❑ Water Supply Engineering

- The branch of Civil Engineering which deals with the supply of water for various purposes e.g., domestic, industrial, commercial and public is called **water supply engineering**. In this engineering a scheme is constituted which is known as **water supply scheme.**
- The branch of environmental engineering which deals with the study of design and construction of structures related to collection, conveyance, treatment and distribution of potable water (water which is safe to drink) towards public is called **Water supply engineering.**

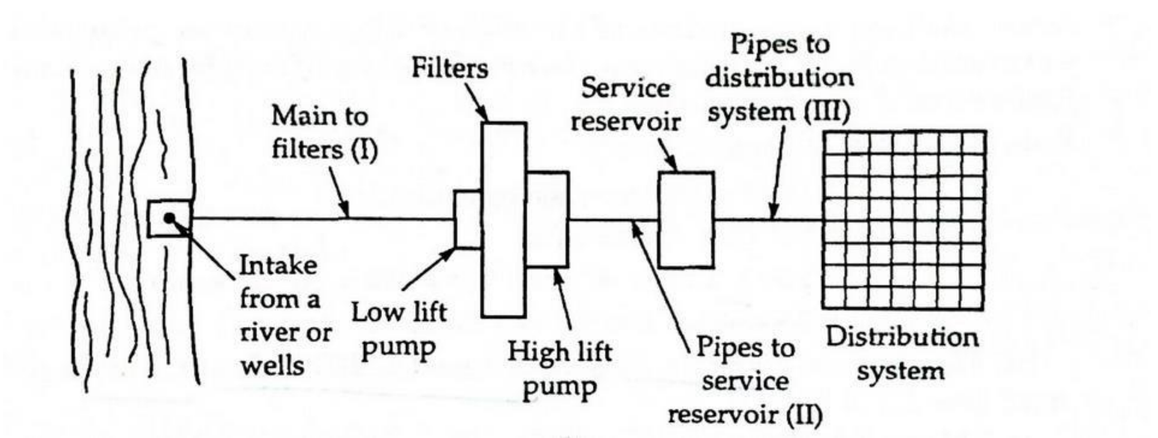


Fig 1. Layout of Water supply scheme

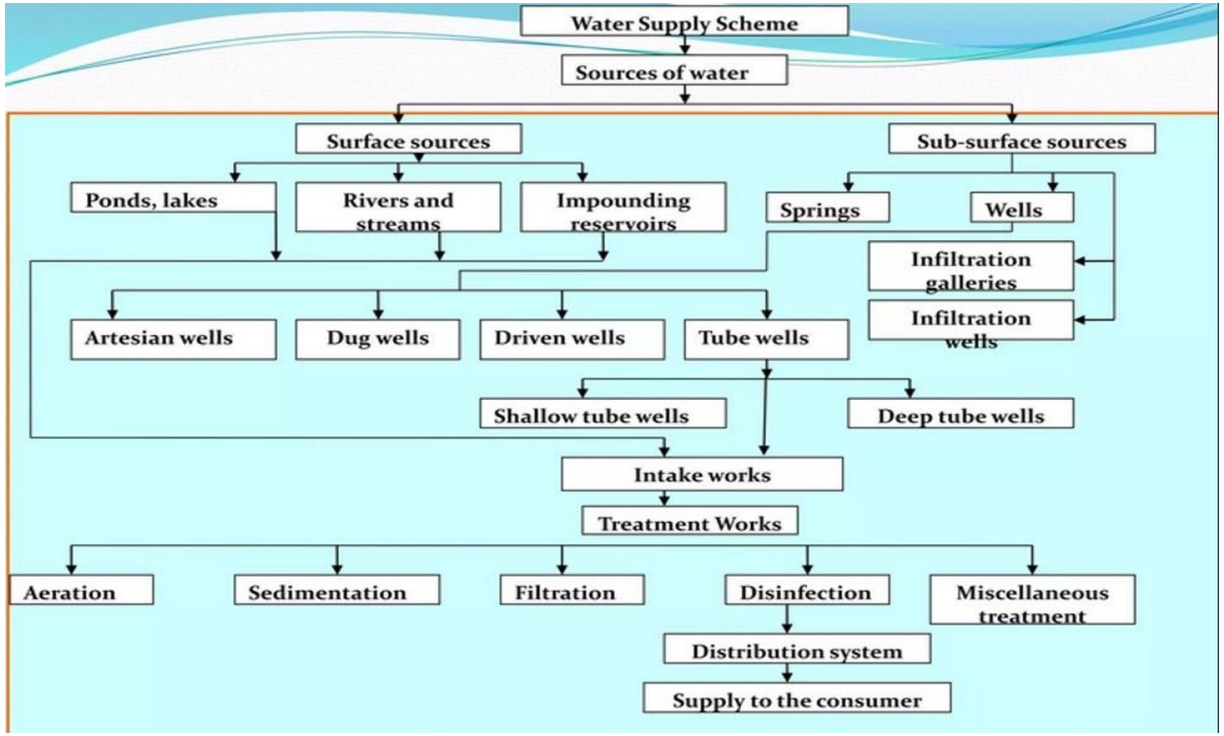


Fig 2. Schematic diagram of typical water supply scheme

❑ Hydrological cycle/Water cycle

- **Hydrology** is the science which deals with the occurrence, distribution and movement of water on the earth, including that in the atmosphere and below the surface of earth.
- **Hydrologic cycle or water cycle** is the process of transfer of moisture from atmosphere to the earth in the form of precipitation, and movement of the precipitated water by streams and rivers to oceans and lakes etc., and evaporation of water back to the atmosphere.

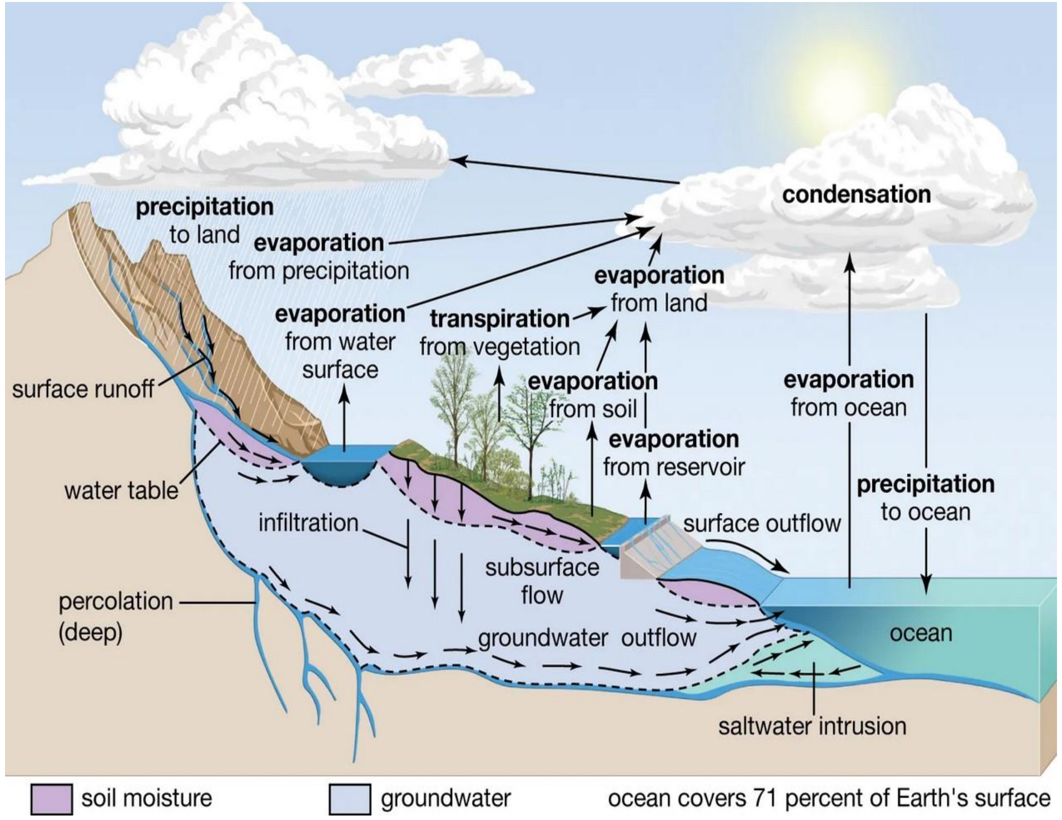


Fig 3. Water supply scheme

❑ Quantity of Water

- Any sample of water collected from natural source and is not being subjected to artificial (man-made) treatment is termed as raw water.
- The quantity of water required depends upon the two important factors

1. The probable population estimated at the end of the design period
2. Rate of water consumed per capita per day

Before designing raw water scheme following terms should be known

1. The amount of water required in a community in one year is called **Annual draft (V).** It is analysed on the basis of observations.
2. Total amount of water required in a community in one day is called **annual average daily draft** (V/365)
3. Total amount of water required in the community in one day by one individual is called as **Annual average per capita daily draft** (V/(365.P))

where P : Present population of community

❑Various types of Water Demand (As per IS: 1172-2002)

1. Domestic Water Demand (135 -225 lpcd)

- The amount of water required in the community to satisfy domestic needs such as drinking, cooking, washing, bathing, gardening, sanitary purposes etc.
- The total domestic water demand amounts to approximatley 50-60% of the total water demand.
- For a city with full flushing system the value is 200 lpcd
- For LIG families the value can be minimized upto 135 lpcd

Different Uses	Consumption (lpcd)
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Washing and cleaning of houses	10
Flushing of water closets etc.	30
Total	135

Table showing Minimum domestic water consumption (Annual Average

2. Industrial Water Demand (50-450 lpcd)

- Industrial water demand represents the water demand of industries, which are either existing or likely to be started in future, in the city for which water supply is being planned.
- On an average, 20-25% of total water demand may be allowed for industrial water demand in designing water supply scheme.
- The impact of this demand over the total demand is comparatively more.

The following table shows the water requirements for industries or factories:

Name of Industry	Unit of Production	Approximate quantity of water required per unit of production
1. Automobiles	Vehicle	40
2. Fertilizers	Tonne	80 – 200
3. Leather	Tonne (or 100 kg)	40 4
4. Paper	Tonne	200 – 400
5. Petroleum Refinery	Tonne (crude)	1 – 2

3. Institutional and Commercial Water Demand (20-50 lpcd)

- The quantity of water consumed in office buildings, hospitals, hotels, hostels, schools, colleges, cinema halls etc. is called as commercial water demand.
- On an average, per capita demand of 20 lpcd is required to meet institutional and commercial water demand. For highly commercialized cities, this value can be 50 lpcd.

Type of buildings	Water requirements in liters per day
Cinema and concert halls	15 per seat
Hospitals with less than 100 beds	340 per bed
Hospitals with more than 100 beds	450 per bed
Hotels	180 per bed
Hostels	135 per head
Offices	45 per head

4. Fire Demand

- It is the quantity of water required in case a fire breaks out.
- The quantity of water required for extinguishing fire is not very large. For a total amount of water consumption for a city of 50 lakh population, it hardly amounts to 1 lpcd of fire demand, but this water should be easily available and kept in storage reservoirs, as quantity of water required is in very less duration.
- The water required to satisfy the fire demand is being utilized from FIRE HYDRANTS
- Fire hydrant is provided in water main (pipe) at the spacing of 100-150 m and the minimum water pressure required to be provided at these hydrants is 100-150 kN/m2 (10-15m) and should be maintained for about 4-5 hr

❑ **Fire Demand Empirical formulas**

National board of writers' formula

$$Q = 4640\sqrt{P}\left(1 - 0{\cdot}01\sqrt{P}\right)$$

(2) Freeman's formula

$$Q = 1135{\cdot}5\left(\frac{P}{10} + 10\right)$$

(3) Kuichling's formula

$$Q = 3182\sqrt{P}$$

(4) Buston's formula

$$Q = 5663\sqrt{P}$$

where Q = Quantity of water (in litre/minute)

and P = Population of town (in thousands)

5. Water for Public Use

- It is the quantity of water required for public utility purposes e.g., washing of roads, cleaning of sewers, flushing of streets, water for public parks etc.
- It is taken to be 5-6 % of total water demand.

6. Losses and Theft

- It is amount of water wasted out due to leakages and theft in water supply scheme such as unauthorized water connections, bad plumbing which leads to leakages from joints and fittings, damaged meters and leaving public taps open
- It may extend up to 10-15 % of total water demand.

	lpcd
Domestic water demand	135-225
Industrial water demand	50-450
Commercial and Institutional demand	20-50
Water for public use	10-20
Fire Demand	1
Losses and theft	10-15% of total demand

TOTAL DEMAND: 250-350 (335 lpcd)

❑ Factors affecting per capita demand

1. **Size of city** : Bigger is the size of city, more is the water demand as more water will be required for public uses and more losses will be observed
2. **Extent of industrialization:** More is the extent of industrialization, more is the water demand (industrial)
3. **Living standards/ Types of gentry** : Higher is the living standard, more is the water demand (domestic)
4. **Climatic Conditions:** Warmer is the climate, more is the water demand (domestic)

   Note: Climatic conditions of a community depends upon its locations (latitude)

5. **Cost of water/ Metered Water**: Higher is the cost of water, lesser is the consumption
6. **Quality of water:** Better is the quality of water, higher is the consumption
7. **Pressure in the distribution system:** Higher is the pressure, more is consumption of water
8. **Types of distribution system:** If water supply is continuous, wastage in general is observed to be more than intermittent system
9. **Types of sewerage system:** The water consumption will be more, if the city is provided with “full flush system” and water consumption will be less if the old conservation system of latrines is adopted.

❑ Design Period

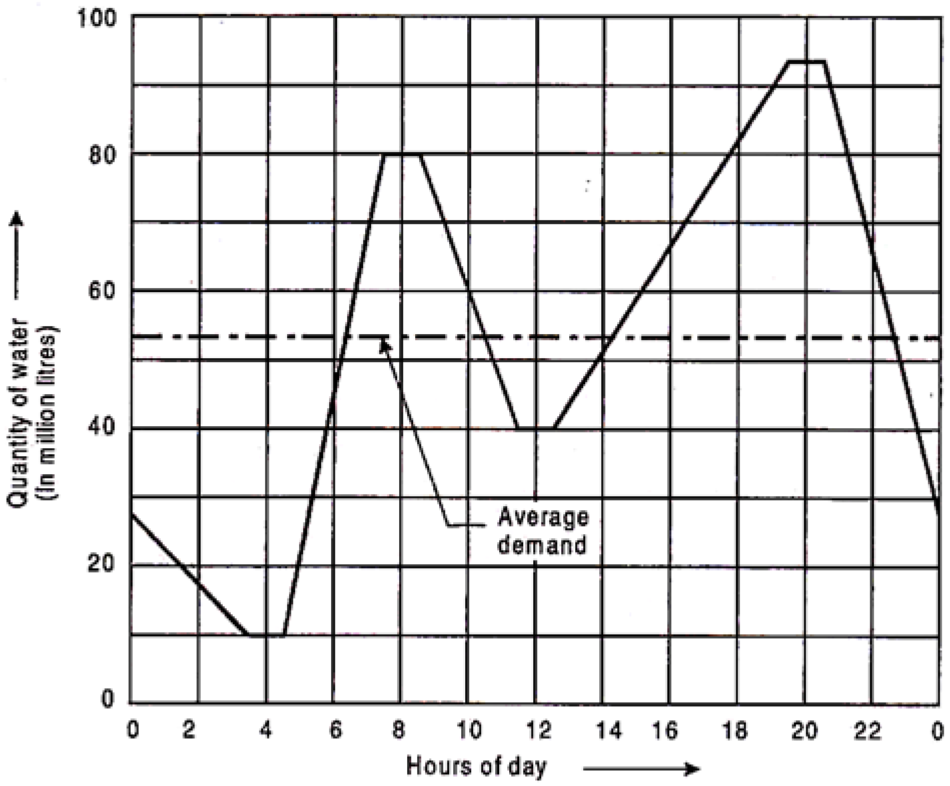
- The future period or the number of years for which the water works are designed is known as design period
- Design period should neither be too long, nor should it be too short and it should not exceed the useful life of the component structure.
- Water supply projects under normal circumstances, may be designed for a design period of 30 years.

Component	Design period
Storage reservoir	50 years
Infiltration works	30 years
Pipe connections	30 years
Distribution systems	30 years
Water treatment units	15 years
Electric motors and pumps	15 years

❑ Variation in demand

- Designing of raw water supply scheme is not done based on annual average daily demand as it would not be capable of fulfilling the demand when it is more than average.
- Hence variation in water demand must be known to an engineer.
- Variation of demand can be classified into following categories

1. **Seasonal variation**
2. **Weekly variation**
3. **Daily variation**
4. **Hourly variation**



The demand of water also varies from hour to hour of the day. A typical graph showing the hourly variation in the rate of demand of water (expressed in million litres per head per hour) is shown in Fig. It may be seen from the graph that the peak or maximum demand of water usually occurs in the morning from about 7 a.m. to 9 a.m. and in the evening from about 7 p.m. to 9 p.m.

- **Normal variations**

1. Maximum daily demand = 1.8 x Annual average daily demand
(Demand of that day in a year which is maximum is termed as maximum daily demand)
2. Maximum Hourly Demand of Water = 1.5 x Average hourly demand of the maximum day

3. Maximum Weekly demand = 1.48 x Average weekly
4. Maximum Monthly Demand = 1.28 x Average monthly

- Coincident Draft

Maxmium of 1. Maximum daily demand + fire demand or 2. maximum hourly demand

Population Forecasting

- Population in any community depends upon

1. Death rate
2. Birth rate
3. Migration rate

- The death rate reduces with the development and advancement of medical facilities.
- The birth rate may also decrease with the increase in education standards, awareness and development of community
- The migration rate depends upon the extent of industrialization and commercialization of community.
- Population also depends upon the annexation of territory.

Population Forecasting methods

1. **Arithmetic Increase Method** : In this method the rate of growth of population is assumed to be constant ie.,

In this method an average of increase in population is considered over the present population to forecast the future population.

Types of population forecasting methods

1. Arithmetical increase method
2. Geometrical increase method
3. Incremental increase method
4. Decreasing rate of growth method
5. Simple graphical method
6. Comparative graphical method
7. Zoning method or master plan method

Arithmetical increase method

- This is the most simple method of population forecast and is based on the assumption that the population is increasing from decade to decade at a constant rate.
- dp/dt = C

Where,

dp/dt is the rate of change of population.

- The population at the end on 'n' decades is given by:

  $$P_n = P + ni$$

Where,

P_n = population after 'n' decades.

P = Present population

i = average increase per decade

n = number of decades

Geometrical increase method

- *In* this method it is assumed that the percentage increase in population from decade to decade is constant. From the population data of previous three to four decades, the percentage increase on population is found and its average is found.
- The population at the end on 'n' decades is given by:

  $$P_n = P\,[1+(r/100)]^n$$

Where,

P_n = population after 'n' decades.

P = Present population

r = average incremental increase

n = number of decades

Incremental Increase method

- The average increase in population is determined by the arithmetical increase method and to this as added the average of the net incremental increase once for each future decade.
- The population at the end on 'n' decades is given by:

$$P_n = P + ni + [\{n(n+1)r\}/2]$$

Where,

P_n = population after 'n' decades.

P = Present population

i = average increase per decade

r = average incremental increase

n = number of decades

Decreasing rate of growth method

- In this method, the average decrease in the percentage increase is worked out , and is then subtracted from the least percentage increase for each successive decades.

Simple graphical method

- In this method, a curve is plotted between the population p and time T, with the help of of census data of previous few decades. The curve is smoothly extended to forecast the future population.

Graphical comparison method

- In this method, the cities having conditions and characteristics similar to the city whose future population is to be determined are first of all selected. It is then assumed that the city under consideration will develop as the selected similar cities have developed in the past.

Zoning method or master plan method

- The city and town are divided into various zones such as commercial, industrial, residential etc. The future expansion of cities is strictly regulated by various bye-laws of corporation and other local bodies.
- The population of a particular zone is fixed and according to that the water supply schemes are designed.

2. **Geometrical Increase method/ uniform increase method/compounding method**

- In this method the percentage rate of growth of population is assumed to be constant i.e.,

- The constant percentage rate of growth is compounded over the present population to forecast the future population.

- Note:1. As per GOI manual use GM Method to compute %r
- 2. AM > GM

3. Incremental Increase method

- In this method the rate of growth of population is not assume to be constant, it may either increase or decrease as per the past data.
- In this method an average incremental increase in population is considered over the increase in population to forecast future population.

NOTE:

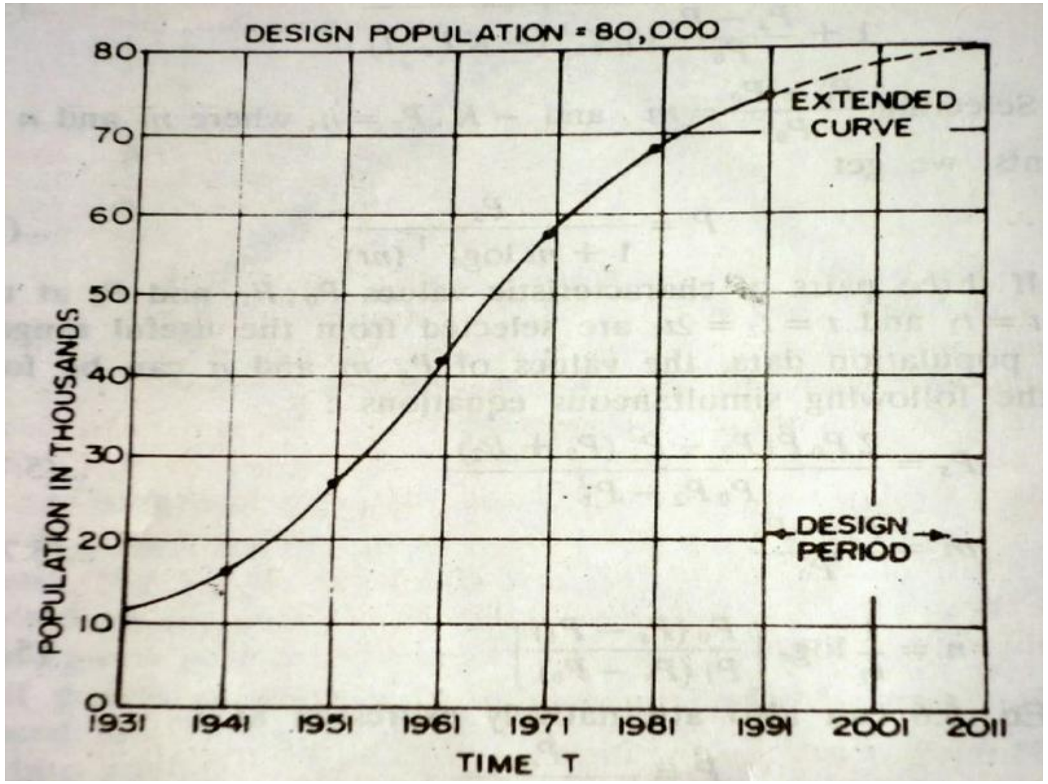
- Out of all the above three, geometric increase method gives highest values of population forecasted, hence is suitable for YOUNG CITY/NEW BUILT CITY, in which in actual % rate of growth increases with time and there is vast scope of future expansion.
- Arithmetic increase method gives LOWEST Value of population forecasted , hence is suitable to be used for very old city, in which %rate of growth decreases with time.
- Incremental increase method gives intermediate result and is suitable to be used for OLD CITY.

4. **Decreasing rate of growth method**

- In this method an average of % decrease in rate of growth of population is considered in order to find the future population.
- This method is suitable to be used for very old city, in which in actual %rate of growth decreases with time.

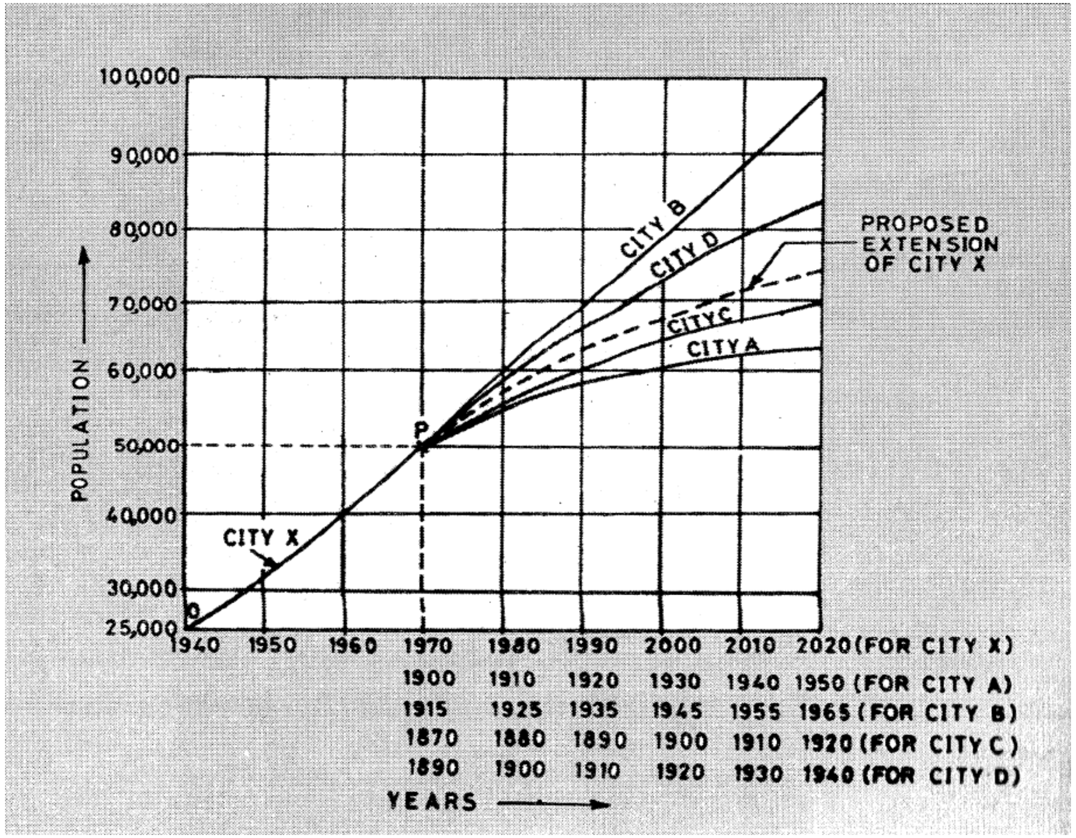
5**. Graphical Extension Method**

- In this method a graph is plotted from the available data between time and population
- The curve is then smoothly extended up to the desored year
- This method gives very approximate result and is dependent upon the experience of designer.



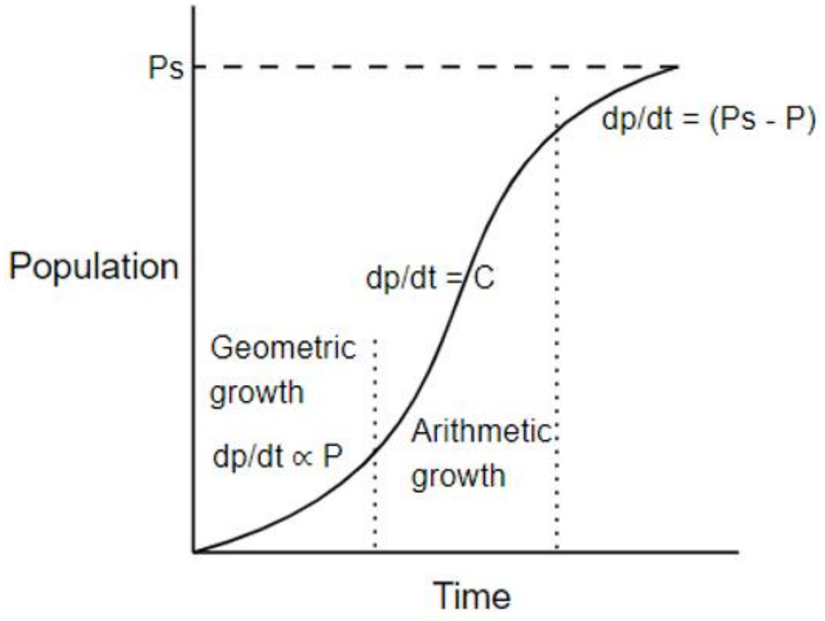
6. **Comparative Graphical Method**

- In this method, the cities of similar condition and characteristics (migration, development activities etc.) are selected, which have grown in similar fashion in the past and their graph are plotted. This method gives satisfactory result.
- Comparative Graphical method is more accurate as compared to simple graphical method.



❑ Logistic Curve

- Logistic curve is an S-shaped curve that is used to model population forecasting that increases initially, rapidly then and slowly later and levels off or reached a saturation value after a period.
- In an ideal environment, populations grow at an exponential rate. The growth curve of these populations is smooth and becomes increases steeply over time. However, exponential growth is not possible because of factors such as limitations in food, competition for other resources, disease etc. Populations eventually reach the carrying capacity or saturation capacity of the environment, causing the growth rate to slow nearly to zero. This produces an **S-shaped curve** of population growth known as the logistic curve.



Introduction

- The quality of drinking water is a powerful environmental **determinant of health**.

- Assurance of *drinking water safety* is a **foundation** for the prevention and control of waterborne diseases.

- Hence, a **guidelines** developed by WHO through a vast global consultative process has been introduced for member states to adhered to.

WATER QUALITY PARAMETERS

- Water quality is one of the most important factors in a healthy ecosystem. Clean water supports a diversity of plants and animals.

- The quality of the water you consume or use in municipal or industrial processes must meet specific parameters to ensure that drinking water remains free from contaminants that could cause health issues.

- Water quality measurement include ***physical***, ***chemical*** and ***biological*** parameters.

Physical Water Quality Parameters

I. Turbidity

II. Temperature

III. Colour

IV. Taste and Odour

V. Solids

VI. Electrical Conductivity

I. Turbidity

- Turbidity refers to how cloudy or opaque water is.
- High levels of turbidity can occur as a result of higher concentrations of silt, clay, and organic materials.
- High turbidity can cause **increase water temperatures** because suspended particles absorb more heat and can also **reduce the amount of light** penetrating the water.
- Turbidity can act as a shield for harmful microorganisms, which makes it more difficult to get rid of these contaminants.
- Suspended materials may damage fish gills, reduce growth rates, and decrease resistance to diseases

II. Temperature

- Water temperature affect the ability of water to hold oxygen.
- The rate of photosynthesis by aquatic plants and the metabolic rate of aquatic organisms cause change in temperature.
- Other causes of temperature change include:
  - ✓Weather
  - ✓Removal of shading stream- bank vegetation
  - ✓Impoundments
  - ✓Urban- storm water
  - ✓Ground water in-flows to the streams.
- The ideal water temperatures range from 50 - 60 degrees Fahrenheit.

III. Colour

- The colour of the water can be altered by materials that decay from organic matter, the primary of which include vegetation. Eg. Tannin.

- Fulvic acid and humic acid contributes to the brownish colour of a water.

- To identify the color of water, it's important to understand the difference between the water's apparent color and its true colour.

- Changes to a water's color don't change how the water tastes.

NB: Pure water contains no color units because it is essentially colourless.

IV. Taste and Odour

- It's possible for the taste of water to change and for odours to develop as a result of foreign matter being introduced to the water.

- This matter can include organic materials, dissolved gases, and inorganic compounds.

- Most of this matter is derived from agricultural, natural, and domestic sources.

NB: Pure water is tasteless and odourless

V. Solids

- Solids can be in suspension or in solution (Total Dissolved Solids) when they get into the water.

- It is highly dependent on the flow of the water and usually increases during and immediately after rain events.

- As the sediments settle-out of the water, aquatic habitat are often destroyed.

- The three different water classifications for TDS include:
  - ✓Freshwater: less than 1,500 mg/L TDS
  - ✓Brackish water: 1,500 - 5,000 mg/L TDS
  - ✓Saline water: more than 5,000 mg/L TDS

VI. Electrical Conductivity

- How well a sample of water can carry or conduct electrical current determines its' contamination levels.
- Conductivity levels will increase as the amount of ions in the water increases.
- High conductivity means that the water contains a high amount of contaminants.
- Potable water and ultra-pure water are practically unable to conduct an electrical current.

Chemical Parameters of Water Quality

I. pH
II. Acidity
III. Alkalinity
IV. Chlorine
V. Hardness
VI. Dissolved Oxygen
VII. Biological Oxygen Demand

I. pH

- pH is the term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0.
- The pH of water is measured with a simple pH sensor or test kit
- Any readings below 7.0 are acidic, while any readings above 7.0 are alkaline. Pure water has a neutral pH (7.0).
- Water is considered to be safe to drink if it has a pH of 6.5 to 8.5.
- High alkalinity or acidity, indicates that the water is contaminated in some way.

pH cont…

- The many effects that changing pH levels can have on plants and animals include:

✓ slight changes could worsen quality of life of majority of aquatic plants and animals.

✓ Slightly acidic water can irritate fish gills, damage membranes, and reduce the number of hatched fish eggs.

✓ extremely high or extremely low pH is fatal to aquatic plants and animals.

✓ Low pH can kill amphibians because their skin is sensitive to contaminants.

II. Acidity

- This refers to the measure of how much acids are in a specific solution.

- Water is acidic when it has a pH lower than 7.0

- Acidity is commonly caused by the presence of ***mineral acids***, ***hydrolyzed salts***, and ***carbon dioxide***.

- Acidity can influence many different processes, which include everything from biological activities and chemical reactions to corrosion.

III. Alkalinity

- Water is alkaline when it has a pH that's at least higher than 7.0
- The presence of ***bicarbonate ions***, ***carbonate ions***, and ***hydroxide ions*** increases the alkalinity of water.
- The most common reason to measure the alkalinity of a sample of water is <u>*to identify how much **soda** and **lime** must be added to the water*</u> for water softening purposes.
- The water softening process is particularly beneficial for mitigating corrosion in boilers.

IV. Chlorine

- Chlorine doesn't occur naturally in water, it's commonly added to water for disinfection purposes.
- Even though base chlorine is a toxic gas, the aqueous solution is completely harmless to humans.
- A small amount of chlorine found in water indicates that the water is clean and essentially free from contaminants.
- Chlorine residual is measure with a spectrophotometer or color comparator test kit.

V. Hardness

- Hardness occurs when water contains high mineral levels.
- Hardness in water is mainly caused by the presence of magnesium and calcium ions, which can enter water from rock and soil.
- Groundwater has more hardness to it than surface water.
- Hardness in water is measured with a colorimeter or test strip.
- Hard water could create scale deposits on hot water pipes and difficult to produce a lather with the soap

VI. Dissolved Oxygen

- This is a critical water quality parameter that can help you determine how polluted rivers, lakes, and streams are.
- When water has a high concentration of dissolved oxygen, you can be confident that the water quality is high.
- Dissolved oxygen in water depends on numerous factors, including the *water's* ***salinity***, ***pressure***, *and* ***temperature***.
- It's possible to measure dissolved oxygen levels with a colorimeter or with the electrometric method.

VII. Biological Oxygen Demand (BOD)

- Microorganisms like bacteria use organic matter as a source of food.

- A substantial amount of organic matter in the water means high amounts of dissolved oxygen will be consumed in order to make sure that the organic matter decomposes.

- However, this creates problems since aquatic plants and animals require dissolved oxygen to survive.

- You can measure biological oxygen demand with the dilution method.

NB: If the BOD levels are high, the water is contaminated.

Biological Parameters of Water

I. Bacteria

II. Algae

III. Viruses

IV. Benthic macro invertebrates

V. Sub-merged aquatic vegetables

I. Bacteria

- Bacteria are microscopic organisms not visible with the naked eye and can live in a variety of environment.
- With an ideal water pH, food supply, and right temperature; bacteria can reproduce at rapid rate.
- In most cases, bacteria will reproduce at a slow rate in colder water.
- High amounts of bacteria in water can cause waterborne diseases. Eg. Cholera and typhoid.

II. Algae

- Algae are tiny, microscopic plants that consist of photosynthetic pigments (chlorophyll).
- Chlorophyll allows plant including **algae** to convert sunlight into organic compounds through photosynthesis.
- Excessive amount of chlorophyll indicates the presence of undesirable algae blooms which is not consume by fish and other predators.
- Unconsumed algae sink to the bottom and decay; **depleting deeper water oxygen.**
- The main issues caused by algae include strange odour and poor taste problem.

III. Viruses

- Viruses are tiny biological structures that can be harmful to a person's health.
- Water-transmitted viral pathogens of public health importance include adenovirus, astrovirus, hepatitis A and E viruses, rotavirus and norovirus
- Because of how small viruses are, they are able to pass through the majority of filters.
- Most water treatment facilities should be able to eliminate viruses during the disinfection process.

IV. Benthic macro invertebrates

- Benthic refers to the bottom of a water way.

- They are aquatic organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate). Eg. insects in their larvae or nymph forms, crayfish, clams, snails and worms.

- Some are more sensitive to pollution than others. Therefore, if a stream site is inhibited by organism that can tolerate pollution and the more pollution sensitive organisms are missing the pollution problem is likely.

V. Sub-merged aquatic vegetables

- It consists of a taxonomically diverse group of plants that lives entirely beneath the water surface.
- This provide food and shelter to fish and invertebrates as well as produces oxygen, traps sediments and absorb nutrients.
- SAV helps increase water clarity and reduce the amount of pollution entering the waterways through sediment erosion.

In conclusion…

- Understanding the three primary types of water quality parameters may prove useful when you want to treat water and remove the many contaminants that can be found in water.

- Whether your water has high turbidity, a low pH, or ample bacteria, there are an array of solutions that you can use to eradicate these issues for good.

W.H.O standards for drinking water in Ghana

- The development of global guidelines ensuring the appropriate use of evidence represents one of the core functions of WHO.

- A WHO guideline is defined broadly as any information product developed by WHO that contains recommendations for clinical practice or public health policy.

- WHO produces international norms on water quality and human health in the form of guidelines that are used as the basis for regulation and standard setting, in developing and developed countries worldwide.

W.H.O standards for drinking water in Ghana with respect to some chemical substance.

Substance	Maximum acceptable concentration (Mg/L)	Maximum allowable concentration (Mg/L)
Iron (Fe)	0.3	1.0
Manganese (Mn)	0.1	0.5
Calcium (Ca)	75.0	200
Magnesium (Mg)	50.0	150.0
Chlorine (Cl)	200.0	600.0
Copper (C)	1.0	1.5
Zinc (Zn)	5.0	15.0
Sulphate (SO4)	200.0	400
Lead (Pb)	0.0	0.05
Mercury (Hg)	0.0	0.001

pH, turbidity, colour, taste and odour standards

Quality	Maximum acceptable level	Maximum allowable value
pH range	7 – 8.5	6.5 – 9.5
Turbidity	5 NTU (Nephelometric Turbidity Unit)	25 NTU
Colour	5 Hazen units	50 Hazen units
Taste	Unobjectionable	Unobjectionable
Odour	Unobjectionable	Unobjectionable

Quality criteria of drinking water

1. Drinking water must be free from organisms which might be injurious to health
2. It must be free from chemical substances which might be injurious to health
3. Drinking water should be of such composition that consumers will not question its safety.
4. Drinking water should be suitable for house keeping.
5. Drinking water should not be aggressive to materials like lead, cupper, asbestor concrete, galvanize steel, etc.

Treatment Processes for Water

Syllabus

- Treatment processes for water: Treatment of water – types of impurities in water, treatment processes for their removal, typical flow – sheets, primary, secondary and tertiary treatments, options, mechanisms, parameters treated, treatment efficiencies, design of various units, disposal, limitations of conventional treatment.

Water Pollution

- Water Pollution can be defined as alteration in physical, chemical, or biological characteristics of water through natural or human activities and making it unsuitable for its designated use.
- Fresh Water present on the earth surface is put to many uses. It is used for drinking, domestic and municipal uses, agricultural, irrigation, industries, navigation, recreation. The used water becomes contaminated and is called waste water.

Water Quality Standards

- The definition of water quality depends on the intended use of the water which may be either human consumption or it may be for industries, irrigation, recreation etc..
- Depending upon the proposed use of water, certain water quality criteria are established and based on these criteria quality standards are specified by health and other regulation agencies.
- Different types of water require different level of water purity.
- Drinking water requires highest standard of purity where as water of lower quality

INDIAN STANDARD SPECIFICATIONS FOR DRINKING WATER IS: 10500

S.NO.	Parameter	Requirement desirable Limit	Remarks
1.	Colour	5	May be extended up to 50 if toxic substances are suspected
2.	Turbidity	10	May be relaxed up to 25 in the absence of alternate
3.	pH	6.5 to 8.5	May be relaxed up to 9.2 in the absence
4.	Total Hardness	300	May be extended up to 600
5.	Calcium as Ca	75	May be extended up to 200
6.	Magnesium as Mg	30	May be extended up to 100
7.	Copper as Cu	0.05	May be relaxed up to 1.5
8.	Iron	0.3	May be extended up to 1
9.	Manganese	0.1	May be extended up to 0.5
10.	Chlorides	250	May be extended up to 1000
11.	Sulphates	150	May be extended up to 400
12.	Nitrates	45	No relaxation
13.	Fluoride	0.6 to 1.2	If the limit is below 0.6 water should be rejected, Max. Limit is extended to 1.5
14.	Phenols	0.001	May be relaxed up to 0.002
15.	Mercury	0.001	No relaxation

S.NO.	Parameter	Requirement desirable Limit	Remarks
15.	Mercury	0.001	No relaxation
16.	Cadmium	0.01	No relaxation
17.	Selenium	0.01	No relaxation
18.	Arsenic	0.05	No relaxation
19.	Cyanide	0.05	No relaxation
20.	Lead	0.1	No relaxation
21.	Zinc	5.0	May be extended up to 10.0
22.	Anionic detergents (MBAS)	0.2	May be relaxed up to 1
23.	Chromium as Cr^{+6}	0.05	No relaxation
24.	Poly nuclear aromatic Hydrocarbons	--	--
25.	Mineral Oil	0.01	May be relaxed up to 0.03
26.	Residual free Chlorine	0.2	Applicable only when water is chlorinated
27.	Pesticides	Absent	--
28.	Radio active	--	--

Quality of Water

- Parameters of water which are required to be tested for determining the quality of water can be divided into
- Physical
- Chemical
- Microbiological

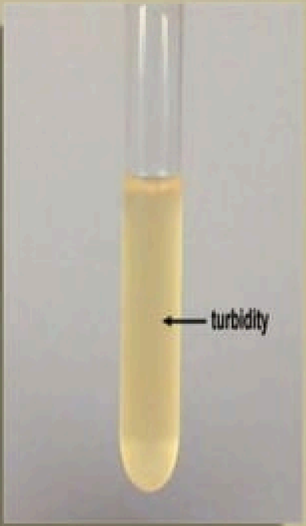
Physical Parameters

It includes

- Turbidity
- Color
- Odour
- Taste
- Temperature

Turbidity

- It is the large amount of suspended matter such as clay, silt, some other finely divided organic matter present in the water, it will appear to be muddy or cloudy or turbid in appearance.
- Turbidity is measured by turbid meter and is expressed in mg/l



Color

- Dissolved organic matter from decaying vegetation or some inorganic materials such as colored soils, may impart color to water. The excessive growth of algae also may impart color to the water.. The presence of color in water is not objectionable from health point of view, but may spoil the color of clothes being washed in it
- Color of water is measured by platinum cobalt scale It should not exceed 20 and should be less than 10

Taste And Odour

- The dissolved organic matter, inorganic salts, or dissolved gases may impart tastes and odours to the water, which generally occurs together.
- Taste and odour may be due to presence of dissolved gases such as H_2S, CH_4, CO_2, O_2, etc.. Some mineral substances like Iron, sulphates, may impart taste to water.
- For drinking purpose water should not contain any undesirable taste and odour.
- Taste of water should be agreeable to the consumers
- And odour of water is measured in terms of threshold odour number.
- For public supplies threshold odour no should be 1 and should not exceed 3.

Temperature

- Temperature of water has no practical significance however temperature of water should be above 10 ^{0} c while temperature above 25 ^{0}C are considered as objectionable.

Chemical Parameters

- Solids (Suspended, Dissolved, Volatile)
- Hardness
- Chlorides
- pH
- Dissolved gases like Oxygen, Carbon dioxide, Hydrogen supplied
- Nitrogen compound like Nitrates, Nitrites.
- Metals and other in organic substance like fluoride, iron, and manganese, lead, Arsenic, Iodide, Cadmium.

Microbiological Parameters

- It Includes various microorganisms i.e. bacteria, virus, protozoa, worms, present in water it may be pathogenic or non pathogenic

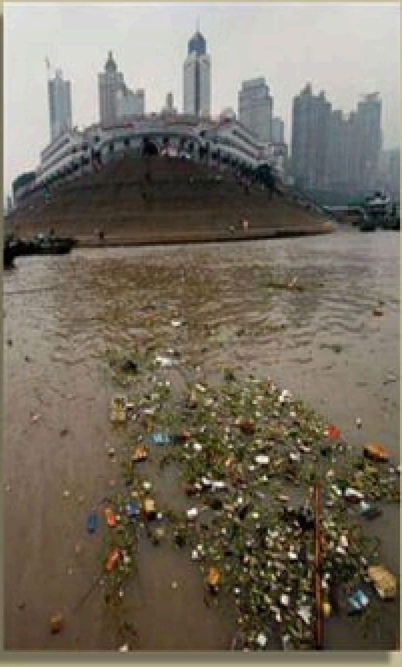
Sources of Water Pollution

- Most of Water Pollution is man made It may also occur naturally by addition of soil particles through erosion animal wastes and leaching of minerals from rocks
- The sources of water pollution can be classified as
  - Municipal Waste Water
  - Industrial Waste
  - Inorganic Pollutants
  - Organic Pollutants
  - Agricultural Wastes
  - Marine Pollution
  - Thermal pollution

Municipal Waste Water

- Municipal waste water includes domestic discharges and commercial and industrial waste water collected in public sewerage system. The sewage contain human and industrial waste water collected in public sewerage system. The sewage contain human and animal excreta, food residue, detergents, and other wastes. **It always contain organic matter, bacteria, and other biological Pollutants.**

Municipal Waste Water



Industrial Waste

- The major source of water pollution is the waste water discharged from industries and commercial bodies, these industries are **chemical, metallurgical, food processing industries, textile, paper industries.** They discharge several organic and inorganic pollutants. That prove highly toxic to living beings.

Industrial Waste

Inorganic Pollutants

- They include fine particles of different metals, chlorides, sulphates, oxides of iron, cadmium, acids and alkalies.

Inorganic Pollutants

Organic Pollutants

- They Include oils, fats, phenols, organic acids grease and several other organic compounds

Agricultural Wastes

- Chemical fertilizers and pesticides have become essential for present day high yielding crops. Consequently , they have become a potential source of water pollution. These fertilizers contain major plants nutrients mainly nitrogen, phosphorous, and potassium. Excess fertilizers may reach the ground water by leaching or may be mixed with surface water of rivers, lakes and ponds by runoff and drainage.

Marine Pollution

- Ocean are the final sink of all natural and manmade pollutants. Rivers discharge their pollutants into the sea. The sewage and garbage of costal cities are also dumped into the sea. The other sources include, discharge of oils, grease, detergents, and radioactive wastes from ships.

Marine Pollution

Thermal Pollution

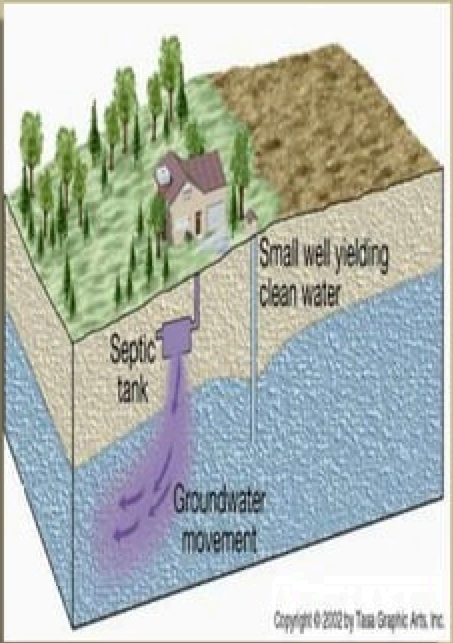
- Thermal Pollution of water is caused by the rise in temperature of water. The main source of thermal pollution are the thermal and nuclear power plants. The power generating plants use water as coolants and release hot water into the original source. Sudden rise in temperature kills fish and other aquatic animals.

Thermal Pollution

Underground Water Pollution

- Underground water was considered fairly safe source of water but in India the ground water is threatened with contamination due to seepage from industrial and municipal waste and effluents, sewage and agricultural runoff. The ground water also gets polluted by leaching of salts and minerals due to overuse of ground water source.

Underground Water Pollution

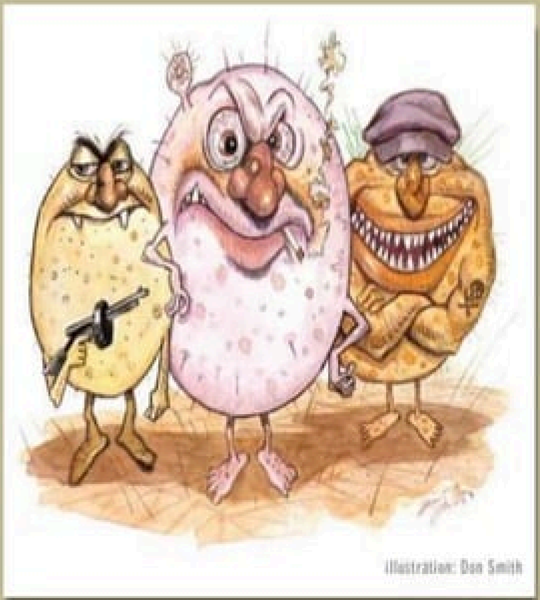


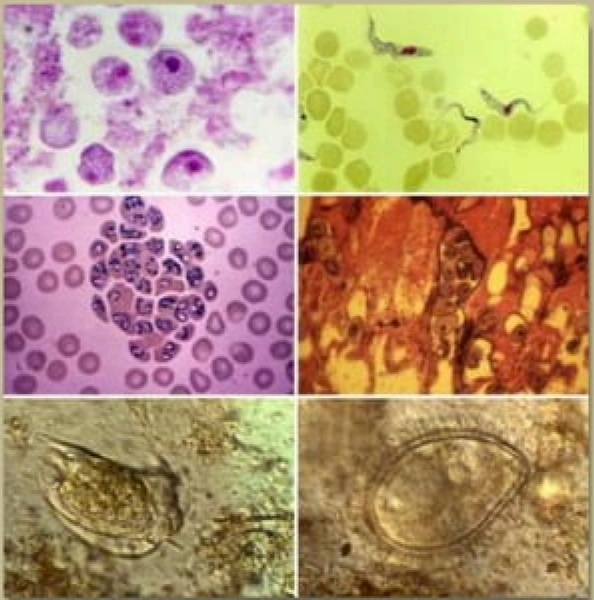
Effects of Water Pollutants

- ***Sediments***:- Excessive amount of soil particles carried by flowing water, when there is severe soil erosion. Sediments clog reservoir and channels, destroy, aquatic life.
- ***Oxygen demanding organic waste***:- Animal waste, plant debris, waste from paper mill and food processing facilities bacteria can decompose organic waste and in the process they deplete oxygen and can cause death of fish and other aquatic life.

- ***Infectious microorganisms***,– Parasitic worms, viruses and bacteria from infected organisms as well as human and animal wastes are responsible for water borne diseases that can kill thousand of Individuals.
- ***Organic Compounds***,– Substances like fats oil, grease as well as some organic acids from industrial effluents can cause many health problems in humans and can disturb aquatic life

Infectious Microorganisms





- ***Inorganic nutrients:-***
- Substances like nitrogen and phosphorous from animal waste, plant residues and fertilizers runoff. These nutrients can cause eutrophication and can effect infant and unborn babies (Blue baby syndrome)
- ***Inorganic Chemicals:-*** Acids salts and heavy metals, such as lead and mercury from industrial effluents, surface runoff and house hold cleaning agents. They make water unfit for drinking, or irrigation, harm fish and other aquatic life.

- ***Radioactive substances.***- Waste from nuclear power plants, nuclear weapons, and the mining of radioactive substances can cause cancer, birth defects etc..
- ***Thermal Pollution.***- Hot Water from industrial processes may lower oxygen levels and make aquatic organisms more vulnerable to disease, parasites and toxic chemicals.

Thermal Pollution

Water Treatment Plants

Water Flow

Water Consumption

Water provided for human consumption requires treatment in order to make it

- safe (potable)
- pleasant to taste (palatable)

Modern technology offers remarkable capabilities to accomplish these goals

- introduction of new and different pollutants
- cost of treating to required levels is a challenge for the water supply industry

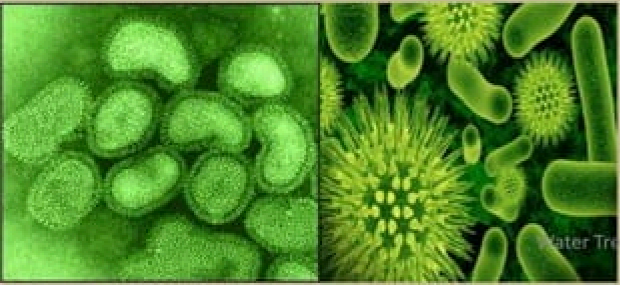
Water Demand

- Municipal water supplies are treated to be both palatable and potable, regardless of their intended use
- If each person uses about 100 litres of water per day
- Commercial and industrial users may increase that demand by more than 5 times

Drinking Water – Quality

Our water supply comes from two sources

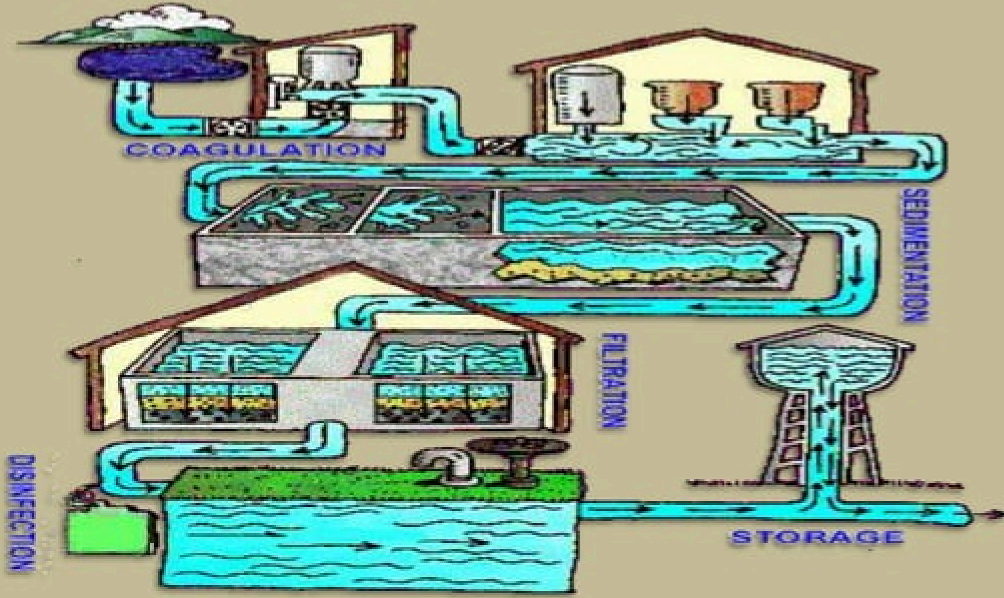
- surface waters i.e. rivers, lakes and reservoirs
- groundwater, which is stored below the earth's surface



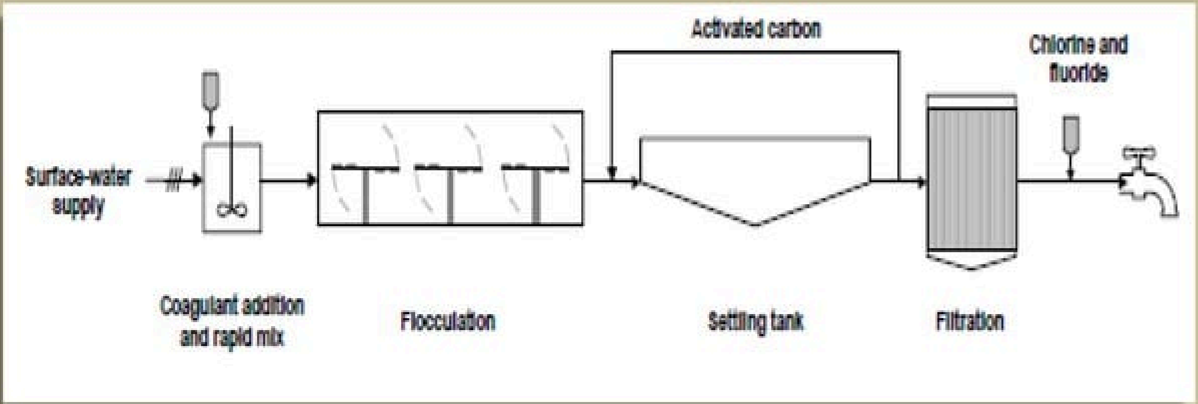
Each source presents its own problems

- Surface water has elevated levels of soil particles and algae, making the water turbid
- may contain pathogens
- Groundwater has higher levels of dissolved organic matter (yellow color) and minerals such as iron
- Both sources may have high levels of calcium and magnesium (hardness)
- both can be contaminated by toxic chemicals

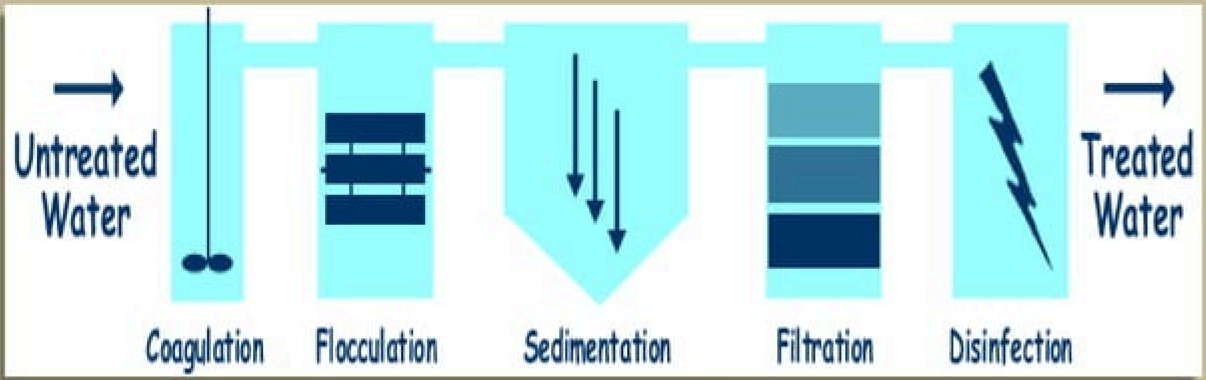
Water Treatment Process



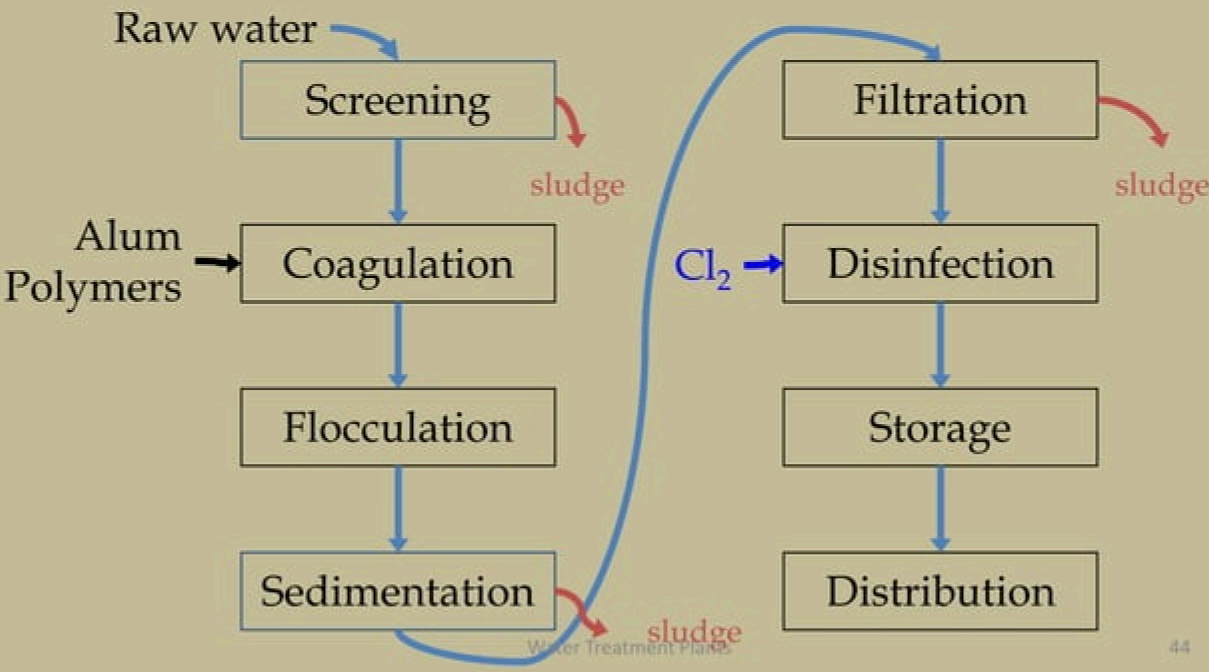
Drinking Water Plant



Untreated to Treated Water

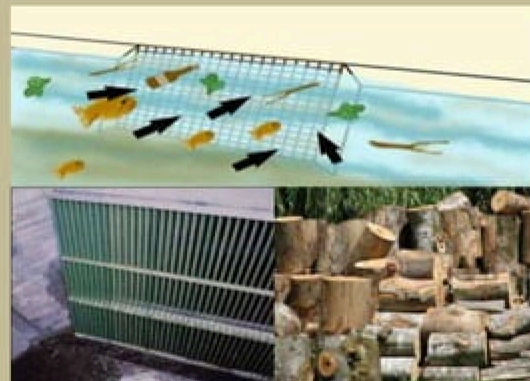


Conventional Surface Water Treatment



Screening

- Removes large solids
  - logs
  - branches
  - rags
  - fish



- Simple process
  - may incorporate a mechanized trash removal system
- Protects pumps and pipes in Water Treatment Plants

Coagulation

- Small particles are not removed efficiently by sedimentation because they settle too slowly
- they may also pass through filters
- easier to remove if they are clumped together
- Coagulated to form larger particles, **but they don't** because they have a negative charge
- repel each other (like two north poles of a magnet)

- In coagulation
- we add a chemical such as alum which produces positive charges to neutralize the negative charges on the particles
- particles can stick together
- forming larger particles
- more easily removed
- process involves addition of chemical (e.g. alum)
- rapid mixing to dissolve the chemical
- distribute it evenly throughout water

Coagulants

- Aluminum Sulfate $Al_2(SO_4)_3$
- Ferrous Sulfate $FeSO_4$
- Ferric Sulfate $Fe_2(SO_4)_3$
- Ferric Chloride $FeCl_3$
- Lime $Ca(OH)_2$

Aluminum salts are cheaper but iron salts are more effective over wider pH range

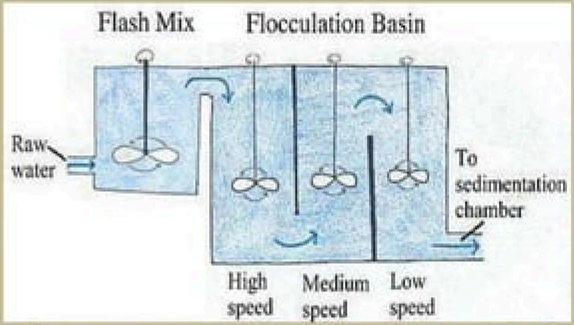
Factors for choosing a coagulant?

1. Easily available in all dry and liquid forms
2. Economical
3. Effective over wide range of pH
4. Produces less sludges
5. Less harmful for environment
6. Fast

Flocculation

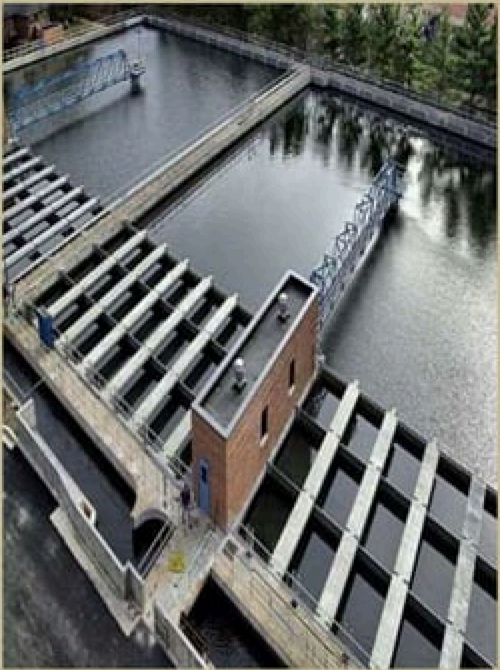
- Now the particles have a neutral charge
- can stick together
- The water flows into a tank with paddles that provide slow mixing
- bring the small particles together to form larger particles called flocs
- Mixing is done quite slowly and gently in the flocculation step

- If the mixing is too fast, the flocs will break apart into small particles that are difficult to remove by sedimentation or filtration.



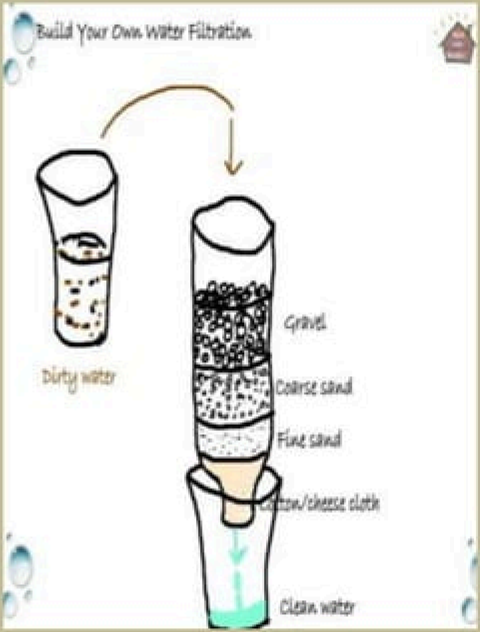
Sedimentation

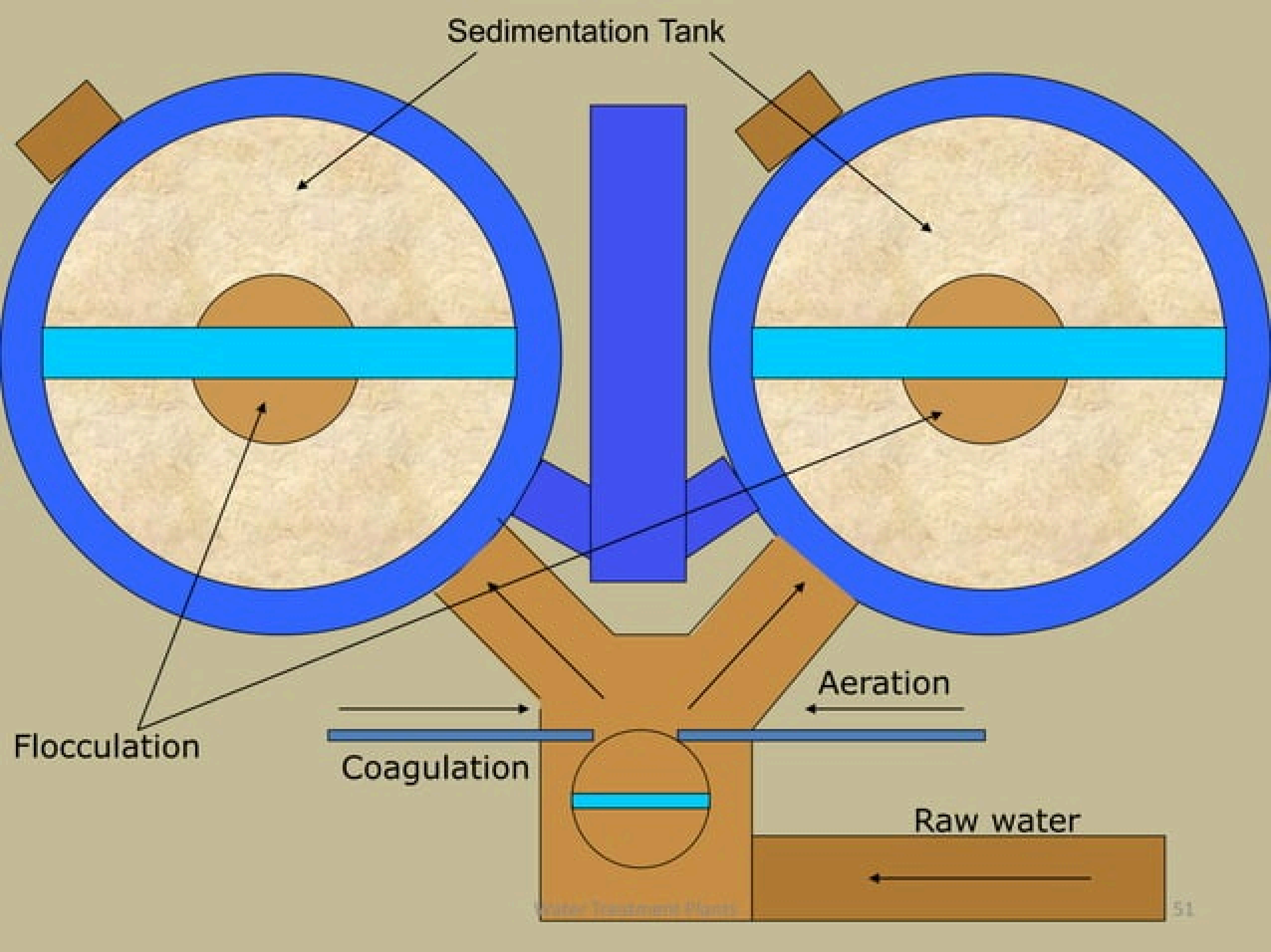
- water flows to a tank called a sedimentation basin
- gravity causes the flocs to settle to the bottom
- Large particles settle more rapidly than small particles
- It would take a very long time for all particles to settle out and that would mean we would need a very large sedimentation basin.
- So the clarified water, with most of the particles removed, moves on to the filtration step where the finer particles are removed

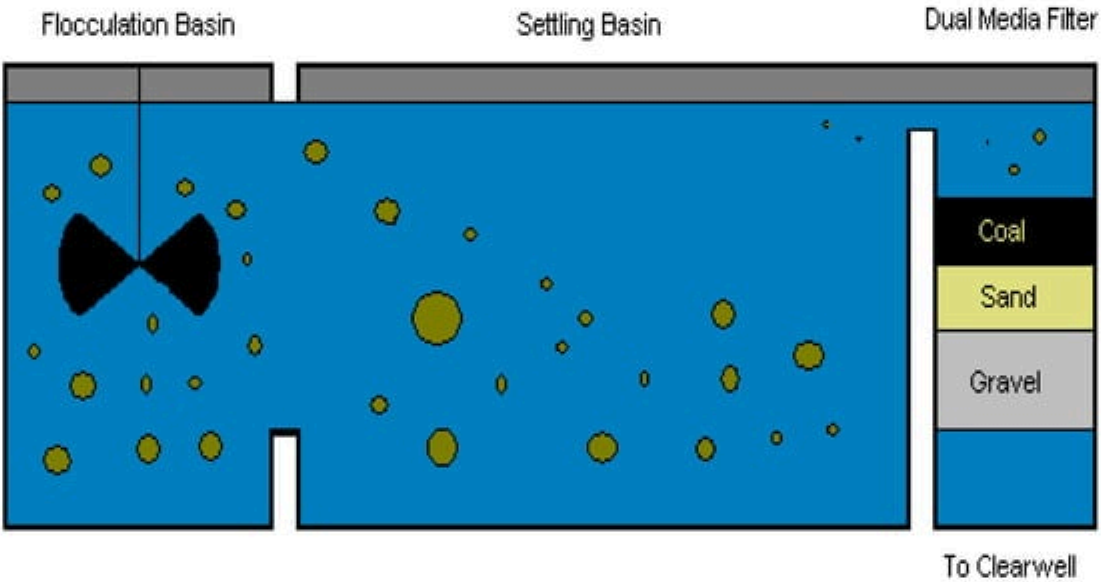


Filtration

- The filtration apparatus is a concrete box which contains sand (which does the filtering), gravel (which keeps the sand from getting out) and underdrain (where the filtered water exits)
- After the filter is operated for a while, the sand becomes clogged with particles and must be backwashed
- Flow through the filter is reversed and the sand and particles are suspended
- The particles are lighter than the sand, so they rise up and are flushed from the system. When backwashing is complete, the sand settles down onto the gravel, flow is reversed and the process begins again

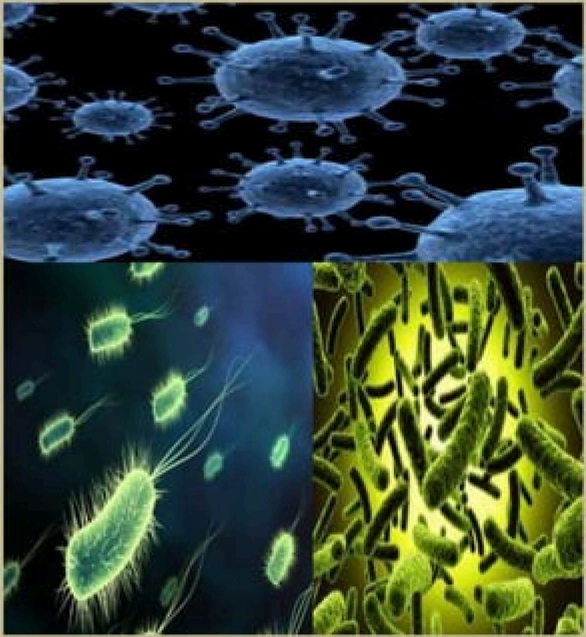



Sedimentation Tank
Flocculation
Coagulation
Aeration
Raw water


Flocculation Basin
Settling Basin
Dual Media Filter
Coal
Sand
Gravel
To Clearwell

Disinfection

- With particles removed, it only remains to provide disinfection, so that no pathogens remain in the water
- Protozoan pathogens are large in size and have been removed with other particles
- Bacteria and viruses are now destroyed by addition of a disinfectant



Chlorination

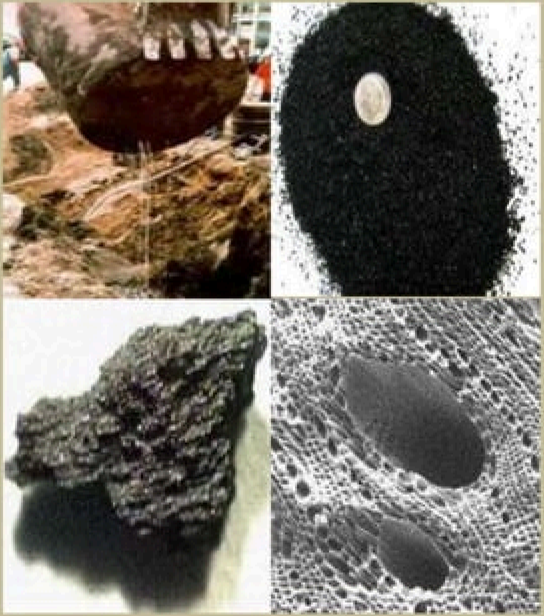
- Enough chlorine is added so that some remains to go out in the water distribution system, protecting the public once the water leaves the plant

Softening

- Areas where water comes into contact with limestone, there may be high levels of calcium and magnesium present
- these chemicals make the water "hard"
- Hardness is removed by a process called softening
- Two chemicals (lime, CaO and soda ash, Na_2CO_3) are added to water
- causing the calcium and magnesium to form precipitates
- solid substance is then removed with the other particles by sedimentation and filtration

Synthetic Organic Chemicals

- Water supplies can be contaminated with synthetic organic chemicals (SOCs) from agricultural runoff or commercial and industrial sources
- such as the leaking underground storage tank
- These chemicals are not efficiently removed by the simple water treatment process
- These chemicals can be removed by passing the water through a layer of activated carbon in a column
- The carbon granules strongly attract organic chemicals removing them from the water by a process called adsorption
- When the carbon is full and can't hold any more chemical, it is removed from the column, heated to burn off contaminants and can then be re-used.



Distribution

- Pumping of the clean water produced at the treatment plant to the community is called distribution
- This can be done directly or by first pumping the water to reservoirs or water storage tanks

Onsite Treatment
Color, Taste and Odor

- The activated carbon technology used in municipal drinking water treatment can be applied in homes as well
- the carbon is contained in a "household-sized" column
- water passes through the carbon removing organic matter (which can cause a yellow color) and also compounds which cause unpleasant taste and odor

Onsite Treatment At The Tap

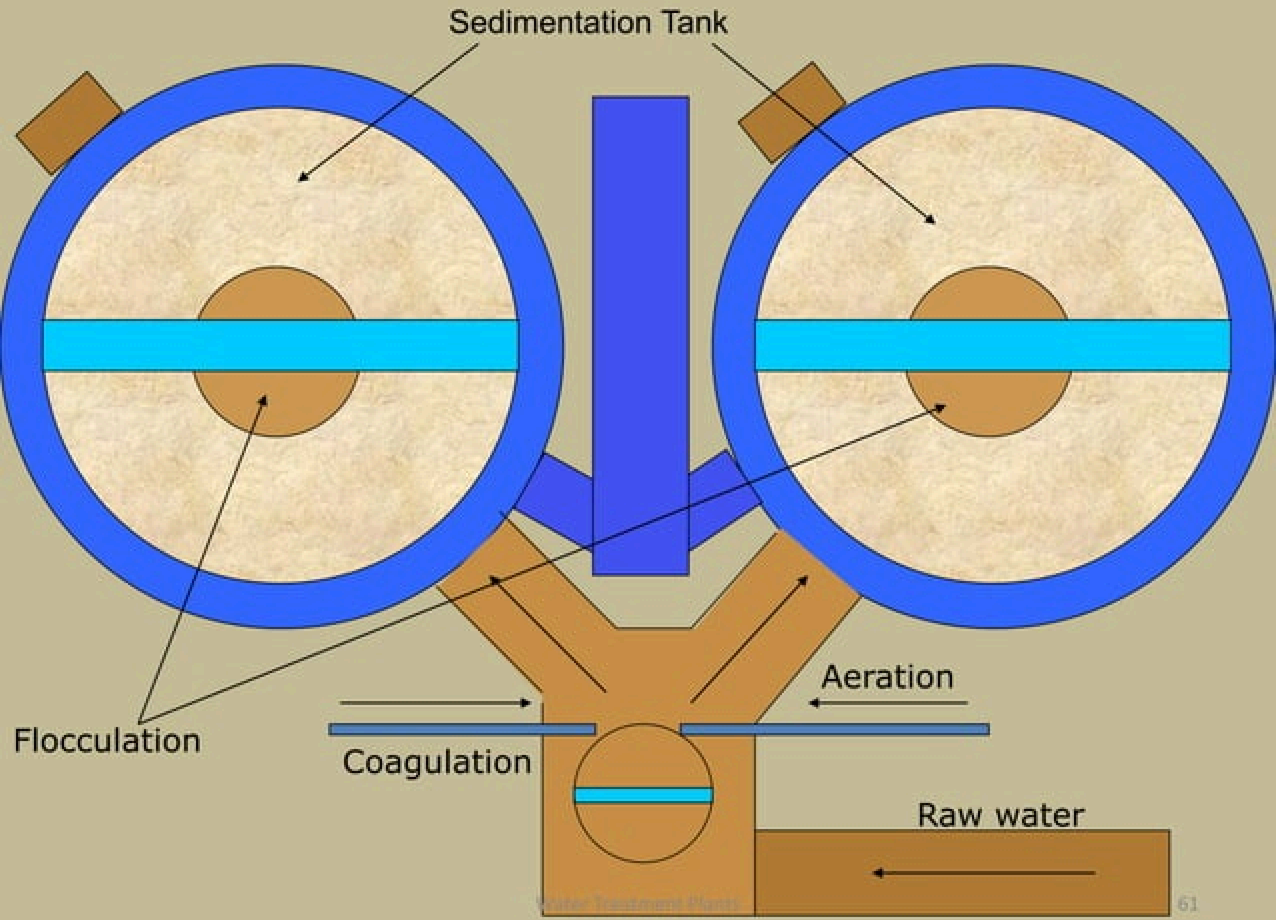
- Home water treatment systems may also be installed at the tap
- Although the technologies vary somewhat among products, they typically include pre-filtration
- hardness and metals removal by ion exchange
- organic matter removal with activated carbon
- post-filtration

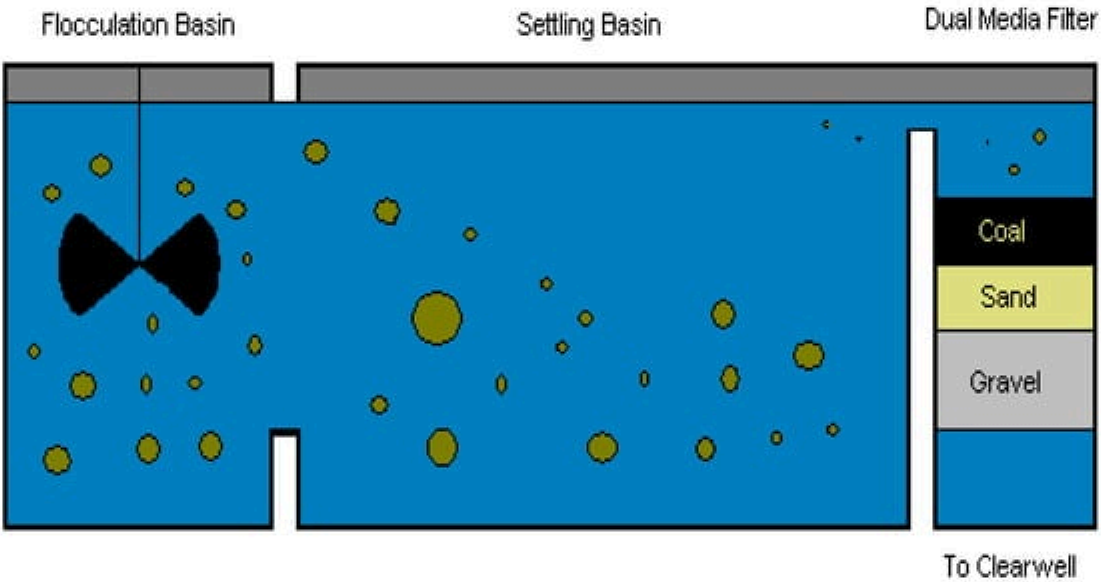
Ground– vs. Surface Water

Groundwater	Surface water
constant composition	variable composition
high mineral content	low mineral content
low turbidity	high turbidity
low color	colored
low or no D.O.	D.O. present
high hardness	low hardness
high Fe, Mn	taste and odor

Main Components

- Screening
- Coagulation
- Aeration
- Flocculation
- Sedimentation
- Filtration
- Disinfection or Chlorination
- Lime Dosing


Sedimentation Tank
Aeration
Flocculation
Coagulation
Raw water


Flocculation Basin
Settling Basin
Dual Media Filter
Coal
Sand
Gravel
To Clearwell

Unit Operations

- Unit operations and Unit processes water treatment plants utilize many treatment processes to produce water of a desired quality.
- These processes fall into two broad divisions:-

A) Unit operations: (UO)

- Removal of contaminants is achieved by physical forces such as gravity and screening.

B) Unit processes (UP)

- Removal is achieved by chemical and biological reactions.

Water Treatment processes

- Raw water may contain suspended, colloidal and dissolved impurities. The purpose of water treatment is to remove all those impurities which are objectionable either from taste and odour point of view or from health or public point of view.

Water Treatment processes

- Following are the purpose of Water treatment
- To remove color, dissolved gases and turbidity.
- To remove taste and odour
- To remove disease causing microorganisms so that water is safe for drinking purposes.
- To remove hardness of water.
- To make it suitable for a wide variety of industrial purpose such as steam generation, dyeing etc.

Water Treatment processes

- For the surface water following are the treatment processes that are generally adopted.

Screening

- This is adopted to remove all the floating matter from surface waters. It is generally provided at the intake point.

Water Treatment processes

Aeration

- This is adopted to remove objectionable taste and odour and also to remove dissolved gases such as carbon-dioxide, hydrogen supplied, etc.. The iron & manganese present in water are also oxidized to some extent.

Sedimentation with or without Coagulation

- The purpose of sedimentation is to remove the suspended impurities. With the help of plain sedimentation, silt, sand, etc., can be removed However with the help of sedimentation with coagulants, very fine suspended particles and some bacteria can be removed.

Sedimentation with or without Coagulation

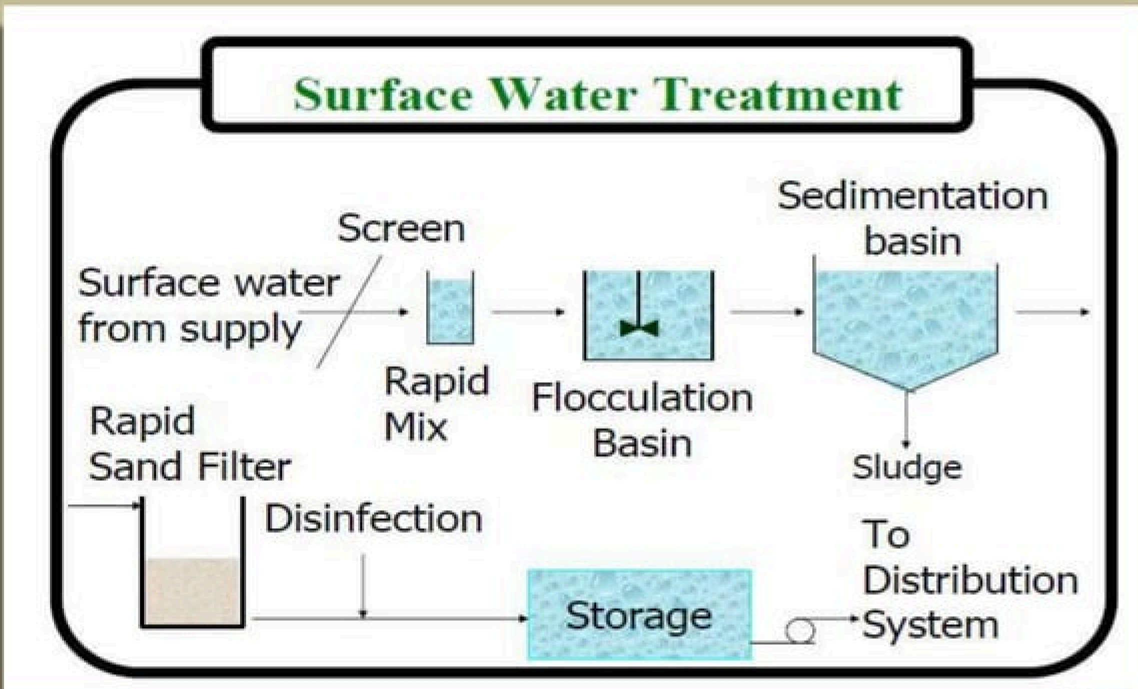
- Filtration
- The process of filtration forms the most important stage in purification of water. Filtration removes very fine suspended impurities and colloidal impurities that may have escaped the sedimentation tanks. In addition the micro-organisms present in water are largely removed.

Sedimentation with or without Coagulation

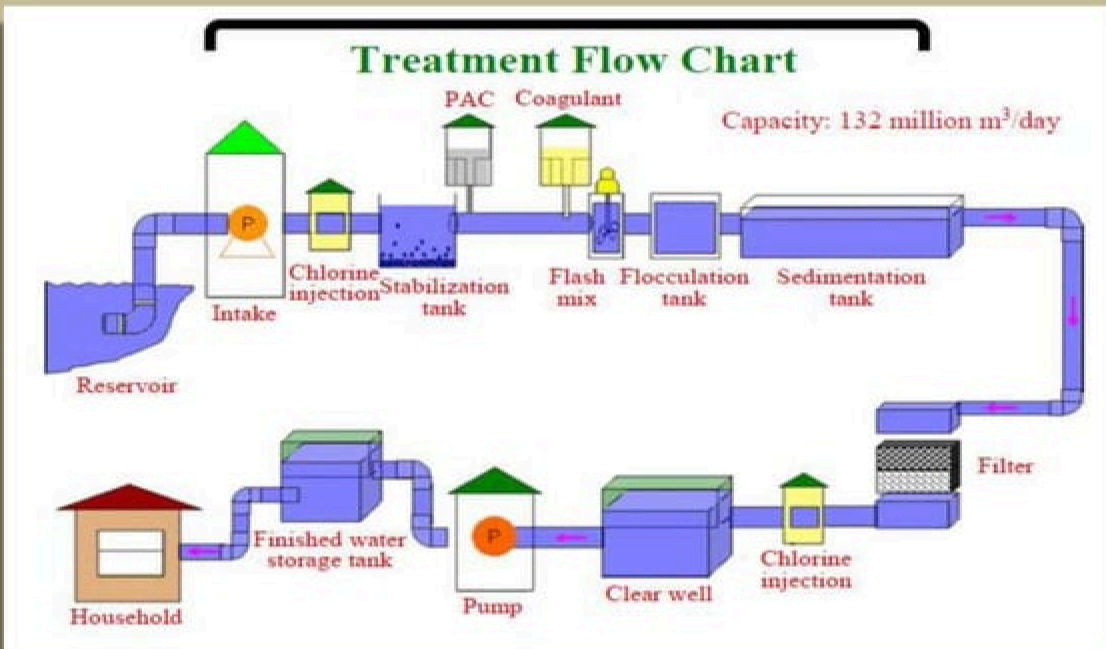
Disinfection

- It is carried out to eliminate or reduce to a safe minimum limit, the remaining micro-organisms, and to prevent the contamination of water during its transit from the treatment plant and to the place of consumption.

Water Treatment Processes



Water Treatment Processes



Water Treatment processes

Screening

- Screens are generally provided in front of the pump or the intake works so as to exclude the large sized particles, such as debris, animals, trees, branches, bushes, ice, etc.. Coarse screens are placed in front of the fine screens. Coarse screens consist of parallel iron rods placed vertically or at a slight slope at about 2 to 10 cm Centre to Centre. The fine screens are made up of fine wire or perforated metal with opening less than 1 cm wide.

Water Treatment processes

- Thee coarse screen first remove the bigger floating bodies and the organic solids; and the fine screen removes the fine suspended solids.
- The coarse screens are also kept inclined at about 450 to 600 to the horizontal. While designing the screens, clear opening should have sufficient total area, so that the velocity is not more than 0.8 to 1 m/sec

Water Treatment processes

Aeration

- It is the type of treatment given for removing colours, odours, and taste from water. Under this process of aeration, water is brought in intimate contact with air, so as to absorb oxygen and to remove carbon-dioxide gas. It may also help in killing bacteria to a certain extent.
- Object of aeration
- To kill bacteria up to some extent
- To have less corrosion to pipes
- To oxidize iron & manganese present in water.

Water Treatment Processes

- Methods of Aeration
- By Using Spray Nozzles
- In this method water is sprinkled in air or atmosphere through special nozzles. Carbon-dioxide gas is thus considerable removed upto 90 % in this process.

Water Treatment processes

By Air Diffusing Method

- In this method supplying ozone treats water. The gas contains oxygen, and it helps in removing carbon dioxide from water.

Water Treatment processes

By permitting water to trickle over cascades

- In this method, compressed air is bubbled through the water, so as to thoroughly mix it with water.
- By Using Trickling Beds
- In this method, the water is allowed to trickle down the beds of coke, supported over perforated trays, and arranged vertically in series.

Water Treatment processes

Sedimentation

- Plain Sedimentation
- **Most of the suspended impurities present in water tend to settle down under gravity, so that the water is allowed to still in basin, and this process is called plain sedimentation**. The basin in which water is detained is **called settling tank** or sedimentation tank or clarifier, and the theoretical average time for which the **water is detained in the tank is called detention time.**

Water Treatment processes

Water Treatment processes

- Sedimentation basins are generally made of reinforced concrete, and may be rectangular or circular in plan. A plain sedimentation under normal condition may remove as much as 70 % of the suspended impurities present in the water.

Water Treatment processes

Object of Sedimentation

- Plain sedimentation is adopted to settle the suspended impurities in water. When water is stored, particles with specific gravity more then one try to settle down, **the forces, which resists the settlement of particles are viscosity, velocity, shape and size of the particles**. When the particles to be removed are bigger in size, so that by reducing the turbulence of water, they can settle, plain sedimentation is recommended.

Water Treatment processes

Design of Sedimentation Tank

- **Surface Loading or Overflow Velocity**
- The discharge per unit area Q/ BL is known as overflow velocity. Normal velocities range from between 500- 750 lit/hr/m^2 of plan area for sedimentation tanks using coagulants.

Water Treatment processes

Water Treatment processes

Detention Time

- Detention time (t) of settling tank may be defined as the average theoretical time required for the water to flow through the tank. It is the time that would be required for the flow of water to fill the water if there will be no overflow. Hence it is the ratio of Volume of the basin to the rate of flow through the basin.

Water Treatment processes

For Rectangular tank.

- Detention Time (t) = $\frac{\text{Volume of Tank}}{\text{Rate of flow}}$

$$= \frac{BLH}{Q}$$

Where,

H= Water depth or Height

L= Length of Tank

B= Width

Q= Discharge

Detention time usually ranges between 4 to 8 hours for plain sedimentation, it is 2 to 4 hrs... as coagulant get used.

Water Treatment processes

Short Circuiting

- For the efficient removal of sediment in sedimentation tank, it is necessary that flow through period uniformly distributed throughout the tank. If current permit a substantial portion of water to pass directly through the tank without being detained for intended time, the flow is said to be short circuited.

Water Treatment processes

Inlet & Out let Zone

- Inlet & Outlet zone near the entrance and exit should be designed which may reduce the short-circuiting tendencies and in such a way distribute the flow uniformly. The size and shape of particle also affect the settling rate. The greater is the specific gravity more readily the particle will settle.

Water Treatment processes

Displacement Efficiency

- The actual average time, which a batch of water takes in passing through a settling tank is called the flowing through period it is always less than the detention period. Which is the corresponding theoretical time. The ratio of the flowing through period to detention time is called 'displacement efficiency'
- Therefore,
- $$\text{Displacement efficiency} = \frac{\text{Flow through period}}{\text{Detention Period}}$$

It generally varies between 0.25 to 0.5 in normal sedimentation tank.

Water Treatment processes

- Types of Sedimentation Tanks
- The Sedimentation tanks can be divided into two types
- Horizontal flow tanks
- Vertical or up-flow tanks

Water Treatment Processes

- Among the horizontal flow tanks, we may have different types of designs, such as.
- Rectangular tanks with longitudinal flow
- Circular tank with radial flow, with central feed.

Water Treatment Processes

- Vertical or Up-flow Tanks
- Vertical tanks usually combine with sedimentation with flocculation, although they may be used for plain sedimentation. They may be square or circular in plan and may have hopper bottoms.
- When used with coagulants, the flocculation takes place in the bottom of the tank leading to the formation of blanket of floc through which the rising floc must pass. Because of this phenomenon, these tanks are called the Up-flow sludge blanket clarifiers.

Types of Settling

- Particles may settle out of a sedimentation tank in the following four ways:
- Type:- I Discrete Settling
- This corresponds to the sedimentation of discrete particles in a suspension of low solid concentration. This is also known as free settling since the particle have tendency to flocculate or coalesce upon contact with each other.

Types of Settling

Discrete Particle

A particle that does not alter its shape, size and weight while settling or rising in water is known as discrete particle.

Type–II

Hindered Settling

This type of settling refers to rather dilute suspension of particles that coalesce or flocculate during sedimentation process. Due to flocculation, particles increase in mass and settle at a faster rate.

Types of Settling

Type–III

- Zone Settling
- This type of settling refer to flocculent suspension of intermediate concentration. Inter particle forces hold the particle to-gather and mass of particle subside as a whole.

Types of Settling

Type IV

- Compression Settling
- This refers to flocculent suspension of so high concentration that particles actually comes in contact with each other resulting in formation of a structure. Further settling can occur only by compression of the structure brought about due to weight of particles which are constantly being added to the structure.

Types of Sedimentation Tank

Fill and Draw type

- As the name indicates the sedimentation tank is first filled with incoming water, and is allowed to rest for a certain time, under this quiescent condition the suspended particles settle down at the bottom of the tank. Generally a detention time of 24 hrs.. is allowed. At the end of the period the clear water is drawn off through the outlet valve without causing any disturbance to the settling mass. This method is obsolete and not in use in recent times.

Types of Sedimentation Tank

Continuous flow type tank

- In this type of tank water after entering through the inlet, keeps on moving continuously with small uniform velocity. Before the water is reached outlet, the suspended particles settles at the bottom, and the clear water is collected from the outlet.
- There are two types
- Horizontal flow tank
- Vertical flow tank

Types of Sedimentation Tank

Horizontal flow Sedimentation Tank

- In the design of a horizontal flow settling tank, the aim is to achieve as nearly as possible the ideal condition of equal velocity at all points lying on each vertical in the settling zone.

Sedimentation Tank

Design aspect of continuous flow type sedimentation tank

- **Detention Period**
- Detention Period
- Detention time or period is the theoretical time taken by a particle of water to pass between entry and exit of a settling tank.
- Detention time to is given by
- $t_o = \dfrac{\text{Volume of the tank}}{\text{Rate of flow}} = \dfrac{V}{Q} = \dfrac{LBH}{Q}$

Detention time for a plain sedimentation tank varies from 4 to 8 hrs.. and for 2 to 4 hrs.. when coagulant are used.

Sedimentation Tank

Flow through period

- Flowing through period
- It is the average time required for a batch of water to pass through the settling tank. It is always less than detention period.
- Displacement efficiency
- It is the ratio of $\frac{\text{Flow through period}}{\text{Detention time}}$

It varies from 0.25 to 0.5 in plain sedimentation tanks

Sedimentation Tank

Overflow Rate

- The quantity of water passing per hour per unit plan area is known as flow rate. This term is also referred to as surface loading rate, because its unit is $m^3/d/m^2$, the unit m^3/d represents discharge or flow of water in tank and m^2 is the surface area of the tank.

Sedimentation Tank

- The normally adopted values varies between 12 – 18 m^3/m^2/day (500 to 750 lit per hour per m^2) for plain sedimentation tank and between 24 – 30 m^3/m^2/day (1000 to 1250 lit per hour per m^2) for sedimentation tank using coagulation.

Sedimentation Tank

Basin Dimension

- The surface area of the tank is determined on the basis of overflow rate or surface loading rate
- **Surface Area A= Rate of flow (m^3/day) / Surface loading rate (m^3/m^2/day)**

$$A = \frac{\text{Rate of flow } (m^3/\text{day})}{\text{Surface loading rate } (m^3/m^2/\text{day})}$$

The length to width ratio of rectangle tank should preferably be 3:1 to 5:1 Width of tank should not exceed 12 m. The depth is kept between 3 to 6 m. For a circular tank the diameter is limited to 60 m

C/s area is such that to provide a horizontal velocity of flow of 0.2 to 0.4 m/min, normally about 0.3 m/min..

Bottom slope is taken as 1 % in rectangular tank to about 8% in circular tank.

Sedimentation Tank

Weir Loading Rate

- It is ratio of flow rate divided by length of the outlet weir over which the water will flow
- Weir loading rate= $\dfrac{\text{flow rate}}{\text{perimeter}}$

Circular tank usually ranges 300 m3/m/day

Sedimentation Tank

Maximum velocity to prevent scour

- It is very essential that once the particle has settled and reach the sludge zone it should not be scoured or lifted up by velocity of flow of water over the bed.
- $Vd = \left(\frac{8\beta(Ss-1)\, d}{f} \right)^{1/2}$

B= 0.04 for uni-granular sand and 0.06 or more for non uniform sand.

f= Darcy Weisbach friction factor

= 0.025 to 0.03 for settling velocity.

d= diameter of particle

Ss= Specific Gravity of particles

Sedimentation Tank

Inlet & Outlet arrangement

- Inlet & outlet arrangement for sedimentation tank are made such that minimum disturbance is caused due to inflow and effluent streams. If this disturbance is not overcome by inlet & outlet arrangement, the effective detention period will be reduced.
- An ideal structure is that which
- Distribute the water uniformly across the width and depth.
- Reduce turbulence
- Initiates the longitudinal or radial flow so as to achieve high removal efficiency.
- Mix it with the water already in the tank to prevent density currents.

Sedimentation Tank

Sludge Removal

- The particles settled in the basin constitutes the sludge which can be removed either manually or mechanically. In manual process the tank has to be put out of service, drained and sludge has to be dug out from the bottom manually. This method is used when the quantity of matter is small. However when quantity is large, mechanical or hydraulic methods are used for sludge removal.

Sedimentation Tank

- Design a suitable sedimentation tank for a town whose daily demand is 12 million lit per day. Tank is fitted with a mechanical scrapper for sludge removal. Assume detention period as 5 hr..... and velocity of flow as 20 cm/sec

Sedimentation Tank

- Quantity of water to be treated
- $= 12 \times 10^{6}$ lit/ day
- $= 12 \times 10^{3}$ m^3 /day
- $\frac{12 \times 10^{3}}{24} = 500\ m^3/hr$

Capacity of tank= Q x detention time

= 500 x 5

2500 m^3

Sedimentation Tank

- Velocity of flow= 20 cm /min
- = 0.2 m/min
- The length of the tank required= Velocity of flow x Detention time
- = 0.2 x 5 x 60
- = 60 m
- The c/s area of the tank required
- $= \frac{\text{Volume of tank}}{\text{Length of the tank}}$
- $= \frac{2500}{60}$

$= 41.66\ m^2$

Sedimentation Tank

- Assume water depth of 3.5 m
- Width of tank required = $\frac{41.66}{3.5}$

= 11.9 m

= 12 m

Using free board of 0.5 m the overall depth = 3.5 + 0.5 = 4.0 m

So provide a tank of 60 x 12 x 4 m

Surface loading rate = $\frac{Q}{L \times B}$

$= \frac{12 \times 10^3}{60 \times 12} = 16.66\ m^3/m^2/day$ (Within limits)

O.K.

Example

- Design a sedimentation tank for a water works which supplies 1.6 MLD to the town. The sedimentation period is 4 hrs.. The velocity of flow is 0.15 m/min and the depth of water in the tank is 4.0 m. Assume an allowance for sludge as 80 cm. Also find the overflow rate.

Example

- Quantity of water to be treated

= 1.6×10^{6} lit/day= 66.66 m^3/hr.

- Volume of tank or capacity of tank
- = Q x detention time

= 66.66 x 4= 266.64 m^3

- The velocity of horizontal flow= 0.15 m/min
- The required length of the tank= Velocity of flow x detention time

= 0.15 x 4 x 60

=36 m

Example

- Cross-Sectional area of the tank= $\frac{\text{Capacity}}{\text{Length}}$

$= \frac{266.64}{36} \; m^3$

$= 7.4 \; m^2$

Depth of tank= 4.0 m

Therefore width of the tank

$= \frac{\text{Cross –Sectional area}}{\text{depth of water}}$

Here total depth of water including sludge= 4.0 m

Sludge depth= 0.8 m

Therefore Water depth= 4-0.8 = 3.2 m

Therefore width of tank = $\frac{7.4}{3.2} \; m$

= 2.31= 2.4 m

Example

Provide a free board of 0.5 m the size of the tank

= 36 x 2.4 x 4.5 m

Overflow rate= $\dfrac{Q}{L \times B}$

= $\dfrac{1.6 \times 10^{6}}{36 \times 2.4 \times 24}$ lit/hr./m ^{2}

= 771.6 lit/hr./m2 or 18.51 m^3/m^2/day

Example

- Design a plain sedimentation tank for water supply scheme having capacity to treat water= 10 MLD

Example

- Design a Continuous horizontal flow Rectangle tank
- Assume detention time= 5 hrs. (4 to 8 hrs.)
- Velocity of flow= 0.2 m/sec (0.15 to 0.30 m/sec)
- Water depth= 3.5 m (3 to 6 m)
- Freeboard= 0.5 m

Example

- Quantity of water to be treated= 10 MLD
- $= 10 \times 10^6$ lit/day
- $= \dfrac{10 \times 10^6 \times 10^{-3}}{24}$

$= 416.66\ m^3/hr.$

Volume of tank= Q x Detention time

$= 416.66 \times 5$

$= 2083.3\ m^3$

Example

- Length of tank required= Velocity of flow x Detention time
- = 0.2 x 5 x 60
- = 60 m
- Cross-Sectional area of the tank
- = $\dfrac{\text{Volume of tank}}{\text{Length of the tank}}$

$= \dfrac{2083.30}{60}$

=34.72 sq.

Example

- Water depth is assumed as 3.5 m
- So required width of the tank = $\frac{34.72}{3.5}$

= 9.92 m

Say 10 m

Provide a free board of 0.5 m total depth

= 3.5 + 0.5 = 4.0 m

Therefore the dimensions of the tank

= 60 x 10 x 4 m

Example

Surface overflow rate

$$SLR = \frac{Q}{A}$$

$$\frac{10 \times 10^{-3}}{60 \times 10}$$

$= 16.66\ m^3/m^2/day$

Within limit so design is O.K.

Filtration

- Sedimentation removes a large percentage of settleble solids, suspended solids, organic matter and small percentage of bacteria. If coagulation is used more percentage of fine colloidal particles will be removed. But water still contains fine suspended particles, micro-organisms and color. To remove these impurities still further and to produce potable and palatable water, the water is filtered through beds of granular material like sand and gravel. This process of passing the water through the beds of such granular materials is known as filtration.

Filtration

Theory of Filtration

- When water is filtered through the beds of filter media, usually consisting of clean sand, the following action takes place:
- Mechanical Straining
- Sedimentation
- Biological action
- Electrolytic action

Filtration

Mechanical Straining

- Sand contains small pores, the suspended particles which are bigger than the size of the voids in the sand layer cannot pass through these voids and get arrested in them as the water passes through the filter media (sand). Most of the particles are removed in the upper few centimeters of the filter media, these arrested particles forms a mat on the top of the bed which further helps in straining out impurities.

Filtration

Sedimentation

- In mechanical Straining, only those particles which are coarser than the void size are arrested. Finer particles are removed by sedimentation. The voids between grains of filters act like small sedimentation tanks. The colloidal matter arrested in the voids is a gelatinous mass and therefore, attract other finer particle. These finer particle thus settle down in the voids and get removed.

Filtration

Biological action

- When a filter is put into operation and the water is passed through it, during the first few days, the upper layer of sand grain become coated with sticky deposit of decomposed organic matter together with iron, manganese aluminum and silica. After some time there exists a upper most layer of sand a film of algae, bacteria and protozoa etc. this film is called schmutzdecke or dirty skin which acts as an extremely fine messed straining mat. This layer further helps in absorbing and straining out the impurities. The organic impurities present in water become food for micro-organisms residing in the film. Bacteria breakdown the organic matter and convert them into harmless compounds.

Filtration

Electrolytic action

- The sand particles of filter media and the impurities in water carry electric charge of opposite nature, therefore they attract each other and neutralize the charge of each other. After long use the electric charge of filter sand is exhausted, which is renewed by washing the filter bed.

Filter Material

- Sand either coarse or fine, is generally used as filter media. The layers of sand may be supported on gravel, which permits the filtered water to move freely to the under drains and allow the wash water to move uniformly upward.
- **Sand**
- The filter sand should generally be obtained from rock like quartzite and should have following properties:
- It should be free from dirt and other impurities
- It should be of uniform size
- It should be hard
- If placed in hydrochloric acid for 24 hrs., it should not lose more than 5 % of weight.

Filter Material

- Effective size of sand shall be
- (a) 0.2 to 0.3 mm for slow sand filters
- (b) 0.35 to 0.6 mm for rapid sand filter
- Uniformity of Sand
- It is specified by the uniformity coefficient which is defined as the ratio between the sieve size in mm through which 60 % of the sample sand will pass to the effective size of the sand.
- Uniformity coefficient for slow sand filter
- = 2 to 3
- 1.3 to 1.7 for rapid sand filters

Filter Material

Gravel

- The sand beds are supported on the gravel bed. The gravel used should be hard, durable, free from impurities, properly rounded and should have a density of about 1600 kg/ m^3
- The gravel is placed in 5-6 layers having finest size on top.
- Other material
- Other material which can be used are anthracite, Garnet, Sand or local material like coconut husks, rice husks.

Types of Filters

- Filters are mainly classified based upon the rate of filtration as
- Slow Sand Filter
- Rapid Sand Filter
- (a) Rapid sand gravity filter
- (b) Pressure Filter

Types of Filters

Slow Sand Filter

- Slow Sand filter was the earliest type , they were called slow sand filter because the rate of filtration through them is about 1/20th or less of the rate of filtration through rapid gravity filter. Du to low filtration rate, slow sand filters require large area of land and are costly to install. They are expensive to operate due to laborious method of bed cleaning by surface scrapping Due to this slow Sand filters are not used these days.

Types of Filters

- A slow sand filter unit consists of the following parts
- Enclosure tank
- Filter media
- Base Material
- Under drainage system
- Inlet & Outlet arrangement
- Other appurtenances

Types of Filters

Enclosure Tank

- It consist of an open water tight rectangular tank made of concrete or masonary. The bed slope is 1 in 100 to 1 in 200 towards the central drain. The depth of tank varies from 2.5 to 4 m. The plan area may vary from 100 to 200 sq.m. depending upon the quantity of water treated.

Types of Filters

Filter Media

- The filter media consist of sand layers about 90 to 110 cm in depth and placed over a gravel support. The effective size varies from 0.2 to 0.35 and uniformity coefficient varies from 2 to 3. Finer is the sand better is the quality of water.

Types of Filters

Base Material

- The filter media is supported on base size material consisting of 30 to 75 cm thick gravel of different sizes, placed in layers, generally 3 to 4 layers of 15 to 20 cm depth are used.

Types of Filters

Under Drainage System

- The base material are supported over the under drainage system which centrally collects the filter water. The water drainage system consists of a central drain collecting water from a number of lateral drains. The lateral drains are open jointed pipe drains or perforated pipes of 7.5 to 10 cm dia spaced at 2 to 4 m centre to centre.

Types of Filters

Inlet & Outlet

- An inlet chamber, is constructed for admitting the effluent from the plain sedimentation tank without disturbing the sand layer of filter and to distribute it uniformly over filter bed

Types of Filters

Other appurtenances

- Various appurtenances that are generally installed for efficient working are the device for
- Measuring loss of head through filter media
- Controlling depth of water above the filter media.
- Maintaining constant rate of flow through filter.

Filters

Efficiency of Slow Sand Filters

- **Bacterial Load**
- The slow sand filter are highly efficient in removal of bacterial load from water. They remove about 98 to 99 % of bacterial Load from raw water.
- **Color**
- The slow sand filter are less efficient in the removal of color of raw water. They remove about 20 to 25 % color of water.
- **Turbidity**
- The slow sand filter are not very effective in removing colloidal turbidity. They can remove turbidity to the extent of about 50 ppm

Example

- Find the area of slow sand filter required for a town having a population of 15000 with average rate of demand as 160 lpcd.

Example

- Maximum daily demand = 15000 x 160 x 1.5
- = 3600000 lit
- Assume the rate of filtration as 150 lit/hr./m^2, the filter area required will be.
- $= \dfrac{3600000}{150 \times 24} = 1000\ m^2$

Let the size of each unit of 20 x 10 = 200 m ^{2}

Then total number of unit required would be 5

Provided one unit as stand by, so provide 6 unit of 20 x 10 m

Rapid Sand Filter

- Rapid sand filters were first developed in last decade of 19^{th} century, on an average these filters may yield as high as 30 times the yield given by the slow sand filter. These filters employ coarser sand with effective size around 0.5 mm. Water from the coagulation sedimentation tank are used in these filters.

Rapid Sand Filter

- A gravity type of rapid sand filters consists of following units
- Enclosure tank
- Filter Media
- Base Material
- Under Drainage System
- Other appurtenances

Rapid Sand Filter

Enclosure tank

- It is generally rectangular in plan, constructed either of masonary or of concrete, coated with water proof material. The depth of the tank varies from 2.5 to 3.5 m. Each unit may have a surface area of 10 to 50 m^2. They are arranged in series. The length to width ratio is kept between 1.25 to 1.35.

Rapid Sand Filter

- Following formula is used to get approximately the number of filter unit beds required
- $$N = \frac{\sqrt{Q}}{4.69}$$

Where N is the number of units or beds and Q is quantity of water in m^3/ hr.... There should be at least 2 units in each plant.

Rapid Sand Filter

Filter media

- The filtering media consists of sand layer, about 60 to 90 cm in depth and placed over a gravel support. The effective size of sand varies from 0.35 to 0.6 mm and the uniformity coefficient ranges between 1.3 to 1.7.

Rapid Sand Filter

Base Material

- The filter sand media is supported on the base material consisting of gravel . In addition to supporting the sand, it distributes the wash water. It total depth varies from 45 to 60 cm. It may be divided into 4 to 5 layers.

Rapid Sand Filter

Under Drainage System

- The under drainage system serves the two purpose
- It collects the filter water uniformly over the area of gravel bed.
- It provides uniform distribution of backwash water without disturbing or upsetting the gravel bed and filter media.

Rapid Sand Filter

- Under drainage should be capable of passing the wash water at a rate of about 300 to 900 lit.min/m^2 . Since the rate application of wash water is much higher then filtration rate, the design of under drainage system is governed by the consideration of even and uniform distribution of wash water.

Rapid Sand Filter

- There are various types of Under drainage System Such as
- Manifold and Lateral
- (a) Perforated & Pipe System
- (b) Pipe and Straining System
- Wheeler System
- Leopald System

Rapid Sand Filter

Manifold and Lateral

- It consist of a manifold running lengthwise along the centre of the filter bottom. Several pipe called laterals taken off in both the direction at right angle to the manifold. The laterals are placed at a distance of 15 to 30 cm centre to centre.

Rapid Sand Filter

- In perforated pipe type of this system, the laterals are provided with holes at the bottom side. These holes are 6 to 12 mm in dia and make an angle 30 0
- Following thumb rules are use in the design of Under drainage System
- Ratio of the total area of the orifice
- Perforation or holes in lateral
- : 0. 15 to 0.5 % perferable about 0.3 %
- Ratio of C/s area of lateral to the area of orifice served 2 to 4:1
- Dia of Orifice : 6 mm to 18 mm
- Ratio of area of manifold to that of the area of lateral served
- 1.5 to 3:1 preferably
- Spacing of Orifices: 7.5 cm for 6 mm dia
- Spacing of lateral 15 to 30 cm
- Length of lateral: not more than 60 times
- Length of lateral > 60
- Dia of lateral

Rapid Sand Filter

Back Washing

- When the clean filter bed is put in to operation, in the beginning the loss of head is very small, but as the bed gets clogged, the loss of head increases, When the head losses becomes excessive, the filtration rate decreases and the filter bed must be washed
- Rapid gravity filters are washed by sending air and water upward through the bed the reverse flow through the underdrainage system

Efficiency and performance of Rapid Sand Filter

Turbidity

- If the influent water does not have turbidity of more than 35 to 40 mg/lit. Since Coagulation and sedimentation always precedes filtration the turbidity of water applied to filter is always less than 35 to 40 mg/lit.

Bacterial Load

- The rapid sand filter are less effective in removal of bacterial load as compare to slow sand filter. They can remove 80 to 90 % of bacterial load

Color

- Rapid sand filter are very efficient in color removal. The intensity of color can be brought down below 3 on cobalt scale.

Iron & Manganese

- Rapid sand filter remove oxidized or oxidizing iron through it is less efficient in removing manganese

Taste & Odor

- Unless special treatment such as activated carbon or pre chlorination is provided, rapid sand filters will not ordinarily remove taste and odor.

Loss of Head & Negative Head

- When a cleaned bed is put into operation, the loss of head through it will be small usually 15 to 30 cm. as the water is filtered through it, impurities arrested by the filter media, due to which the loss of head goes on increasing. A stage comes when the frictional resistance exceeds the static head above the sand bed, at this stage, the lower portion of media and the under drainage system are under partial vacuum or negative head.
- Due to the formation of negative head, dissolved gases and air are released filling the pores of the filter and the under drainage system.
- In rapid sand filter permissible head loss will be 2.5 m to 3.5 m

Comparison of Slow Sand Filter & Rapid Sand Filter

Item	Slow Sand Filter	Rapid Sand Filter
Rate of filtration	100 to 200 lit/ hr./m^2	3000 to 6000 lit/hr./m^2
Loss of head	15 cm to 100 cm	30 cm to 3 m
Area	Requires Larger Area	Requires smaller area
Coagulation	Not Required	Essential
Filter media	Effective Size 0.2 to 0.35 mm Depth 90 to 110cm	Effective size 0.35 to 0.6 mm Depth 60 to 90 cm
Base material	Size 3 to 65 mm Depth 30 to 75 cm	Size. 3 to 40 mm Depth 40 to 65 mm
Method of cleaning	Scrapping the top layer	Agitation and back washing

Comparison of Slow Sand Filter & Rapid Sand Filter

Item	Slow Sand Filter	Rapid Sand Filter
Amount of wash water required	0.2 to 0.6 % of water filtered	2 to 4 % water filtered
Efficiency	Very efficient in the removal of bacteria less efficient in removal of color and turbidity.	Less efficient in removal of bacteria more efficient in the removal of color & turbidity.
Cost	High initial cost	Cheap & economical
Cost of maintenance	Less	More
Skilled Supervision	Not essential	Essential
Depreciation Cost	Relatively low	Relatively high.

Example

- A City has population of 50,000 with an average rate of demand of 160 lpcd find area of rapid sand filters. Also find number of units or beds required.

Example

- Population= 50,000
- Rate of water supply= 160
- Maximum daily demand per day= 1.5 x 160 x 50000
- = 12×10^6 lit /day
- Assume rate of filtration = 4500 lit /hr./sq.m
- Area of filter beds required= $\frac{12 \times 10^6}{24 \times 4500}$

= $111.11\ m^2$

Example

- Number of filter beds can be found out by
- (i) assuming area of one bed/ unit and then finding out the number of beds/ units required.
- (ii) By using the following eel
- $N = \frac{\sqrt{Q}}{4.69}$

Where, N= No of beds

Q= Quantity of water to be filtered in m^3 /hr...

Example

- Q= 12 MLD
- $= \frac{12 \times 10^{6} \times 10^{-3}}{24}$

$= 500\ m^{3}/hr...$

$N = \frac{\sqrt{Q}}{4.69}$

$= \frac{\sqrt{500}}{4.69}$

= 5 units

Area of each unit $= \frac{111.11}{5}$

= 22.22

Example

Assume L:B ratio as 1.3

L= 1.3 B

A= 1,3 B x B

= 22.22= 1.3 B x B

B= 4.13 m

L= 1.3 x 4.13

= 5.369 m

Provide B= 4.2 m and L= 5.4 m

Provide 6 such units one as stand by

Example

- Design a rapid sand filter Unit for supplying 10 MLD to a town with all its principle components

Example

Step–I Design of filter Units

- Water Required per day= 10 MLD
- Assuming that 3 % of filtered water is used for washing of filter every day
- Therefore total filter water required per day
- = 1.03 x 10
- = 10.3 MLD
- $\frac{10.3}{24-0.5}$ = 0.438 ML/hr
- Assuming the rate of filtration as 5000 lit /hr./m ^{2}
- Area of filter required= $\frac{0.438 \times 10^6}{5000}$

= 87.6 sq.

Example

- No of Unis Required
- $N = \frac{\sqrt{Q}}{4.69}$

$= \frac{\sqrt{438}}{4.69}$

= 4.46

= 5

Area of each Unit $= \frac{87.6}{5}$

= 17.52

Assume L/B= 1.3

1.3 B x B= 17.52

B= 3.67= 3.7 m

L= 3.67 x 1.3 = 4.771= 4.8m

Say provide total 6 units of 4.8 m x 3.7 m

Design of Under drainage System

- Laterals & manifold system is used for Underdrainage System
- Let us assume that the total area of perforations in the underdrainage system as 0.3 % of area of filter bed/ unit.
- $\frac{0.3 \times 4.8 \times 3.7}{100} = 0.533\ m^2 = 533\ cm^2$
- Total Area of Laterals= 2 time the area of perforation
- = 2 x 533
- = 1066 cm^2 = 0.1066 m^2
- Assume the area of manifold as twice the total area of laterals we have
- Area of manifold= 2 x 0.1066
- = 0,2132 m^2
- = 0.52 m
- Let us provide manifold of 0.55 or 55 cm let the spacing of lateral as 15 cm

Design of Under drainage System

- Hence number of laterals = $\frac{4.8 \times 100}{15}$

= 32 laterals

Hence provide 32 laterals on either side of the manifold

Hence total no of lateral in each filter unit

= 2 x 32 = 64

Length of each lateral =

$\frac{\text{width of filter} - \text{dia of manifold}}{2}$

= $\frac{3.7 - 0.55}{2}$

= 1.575 m

Let n be the total no of perforation, each of 12 mm dia in all 64 laterals

Design of Under drainage System

- Total area of perforations= 533 cm^2
- $\frac{n \times \prod (1.2)^2}{4} = 533$

n= 472

No of perforations = $\frac{472}{64}$

= 7.8

Hence provide 8 perforation per lateral

Area of perforation per lateral = $8 \times \frac{\prod \times (1.2)^2}{4}$

= 9.04 x 2 = 18.08 cm^2

Therefore dia of lateral = $\left(\frac{18.8 \times 4}{\prod}\right)^{1/2}$ = 4.8 cm

Hence provide 64 laterals each of 4.8 cm at 15 cm c/c spacing and having 8 perforations of 12 mm dia

Design of Under drainage System

$$\frac{\text{Length of Lateral}}{\text{Dia of Lateral}} = \frac{1.575 \times 100}{4.8} = 32.81 < 60$$

- Also spacing of perforation = $\frac{1.575}{8}$ = 20
- Therefore O.K.

Thank You

INTRODUCTION

- The ultimate aim of waste water treatment process or drinking water purification process is to provide water which is free from any pathogenic microorganism
- Primary, secondary even tertiary treatment cannot be expected to remove 100 percent of the incoming waste load and many microorganisms still remain in waste water stream.
- Disinfection is carried out to destroy pathogenic microorganism in waste water that may remain in waste water even after primary,secondary and tertiary treatment.

DISINFECTION

- Sewage disinfection is defined as process of destroying pathogenic microorganisms in the waste water stream by physical or chemical treatment.
- The main aim of sewage disinfection is to prevent spread of diseases

  protect potable water supplies ,bathing beaches ,shellfish growing areas etc…..

- Disinfection process is affected by various factors:

1. The nature of water to be disinfected.
2. The temperature of water to be disinfected.
3. The Ph is either acidity or alkalinity of the water.
4. The nature and number of organisms to be destroyed.
5. The type and concentration of the disinfectant employed.
6. Mixing of water and the disinfectant.
7. The time of contact.

- Disinfection can be done by two methods:

  Physical Methods

  - heating to boiling
  - incineration
  - irradiation with X-rays or UV rays

  Chemical Methods

  - Chlorination
  - Ozonation

UV LIGHT

- UV light is an electromagnetic radiation with a wavelength of approximately 200-400 nm.
- It has been used since the early 1900s in Europe for the disinfection of municipal water supplies.
- A major reason for this is that UV adds nothing to waste water during disinfection process.
- UV light disinfects by altering the DNA of the bacterial cells that are exposed.

- In waste water treatment plants,UV light is produced by low pressure mercury lamps.
- These lamps ,which provide radiation of 253.7 nm ,are usually housed in specially fused quartz sleeves(acts as electrical insulator & as temperature buffer).
- For the UV disinfection process to be effective ,the UV radiation must be directed on the bacteria.
- To achieve disinfection ,most bacteria require 6000-13000 microwatt per seconds of exposure.

DISADVANTAGES

1. High cost of operation.
2. Anything that can prevent the UV from reaching the bacteria will prevent an effective kill.
3. UV light tends to ionize compounds and break them apart.

CHEMICAL AGENTS AS DISINFECTANTS

REQUERMENTS OF A GOOD CHEMICAL DISINFECTANT ARE:

1. Should quick and effective in killing pathogenic microorganisms present in the water.
2. Should be readily soluble in water at concentration required for disinfection and it should also leave a residual effect.
3. Should not impart any taste ,odor or color to water.
4. Should not be toxic to human and animal life.
5. Should be easy to detect and measure in water.
6. Should be easy to handle, transport, apply and control.
7. Should be readily available at moderate cost.

- Of all chemicals agents chlorine is widely used as disinfectant.

ADVANTAGES

- It is readily available as gas ,liquid or powder.
- It is cheap.
- It is easy to apply due to relatively highly solubility(7000mg/ litre).
- It leaves a residual in solution ,which while not harmful to man, provides protection in the distribution system.
- It is toxic to most microorganisms ,interfering with metabolic activities.
- It also plays an important role in the treatment of cyanide wastes which are highly toxic.

CHLORINATION

- Disinfection of water with chlorine is generally refered to as chlorination.
- Chlorine was first used as a disinfectant around 1800 A.D. by de Morveau in France and by Cruikshank in England.
- The primary use of chlorine in sewage disposal system was for odor control , hydrogen sulphide destruction and prevention of septicity.
- Although chlorine is a strong oxidising agent its toxicity against microorganisms is not due to its oxidation effect.
- Actually chlorine interferes with vital enzymes of microorganisms and this brings out their death.

- Chlorine when added to water undergoes various reactions with water and other constituents in water.
- The first important reaction is the formation of hypochlorous acid (HOCl).
- HOCl is acid is a weak acid and often dissociates to H+and OCl¯ ions.
- The extent of dissociation actually depends on the ph.
- The preferred ph for disinfection with chlorine is 6.7.
- In the presence of ammonia in water ,hypochlorous acid reacts with ammonium ion and successively gives monochloramine ,dichloramine ,trichloramine.

- The chloramines ,along with other chlorine compounds are referred to as combined chlorine residuals or combined available chlorine.
- Chlorine ,hypochlorous acid and chlorite ion are collectively referred to as free chlorine residuals or free available chlorine.

METHODS OF CHLORINATION

BREAKPOINT CHLORINATION

- If the water to be chlorinated contains significant amounts of ammonia the amount of chlorine added will be sufficient only to form monochloramine.
- Further addition of chlorine may lead to formation of di-or tri-chloramines.
- But their formation can be prevented by maintaining the chlorine to nitrogen ratio very low.

- Mixtures of mono and di-chloramines are usually unstable.
- Tri-chloramine is also unstable in presence of mono-chloramine.
- At this stage further addition of chlorine causes a break down of chloramines.
- Thus a break point is reached where no ammonia or mono-chloramine is left in the solution and no free available chlorine is present.
- Further addition of chlorine produces free available chlorine in water .
- Adding chlorine to exceed the breakpoint is called breakpoint chlorination.

SUPER CHLORINATION

- Sometimes the quality of raw water may be uncertain and may be cases where the presence of resistant microorganisms may be suspected.
- In these cases addition of chlorine in excess amounts may be required for a given period of contact time.This type of chlorination is referred to as super chlorination.

CHLORAMINATION

- In certain cases presence of combined available chlorine may be desirable over that of free available chlorine in spite of their low disinfective capacity.
- For eg. Chloramination of water rich in organic matter may give undesirable odor .
- But chloramines are reactive towards organic matter , thus in this case chloramines are preferred over hypochlorous acid.
- In chloramination formation of monochloramine is favoured by the addition of chlorine along with ammonia to water.

CHLORINE DIOXIDE

- Chlorine dioxide is treated as a separate disinfectant since it is not formed by the direct addition of chlorine to water.
- Also it is not a product from the reaction of chlorine with any compound in water.
- Chlorine dioxide can be generated by adding either chlorine or hydrochloric acid in sodium chlorite.
- Chlorine dioxide is a more powerful disinfectant than chlorine in alkaline conditions.
- It does not combine with ammonia and hence can be used to obtain free chlorine residuals even in waters with high ammonium content.
- The disadvantage is it is much more expensive.

- The amount of chlorine used up by organic and inorganic reducing substances is defined as chlorine demand.

Chlorine demand =

Applied chlorine dose-chlorine residual

- Disinfection is carried out by that amount of chlorine remaining after the chlorine demand has satisfied.
- This quantity is defined as residual chlorine and expressed as mg per litre.

DISADVANTAGES OF CHLORINE

1. It is a toxic gas and need careful handling.

1. It can cause taste and odor problems especially in the presence of phenols.

CHLORINATION BY-PRODUCTS

- By-products created from the reactions between inorganic compounds and chlorine are harmless and can be easily removed by filtration.
- Other by-products such as chloramine are beneficial to disinfection process.
- Other by-products are:
  - TRIHALOMETHANES
- Formed by reaction between chlorine and organic material such as humic acid and fulvic acid to create haloginated organics.

- Trihalomethanes are carcinogenic.
- The trihalomethane of most concern is chloroform.
- Chronic exposure may cause damage to liver and kidneys.

> TRICHLOROACETIC ACID

- Produced commercially for use as a herbicide and is also produced in drinking water.

> DICHLOROACETIC ACID

- It is an irritant ,corrosive and destructive against mucous membrane.

> HALOACETONITRILES

- Used as pesticide in the past ,but no longer manufactured.

- They are produced as a result of reaction between chlorine ,natural organic matter and bromide.

- CHLOROPHENOLS
- Cause taste and odor problems.
- They are toxic when present in higher concentrations.
- Affect the respiration and energy storage process in the body.