** (mili equivalent per litre)
- ***1 mEq / L = 50 mg $CaCO_3$ in 1 litre of water***

Classification of Hardness in water

Classification	Level of Hardness (mEq / L)	Level of Hardness (mg / L)
1. Soft water	< 1	< 50
2. Moderately hard water (Drinking water should be moderately hard)	1 - 3 (Softening of water is recommended at hardness > 3 mEq / L or 150mg/ L)	50 – 150
3. Hard water	3 - 6	150 - 300
4. Very hard water	> 6	> 300

Advantages

- There is an inverse association between hardness of drinking water & Cardiovascular disease

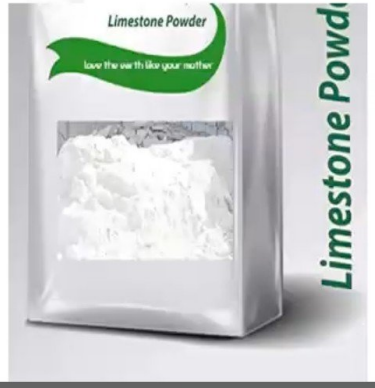
Disadvantages

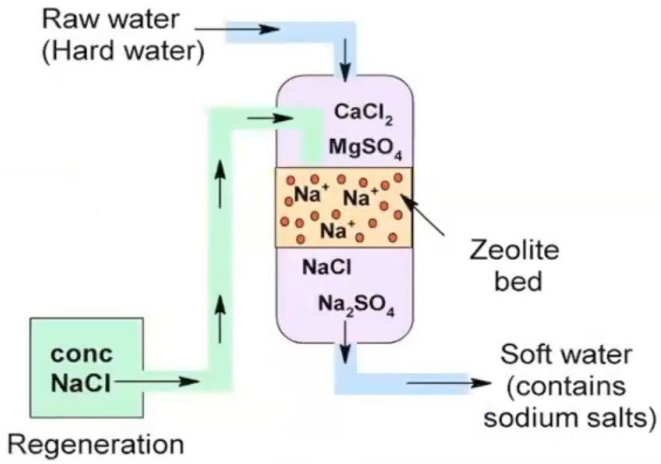
- Consumes more soap & detergents
- Scaling of boilers
- Shortens life of Fabrics & supply pipes (by erosion)

Methods of removal of hardness of water

[LBW – (W is 3) - LB3]

1. ***Temporary hardness removed by***
   - i. ***Boiling***
   - ii. ***Addition of Lime***
   - iii. ***Addition of Sodium Bicarbonate***
   - iv. ***Base exchange process / Permutit process***
2. ***Permanent hardness removed by***
   - i. **Addition of Sodium Bicarbonate**
   - ii. ***Base exchange process / Permutit process***





- **Boiling**

  - Precipitates the insoluble calcium carbonate

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + C0_2$$

- **Addition of Lime**

  - Lime absorbs carbon dioxide & precipitates the insoluble calcium carbonate

$$Ca(OH)_2 + Ca(HCO)_3 \rightarrow 2CaCO_3 + 2H_2O$$

❖ **Clarke's method** - **1 ounce of lime** added to **700 gallons of water** for **each degree** of hardness **[hard cLarke – L – 7 - 700]**

- **Addition of Sodium Bicarbonate**

  - Sodium bicarbonate (**soda ash**) removes both **temporary** & **permanent hardness**

$$Na_2CO_3 + Ca(HCO_3)_2 \rightarrow 2NaHCO_3 + CaCO_3$$

$$Na_2CO_3 + CaSO_4 \rightarrow CaCO_3 + Na_2SO_4$$

- ***Base Exchange Process / Permutit Process***

  - **Sodium Permutit** a complex compound of ***Sodium, Aluminum & Silica*** ($Na_2 Al_2 Si_2O H_2O$) has the property of **exchanging sodium cation** for **calcium** & **magnesium ions**

  - By this process water can be softened to **zero hardness**

  - Water with zero hardness is corrosive so

    a part of **raw water** is mixed to secure desired hardness