SSIT POLYTECHNIC, KALAKAD, KARANJIA

LECTURE NOTE WATER SUPPLY & WASTE WATER ENGINEERING, (Th.4) SEM-5 TH BRANCH-CIVIL ENGINEERING

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Necessity of Treated Water Supply

Introduction to Water Supply, Quantity and Quality of Water

This section covers the necessity of treated water supply, per capita demand, variation in demand, and factors affecting demand. It also includes methods of forecasting population with numerical problems, and the analysis of water for physical, chemical, and bacteriological impurities.

- **Necessity of treated water supply**
- **Per capita demand, variation in demand and factors affecting demand**
- **Methods of forecasting population, Numerical problems using different methods**
- **Impurities in water organic and inorganic, Harmful effects of impurities**
- **Analysis of water –physical, chemical, and bacteriological**

Water Quality Standards for Different Use

Definition and Importance of Water

Water is one of the most essential natural resources. Life cannot exist without water. It is needed for:

- Drinking and cooking
- Bathing and washing
- Agriculture (irrigation)
- Industrial processes
- Firefighting
- Public sanitation

Objectives of Water Supply Engineering

To provide safe and adequate water to the public.

To ensure continuous supply with proper pressure.

To maintain water quality standards.

To design, construct, and maintain efficient water supply systems.

Necessity Of Treated Water Supply

Removes harmful germs and disease-causing bacteria.

Ensures safe drinking water for domestic use.

Required for industries, hospitals, and public places.

Prevents waterborne diseases like cholera, typhoid, and dysentery.

Improves odor, color, and taste of water.

Per Capita Demand, Variation in Demand and Factors Affecting Demand

Various Types of Water Demands

While designing the water supply scheme for a town or city, it is necessary to determine the total quantity of water required for various purposes by the city. As a matter of fact, the first duty of the engineer is to determine the water demand of the town and then to find suitable water sources from where the demand can be met. But as there are so many factors involved in demand of water, it is not possible to accurately determine the actual demand. Certain empirical formulae and thumb rules are employed in determining the water demand, which is very near to the actual demand.

Following are the various types of water demands of a city or town:

- Domestic water demand
- Industrial demand
- Institution and commercial demand
- Demand for public use
- Fire demand
- Loses and wastes

Per Capita Demand, Variation in Demand & Factors Affecting Demand

Per capita demand is the average quantity of water required per person per day, measured in LPCD (litres per capita per day).

Formula: Per Capita Demand = Total Water Requirement per Day / Population Standard in India: 135 LPCD

Drinking	5 litres
Cooking	5 litres
Bathing	55 litres
Clothes washing	20 litres
Utensils washing	10 litres
House washing	10 litres
Other uses	20 litres
Total	135 litres/day/capita

Types of Water Demand

Domestic Water Demand

Domestic water demand refers to the amount of water needed for household activities. In India, a common estimate for domestic water demand is 200 litres per capita per day (lpcd), according to the Bureau of Indian Standards. This includes water for drinking, cooking, washing clothes and utensils, bathing, and toilet use.

Industrial Demand

The water required in the industries mainly depends on the type of industries, which are existing in the city. The water required by factories, paper mills, Cloth mills, cotton mills, Breweries, Sugar refineries etc. comes under industrial use. The quantity of water demand for industrial purpose is around 20 to 25% of the total demand of the city.

Institution and Commercial Demand

Universities, Institution, commercial buildings and commercial centers including office buildings, warehouses, stores, hotels, shopping centers, health centers, schools, temple, cinema houses, railway and bus stations etc comes under this category.

Demand for Public Use

Quantity of water required for public utility purposes such as for washing and sprinkling on roads, cleaning of sewers, watering of public parks, gardens, public fountains etc comes under public demand. To meet the water demand for public use, provision of 5% of the total consumption is made designing the water works for a city.

Fire Demand

Fire may take place due to faulty electric wires by short circuiting, fire catching materials, explosions, bad intension of criminal people or any other unforeseen mishappenings. If fires are not properly controlled and extinguished in minimum possible time, they lead to serious damage and may burn cities.

Empirical Formulae for calculating fire demand

(1) National board of Fire underwriters 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

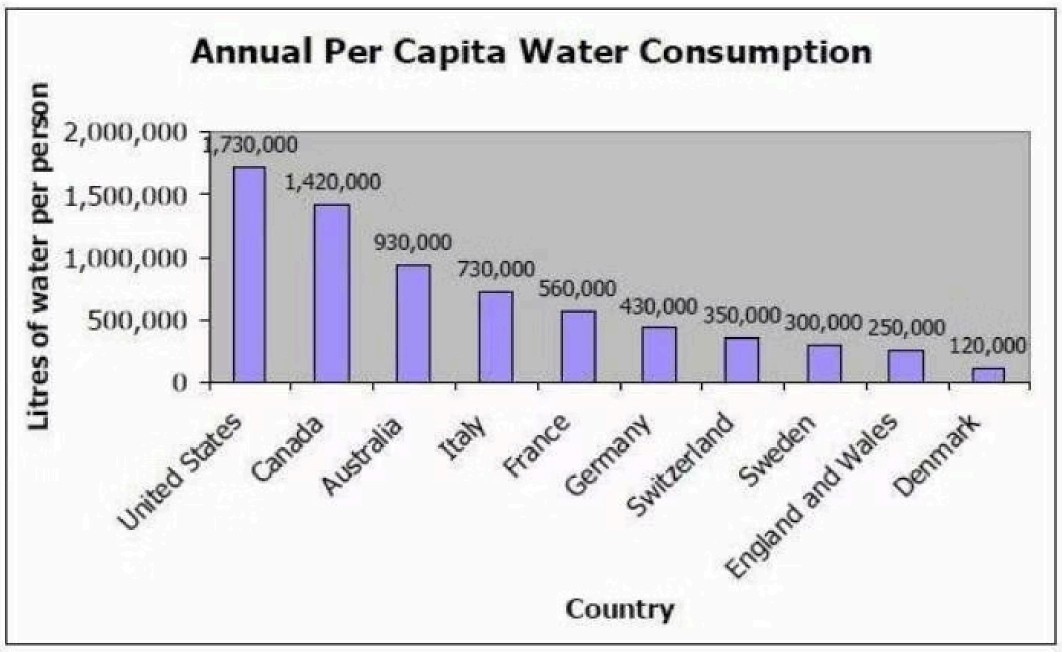
$$Q = 3182\sqrt{P}$$

(4) Buston's formula

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

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

and P = Population of town (in thousands)



Per Capita Water Demand and Variations

If 'Q' is the total quantity of water required by various purposes by a town per year and 'P' is population of town, then per capita demand will be

$$Q/(Px365) litres/day$$

Per capita demand of the town depends on various factors like standard of living, no. and type of commercial places in a town etc. For an average Indian town, the requirement of water in various uses is as under:

Income Group	Litres/c/d	Litres/c/d
Litres/c/d	40 lpcd	15 lpcd
200 lpcd	25 lpcd	55 lpcd

Total: 270 lpcd 335 lpcd

The total quantity of water required by the town per day shall be 270 multiplied with the total population in litres/day.

Variations in Demand

The per capita demand of town is the average consumption of water for a year. In practice it has been seen that this demand does not remain uniform throughout the year but it varies from season to season, even hour to hour.

Seasonal Variations

The water demand varies from season to season. In summer the water demand is maximum, because the people will use more water in bathing, cooling, lawn watering and street sprinkling. This demand will become minimum in winter because less water will be used in bathing and there will be no lawn watering. The variations may be upto 15% of the average demand of the year.

Daily and Hourly Variations in Water Demand

Daily Variations

This variation depends on the general habits of people, climatic conditions and character of city as industrial, commercial or residential. More water demand will be on Sundays and holidays due to more comfortable bathing, washing etc as compared to other working days. The maximum daily consumption is usually taken as 180% of the average consumption.

Hourly Variations

On Sundays and other holidays the peak hours may be about 8 A.M. due to late awakening where as it may be 6 A.M. to 10 A.M. and 4 P.M. to 8 P.M. and minimum flow may be between 12 P.M. to 4 P.M. when most of the people are sleeping. But in highly industrial city where both day and night shifts are working, the consumption in night may be more. The maximum consumption may be rise up to 200% that of average daily demand. The determination of this hourly variations is most necessary, because on its basis the rate of pumping will be adjusted to meet up the demand in all hours.

1

Average Daily Per Capita Demand

= Quantity Required in 12 Months/ (365 x Population)

2

Maximum daily demand

= 1.8 x average daily demand

3

Maximum hourly demand of maximum day i.e. Peak demand

= 1.5 x average hourly demand

= 1.5 x Maximum daily demand/24

= 1.5 x (1.8 x average daily demand)/24

= 2.7 x average daily demand/24

= 2.7 x annual average hourly demand

Factors Affecting Per Capita Demand

The following are the main factors affecting per capita demand of the city or town.

1

Climatic conditions

The quantity of water required in hotter and dry places is more than cold countries because of the use of air coolers, air conditioners, sprinkling of water in lawns, gardens, courtyards, washing of rooms, more washing of clothes and bathing etc. But in very cold countries sometimes the quantity of water required may be more due to wastage, because at such places the people often keep their taps open and water continuously flows for fear of freezing of water in the taps and use of hot water for keeping the rooms warm.

2

Size of community

Water demand is more with increase of size of town because more water is required in street washing, running of sewers, maintenance of parks and gardens.

3

Living standard of the people

The per capita demand of the town increases with the standard of living of the people because of the use of air conditioners, room coolers, maintenance of lawns, use of flush, latrines and automatic home appliances etc.

4

Industrial and commercial activities

As the quantity of water required in certain industries is much more than domestic demand, their presence in the town will enormously increase per capita demand of the town. As a matter of the fact the water required by the industries has no direct link with the population of the town.

5

Pressure in the distribution system

The rate of water consumption increase in the pressure of the building and even with the required pressure at the farthest point, the consumption of water will automatically increase. This increase in the quantity is firstly due to use of water freely by the people as compared when they get it scarcely and more water loss due to leakage, wastage and thefts etc.

6

System of sanitation

Per capita demand of the towns having water carriage system will be more than the town where this system is not being used.

7

Cost of water

The cost of water directly affects its demand. If the cost of water is more, less quantity of water will be used by the people as compared when the cost is low.

Methods of Forecasting Population

The various methods adopted for estimating future populations are given below. The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discretion and intelligence of the designer.

- Arithmetic Increase Method
- Geometric Increase Method
- Incremental Increase Method
- Decreasing Rate of Growth Method
- Simple Graphical Method
- Comparative Graphical Method
- Ratio Method
- Logistic Curve Method

Arithmetic Increase Method

This method is applied to areas where it is found that the rate of increase of population with time is constant i.e. dP/dt = Constant;

If Pn = Population of an area after any time 't' or Population after 'n' decades Po = Last known Population of that area; n = number of decades (10 years = 1 decade); X' = average increase in population. Then

$$Pn = Po + nx'$$

* This method is suitable for large development.

Example 1

Predict the population for the year 2021, 2031, and 2041 from the following population data.

1961	8,58,545
1971	10,15,672
1981	12,01,553
1991	16,91,538
2001	20,77,820
2011	25,85,862

Solution:

1961	858545	-
1971	1015672	X1 = 157127
1981	1201553	X2 = 185881
1991	1691538	X3 = 489985
2001	2077820	X4 = 386282
2011	2585862	X5 = 508042

X' = (X1+X2+X3+X4+X5) / 5 = (157127 + 185881 + 489985 + 386282 + 50804) ÷ 5 = 345463 Population in year 2021 is, P2021 = 2585862 + 345463 x 1 = 2931325 Similarly P2031 = 2585862 + 345463 x 2 = 3276788 P2041 = 2585862 + 345463 x 3 = 3622251

Geometric and Incremental Increase Methods

Geometric Increase Method

In this method the percentage increase in population from decade to decade is assumed to remain constant. Geometric mean increase is used to find out the future increment in population. The population at the end of nth decade 'Pn' can be estimated as:

$$Ph = Po(1 + \frac{r}{100})^n$$

Where, r = geometric mean (%) Po = last known population N = no. of decades. Pn = population after 'n' decades.

* This method is employed in a rapidly increasing or new city.

$$r = (r1 \times r2 \times \times rn)^1/n$$

Example 2:

Considering data given in example 1 predict the population for the year 2021, 2031, and 2041 using geometrical increase method.

1961	858545	-	-
1971	1015672	X1 = 157127	r1 =(157127/858545) = 0.18
1981	1201553	X2 = 185881	r2 =(185881/1015672) = 0.18
1991	1691538	X3 = 489985	r3 =(489985/1201553) = 0.40
2001	2077820	X4 = 386282	r4 =(386282/1691538) = 0.23
2011	2585862	X5 = 508042	r5 =(508042/2077820) = 0.24

Geometric mean = (0.18 × 0.18 × 0.40 × 0.23 × 0.24)^ 1/5 = 0.235 i.e 23.5 % Population in year 2021 is, P2021 = 2585862 x (1+ 0.235)^1 = 3193540 Similarly for year 2031 and 2041 can be calculated by, P2031 = 2585862 x (1+ 0.235)^2 = 3944021 P2041 = 2585862 x (1+ 0.235)^3 = 4870866

Incremental Increase Method

This method is modification of arithmetical increase method and it is suitable for an average size town under normal condition where the growth rate is found to be in increasing order. While adopting this method the increase in increment is considered for calculating future population. The incremental increase is determined for each decade from the past population and the average value is added to the present population along with the average rate of increase. Hence,

population after nth decade is Pn = P+ n.X + {n (n+1)/2}.Y

Where, Pn = Population after nth decade X = Average increase Y = Average incremental increase

Example 3

Considering data given in example 1 predict the population for the year 2021, 2031, and 2041 using incremental increase method.

1961	858545	-	-
1971	1015672	X1 = 157127	-
1981	1201553	X2 = 185881	+28754
1991	1691538	X3 = 489985	+304104
2001	2077820	X4 = 386282	-103703
2011	2585862	X5 = 508042	+121760
TOTAL	1727317	350915	
	AVERAGE	345463	87729

Population in year 2021 is, P2021 = 2585862 + (345463 x 1) + {(1 (1+1))/2} x 87729 = 3019054 For year 2031 P2031 = 2585862 + (345463 x 2) + {((2 (2+1)/2)}x 87729 = 3539975 P2041 = 2585862 + (345463 x 3) + {((3 (3+1)/2)}x 87729 = 4148625

Impurities in Water: Organic and Inorganic Harmful Effects

Water quality is crucial for various uses, and understanding the types and effects of impurities is essential. Impurities can be broadly categorized into suspended, colloidal, and dissolved, each posing distinct challenges.

Types of Impurities and Their Harmful Effects

Suspended Impurities:

They cause turbidity. The concentration of suspended impurities is measured by turbidity. Eg: silt, clay, bacteria, fungi, algae.

Colloidal Impurities:

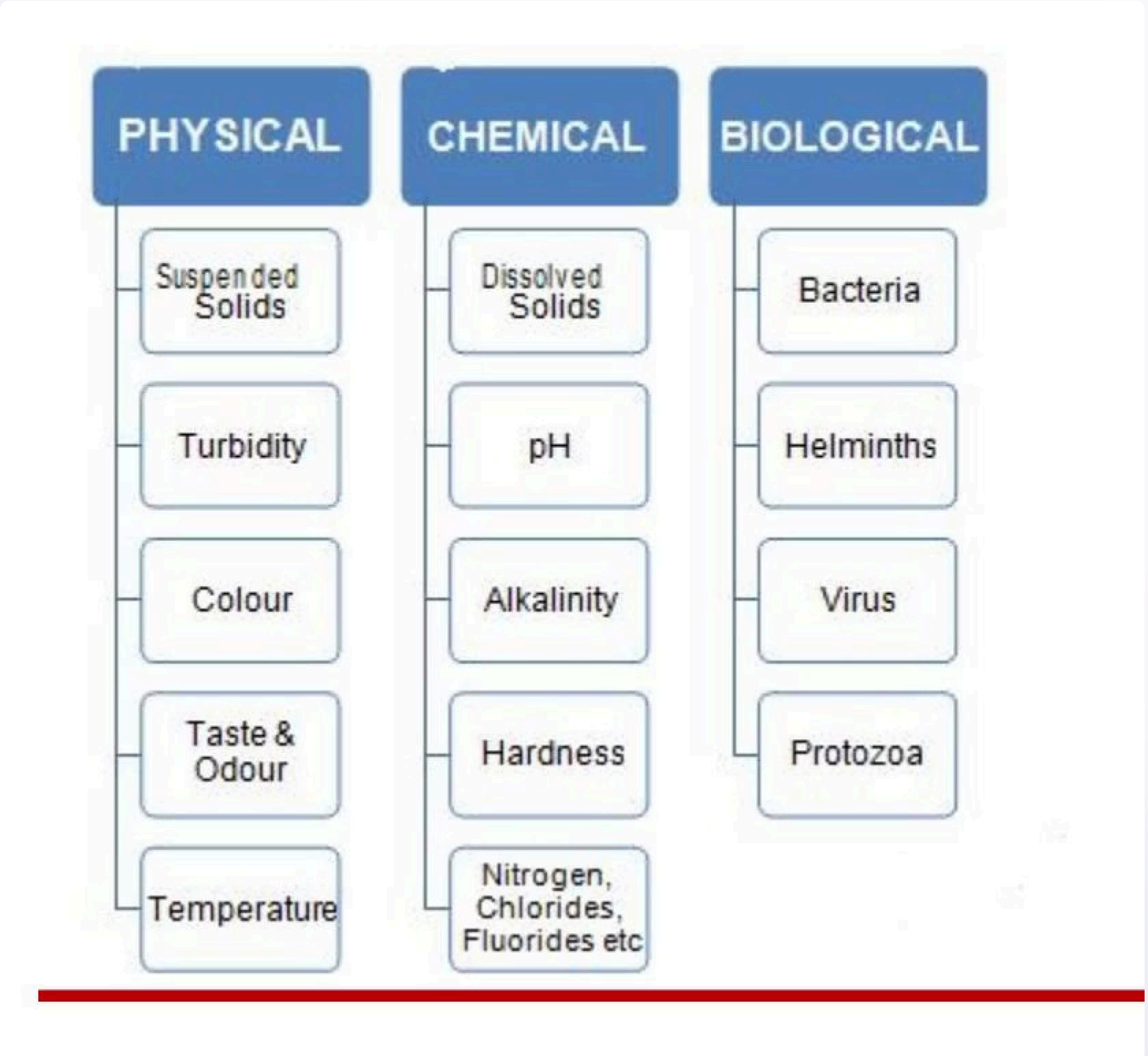
These are finely divided dispersion of solid particles, not various visible to the naked eye. These impurities if associated with organic matter having bacteria becomes the chief source of epidemic.

Dissolved Impurities:

It includes organic compounds, inorganic salts and gases.

- **Salts:** $CaCl_2$, $MgCl_2$, CO_3, HCO_3. They cause hardness and alkalinity in water.
- **Metals:** Iron causes red colour, Manganese causes brown colour. Lead and arsenic: It cause poisoning.
- **Gases:** Oxygen causes corrosion of metals. Chlorine and Ammonia cause bad taste and odour. CO_2, and Hydrogen sulphide cause acidity in water.

Analysis of Water: Physical Characteristics



Physical characteristics of water refer to observable or measurable properties that affect its appearance, taste, and smell but not chemical composition. These parameters are important in water supply engineering.

1

Temperature

Degree of hotness or coldness of water. Ideal Range: 10°C to 25°C. Importance: Affects taste, microbial growth, and chemical solubility.

2

Color

Tint caused by dissolved substances or decaying matter. Measurement: Platinum-Cobalt Scale (Pt-Co Units). Limit (BIS): 5 to 15 Pt-Co Units. Desirable: Colorless water.

3

Turbidity

Cloudiness caused by suspended particles (silt, clay, microbes). Measurement: NTU (Nephelometric Turbidity Unit). Instrument: Nephelometer. Limit: Desirable - 1 NTU, Maximum - 5 NTU.

4

Taste and Odor

Sensory properties affected by organic matter or disinfectants. Measurement: Organoleptic method. Standard: Should be tasteless and odorless.

5

Transparency

Clarity or how light passes through water. Measurement Tool: Secchi Disk. Related to: Turbidity level.

6

Conductivity

Definition: Water's ability to conduct electricity due to dissolved salts. Unit: µS/cm (Microsiemens per centimeter). Indicates: Total ion concentration.

Analysis of Water: Chemical and Bacteriological Characteristics

Chemical Characteristics:

Chemical characteristics refer to the presence and concentration of chemical substances in water that may affect its safety, taste, odor, and usability. These include minerals, salts, metals, and other dissolved substances.

- **pH Value:** Indicates whether water is acidic or basic. Ideal Range: 6.5 to 8.5. Low pH = Acidic (corrosive), High pH = Alkaline (bitter taste).
- **Hardness:** Caused by calcium and magnesium salts. Types: Temporary and Permanent Hardness. Limit: Desirable - 200 mg/L, Maximum - 600 mg/L.
- **Alkalinity:** Ability to neutralize acids; mainly due to bicarbonates, carbonates, hydroxides. Significance: Indicates buffering capacity. Acceptable limit: 200 mg/L.
- **Chlorides:** Source: Sewage, industrial waste, saltwater intrusion. Effect: High level gives salty taste. Limit: Desirable - 250 mg/L, Maximum - 1000 mg/L.
- **Nitrates:** Source: Agricultural runoff, sewage. Effect: Causes 'blue baby syndrome' in infants. Limit: Maximum - 45 mg/L.
- **Fluorides:** Effect: Helps in dental protection in low levels, toxic in high. Limit: Desirable - 1.0 mg/L, Maximum - 1.5 mg/L.
- **Iron and Manganese:** Source: Natural minerals in soil. Effect: Metallic taste, staining. Limit: Iron - 0.3 mg/L, Manganese - 0.1 mg/L.
- **Sulphates:** Effect: High levels cause taste issues, laxative effect. Limit: Desirable - 200 mg/L, Maximum - 400 mg/L.
- **Dissolved Oxygen (DO):** Indicates: Water freshness and aerobic condition. Low DO: Indicates pollution or organic decay. Standard: >5 mg/L for drinking water.
- **Chemical Oxygen Demand (COD) & Biological Oxygen Demand (BOD):** COD: Total amount of oxygen needed to oxidize chemicals. BOD: Oxygen needed by bacteria to decompose organic matter. High BOD/COD = Pollution.

Bacteriological Characteristics:

Bacterial examination of water is very important, since it indicates the degree of pollution. Water polluted by sewage contain one or more species of disease producing pathogenic bacteria. Pathogenic organisms cause water borne diseases, and many non pathogenic bacteria such as E.Coli, a member of coliform group, also live in the intestinal tract of human beings. Coliform itself is not a harmful group but it has more resistance to adverse condition than any other group. So, if it is ensured to minimize the number of coliforms, the harmful species will be very less. So, coliform group serves as indicator of contamination of water with sewage and presence of pathogens.

The methods to estimate the bacterial quality of water are:

- Standard Plate Count Test
- Most Probable Number
- Membrane Filter Technique

Water Quality Standards for Different Uses

Turbidity (NTU unit)	25	
Colour (Hazen scale)	< 10	50
Taste and Odour	Un-objectionable	Un-objectionable
pH	7.0-8.5	6.5-9.2
Total Dissolved Solids mg/l	500-1500	3000
Total Hardness mg/l (as $CaCO_3$)	200-300	600
Chlorides mg/l (as Cl)	200-250	1000
Sulphates mg/l (as SO_4)	150-200	400
Fluorides mg/l (as F)	0.6-1.2	1.5
Nitrates mg/l (as NO_3)	45	45
Calcium mg/l (as Ca)	75	200
Iron mg/l (as Fe)	0.1-0.3	1.0

Water Quality: Questions and Answers

LONG ANSWER TYPE QUESTION

1. What are the various types of water demand ?
2. What do you mean by per capita demand and fluctuation of demand ?
3. State the factors that affect the rate of water demand
4. State the method of population forecasting ?
5. State different type of physical , chemical, biological characteristics of water.

SHORT ANSWER TYPE QUESTION

1. What do you mean by per capita demand ?
2. What are the emperical formulae used for calculating fire demand ?
3. Differentiate between permanent hardness and temporary hardness
4. What is the difference between suspended particle and colloidal particle ?
5. Name various types of water demand.

MULTIPLE CHOICE TYPE QUESTIONS

1. The nitrate concentration in domestic water supplies, is generally limited to
   (A) 10 ppm (B) 15 ppm (C) 30 ppm (D) 45 ppm
   Correct Answer: Option D
2. Carbonates in water produce
   (A) Temporary hardness (B) Permanent hardness (C) Acidity (D) Alkanity
   Correct Answer: Option A
3. The ratio of maximum hourly consumption and average hourly consumption of the maximum day, is
   (A) 1.2 (B) 1.5 (C) 1.8 (D) 2.7
   Correct Answer: Option D
4. Mathamoglobinemia or blue baby disease is caused due to
   (A) Chlorides (B) Nitrites (C) Nitrates (D) Sulphides
   Correct Answer: Option C
5. Maximum threshold number permitted for indicating the odour of public water supplies, is
   (A) 1 (B) 2 (C) 3 (D) 4
   Correct Answer: Option C
6. As per IS : 1172-1963, water required per head per day for average domestic purposes, is
   A.50 litres B.65 litres C.85 litres D.105 litres E.135 litres.
   Answer: Option E
7. Increase in population of a rapidly growing city, may be estimated by
   A.arithmetical mean method B.geometrical method C.incremental increase method D.graphical comparison method.
   Answer: Option B
8. The prescribed hardness limit of potable water ranges between
   A. 50 to 75 P.P.M. B. 75 to 115 P.P.M. C. 100 to 150 P.P.M. D. 150 to 200 P.P.M.
   Answer: Option B
9. For maximum alkalinity of water, pH value should be
   A.zero B.less than 7 C.more than 7 D.14
   Answer: Option D
10. According to Buston's formula, fire demand in litres per minute for a population of P thousands, is
    A.3182 $\sqrt{P}$ B.4637$\sqrt{P}$ (1 - 0.01 $\sqrt{P}$) C.5663 $\sqrt{P}$ D.none of the above
    Answer: Option C
11. To detect the turbidity of the order of 0 to 1000 P.P.M. the instrument used is
    A.turbidimeter B.Jackson turbidimeter C.Baylis turbidimeter D.Hallige turbidimeter.
    Answer: Option C
12. Color test of water is done with an instrument called
    A. Tintometer B. Colorimeter C. Electro-chemical cell D. Turbidimeter
    Answer: Option A

Yield of Well

It is defined as the rate of pumping of water from the well without causing its failure. Measurement of an open yield: The yield can be determined by the following two methods:

Methods of Yield Determination

1

Actual Pumping Method

The specific yield of a well can be determined by the following formula:

$$C'/A = (2.303/T)\log_{10}(S_1/S_2)$$

Where:

- C'/A = Specific yield
- S1 = Depression head in the well at the time immediately after the pumping was stopped.
- S2 = Depression head in the well at time t" after the pumping was stopped.
- T = Time after pumping when measurement S2 was taken.

Knowing the value of C'/A, the discharge — Q of the well can be determined by:

$$Q = (C'/A) \times A \times S$$

Where:

- A = Cross sectional area of the well
- S = Depression head

2

Theoretical Method

The approximate quantity of water entering or percolating in the wall can be calculated as:

$$Q = A \times V \times B$$

Where:

- A = cross sectional area of the well opening
- V = Velocity of water percolating in the well
- B = Permeability constant.

Numerical Problem: Yield from Well

The water level in an open well was depressed by pumping up to 3.0 meter. The water level was raised by 1.5meter within 50 minutes just after stopping the pumping. Determine Yield from well, if the diameter of the well is 2.5 meter & the depression head is 3.3 meter.

Given:

$S1 = 3.0m$

$S2 = 3 – 1.5 = 1.5m$

$T = 50$ minutes $= 3000$ sec

$d = 2.5m$

$S = 3.3m$

$C'/ A = (2.3 / T) \log10 (S1 /S2)$

$C'/A = (2.3/3000) \log10 (3/1.5)$

$C'/A = 0.0002307$

If $d = 2.5m$ & $S= 3.3m$, then $A = 3.142d^2 = 4.909\ m^2$

Then $Q = (C'/A) *A *S = 0.0002307 * 4.909 * 3.3 = 3.737 * 10^{-3}$ litre per second

Question Bank – Chapter 2: Sources and Conveyance of Water

2.1 Surface Sources – Lake, Stream, River, and Impounded Reservoir

Short Answer Questions:

1. Define surface sources of water.
2. Give two examples each of surface water sources.
3. What is an impounded reservoir?

Long/Descriptive Questions:

1. Compare rivers, lakes, and reservoirs as water sources.
2. Explain advantages and disadvantages of river and lake water as sources of supply.

2.2 Underground Sources – Aquifer Types & Occurrence, Infiltration Gallery, Infiltration Well, Springs, Well

Short Answer Questions:

1. What is an aquifer? Name its types.
2. Define infiltration gallery and infiltration well.
3. What is the difference between a spring and a well?

Long/Descriptive Questions:

1. Explain confined and unconfined aquifers with diagrams.
2. Describe the working and location suitability of infiltration galleries.
3. Compare shallow and deep wells.

2.3 Yield from Well – Methods of Determination, Numerical Problems

Short/Concept Questions:

1. Define yield of a well.
2. Name the methods used to determine well yield.

Long/Procedure Questions:

1. Explain the constant level method and recuperation method of yield estimation.
2. State the factors affecting yield from wells.

Numerical Questions:

1. Solve numerical using constant level method.
2. Solve numerical using recuperation test method.

2.4 Intakes – Types and Description of River, Reservoir, Canal Intakes

Short Questions:

1. What is an intake structure?
2. List types of water intakes.

Descriptive Questions:

1. Describe river intake with a neat sketch.
2. Explain reservoir intake structure and its working.
3. Compare canal and reservoir intake structures.

2.5 Pumps for Conveyance and Distribution – Types, Selection, Installation

Short Questions:

1. Define pump and its necessity in water supply.
2. What factors are considered for selecting a pump?

Long Questions:

1. Differentiate between centrifugal and reciprocating pumps.
2. Explain installation procedure of a centrifugal pump.
3. Describe the working of any one pump with a diagram.

2.6 Pipe Materials – Necessity, Suitability, Merits & Demerits

Short Questions:

1. Name commonly used pipe materials.
2. Why are CI and PVC pipes used in water supply?

Long Questions:

1. Compare Cast Iron, Steel, RCC, and HDPE pipes for water supply.
2. List the advantages and disadvantages of asbestos cement pipes.

2.7 Pipe Joints – Necessity, Types, Suitability, Methods of Jointing

Short Questions:

1. What is the purpose of pipe joints?
2. Name different types of pipe joints.

Descriptive Questions:

1. Explain socket and spigot joint with a sketch.
2. Discuss suitability of flanged and collar joints.
3. Describe the method of laying pipes in the field.

Long Answer Questions – Chapter 2: Sources and Conveyance of Water

2.1 Surface Sources – Lake, Stream, River, and Impounded Reservoir

1. Compare lakes, streams, rivers, and impounded reservoirs as sources of water supply.
2. Discuss the merits and demerits of surface water sources with examples.
3. Explain the criteria for selecting a surface source for a water supply scheme.

2.2 Underground Sources – Aquifer Types & Occurrence, Infiltration Gallery, Infiltration Well, Springs, Well

1. Describe the different types of aquifers with neat sketches.
2. Explain the occurrence and movement of groundwater.
3. Describe the construction and working of an infiltration gallery.
4. Compare infiltration gallery and infiltration well in terms of construction and application.
5. Write a note on springs and their types with examples.
6. Differentiate between shallow well and deep well with respect to yield, depth, and construction.

2.3 Yield from Well – Methods of Determination

1. Explain the Constant Level Method and Recuperation Method for determining yield of a well with formulae.
2. List and explain the factors affecting the yield of a well.
3. Describe step-by-step procedure to determine well yield using the recuperation test.

2.4 Intakes – Types, Description of River Intake, Reservoir Intake, Canal Intake

1. Describe the construction and working of a river intake structure with a neat diagram.
2. Explain the features and suitability of a reservoir intake.
3. Compare canal intake and reservoir intake based on design, function, and use.
4. Explain the general criteria and requirements of a good intake structure.

2.5 Pumps for Conveyance and Distribution – Types, Selection, Installation

1. Differentiate between centrifugal and reciprocating pumps with diagrams.
2. Explain the working principle and components of a centrifugal pump.
3. List the factors to be considered while selecting a pump for water supply.
4. Describe the installation procedure of a pump in a water distribution system.

2.6 Pipe Materials – Necessity, Suitability, Merits and Demerits

1. Compare Cast Iron, Steel, PVC, and RCC pipes in terms of cost, durability, and usage.
2. Discuss the suitability, advantages, and disadvantages of AC (Asbestos Cement) pipes.
3. Explain the necessity of selecting appropriate pipe materials in water supply systems.

2.7 Pipe Joints – Necessity, Types, Suitability, Methods of Jointing

1. Explain the necessity and classification of pipe joints.
2. Describe socket and spigot joint and flanged joint with neat sketches.
3. Explain the method of laying pipes and the precautions taken during jointing.
4. Compare different types of pipe joints in terms of application and durability.

Treatment of Water

This document outlines the essential aspects of water treatment, from intake structures to various treatment processes and the conveyance and distribution of treated water.

Notes on Water Treatment

- Design of treatment units excluded.
- Students may be asked to prepare detailed sketches of units, preferably from working drawing, as home assignment.
- Field visit to treatment plant, under practical should be arranged after covering this unit.

3.1 Flow Diagram of Conventional Water Treatment System

3.2 Treatment Process / Units:

3.2.1 Aeration

Necessity

3.2.2 Plain Sedimentation

Necessity, working principles, Sedimentation tanks – types, essential features, operation & maintenance

3.2.3 Sedimentation with Coagulation

Necessity, principles of coagulation, types of coagulants, Flash Mixer, Flocculator, Clarifier (Definition and concept only)

3.2.4 Filtration

Necessity, principles, types of filters Slow Sand Filter, Rapid Sand Filter and Pressure Filter – essential features

3.2.5 Disinfection

Necessity, methods of disinfection Chlorination – free and combined chlorine demand, available chlorine, residual chlorine, pre-chlorination, break point chlorination, superchlorination

3.2.6 Softening of Water

Necessity, Methods of softening – Lime soda process and Ion exchange method (Concept Only)

Intakes

Intakes – types, description of river intake, reservoir intake, canal intake

Intake structures are used for collecting water from the surface sources such as river, lake, and reservoir and conveying it further to the water treatment plant.

- 2.1 These structures are masonry or concrete structures and provides relatively clean water, free from pollution, sand and objectionable floating material.
- 2.2 An intake structure consist of two sections-
- 2.3 intake conduit with screen at inlet end and valve to control the flow of water and
- 2.4 the structure permitting the withdrawal of water from source and housing and supporting intake conduit valves, pumps etc.

2.5 Types of Intake Structures

2.6

2.7 Intakes are classified under three categories:

2.8 Category 1:

- 2.9 Submerged intake:- Those intakes that are constructed entirely under water are termed as submerged intakes.
- 2.10 . Submerged intake structures are commonly used to obtain water from lakes.
- 2.11 Exposed intake:- Exposed intakes are in the form of oil or tower constructed near the bank of river, or in some cases even away from the bank of river and are common due to ease in its operation.

2.12 Category 2:

- 2.13 Wet intake:- The water level of intake tower is practically the same as that of the water level of sources of supply in wet intake. It is also known as jack well.
- 2.14 Dry intake:- There is no water in the water tower in the case of dry intake. Water enters through the port directly into the conveying pipes. In this type of intake the dry tower is simply used for the operation of valves

2.15 Catagory-3

- River intake
- Reservoir intake
- Lake intake

Canal Intake

2.16 River Intake Structures

- 2.17 It is a type of intake which may either located sufficiently inside the river so that demands of water are met
- 2.18 with in all the seasons of the year, or they may be located near the riverbank where a sufficient depth of water is available.
- 2.19 Sometimes, an approach channel is constructed and water is led to the intake tower.
- 2.20 If the water level in the river is low, a weir may be constructed across it to raise the water level and divert it to the intake tower.

2.21

2.22 Reservoir Intake Structures

- 2.23 When the flow in the river is not guaranteed throughout the year, a dam is constructed across it to store water in the reservoir so formed.
- 2.24 These are similar to river intake, except that these are located near the upstream face of the dam where maximum depth of water is available.
- 2.25 Design of intake may vary based on the type of dam.

2.26

2.27 Lake Intake Structures

- 2.28 Generally submerged intakes are preferred for lake intakes.
- 2.29 These are constructed as cribs or bell mouths. The cribs are made of heavy timber frame work which is partly or wholly filled with rip-rap to protect the intake conduit against damage by waves etc.
- 2.30 The top of the crib is covered with cast iron or mesh grating.

2.31

2.32 Canal Intake Structures

- 2.33 In some cases, source of water supply to a small town may be an irrigation canal passing nearer or through the town. Then it will be constructed.
- 2.34 Generally it consists of masonry or concrete intake chamber of rectangular shape, admitting water through a coarse screen.
- 2.35 A fine screen is provided over the bell mouth entry of the outlet pipe.
- 2.36 The intake chamber may be constructed inside the canal bank if it does not offer any appreciable resistance to normal flow in the canal.
- 2.37 It's preferred to provide lining to the canal near the intake chamber.

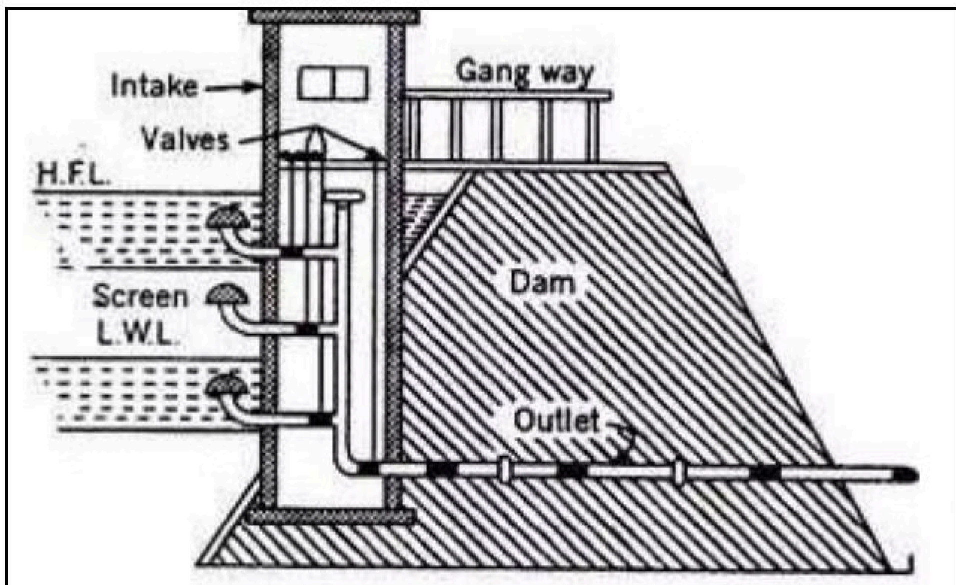


Fig. 7.7. Reservoir intake.

Pumps for Conveyance & Distribution

2.38 Pumps for conveyance & distribution – types, selection, installation Pumps

A pump is a device which converts mechanical energy into hydraulic energy. It lifts water from a lower to a higher level and delivers it at high pressure. Pumps are employed in water supply projects at various stages for following purposes:

- To lift raw water from wells.
- To deliver treated water to the consumer at desired pressure.
- To supply pressured water for fire hydrants.
- To boost up pressure in water mains.
- To fill elevated overhead water tanks.
- To back-wash filters.
- To pump chemical solutions, needed for water treatment.

1) 2) Classification of Pumps

Based on principle of operation, pumps may be classified as follows:

1. Displacement pumps (reciprocating, rotary)
2. Velocity pumps (centrifugal, turbine and jet pumps)
3. Buoyancy pumps (air lift pumps)
4. Impulse pumps (hydraulic rams)

Capacity of Pumps

Work done by the pump, H.P.=gQH/75 where, g= specific weight of water kg/m3, Q= discharge of pump, m3/s; and H= total head against which pump has to work. H= Hs + Hd + Hf + (losses due to exit, entrance, bends, valves, and so on) where, Hs=suction head, Hd = delivery head, and Hf = friction loss.

Efficiency of pump (E) = gQH/Brake H.P.

Total brake horse power required = gQH/E

Provide even number of motors say 2,4,... with their total capacity being equal to the total BHP and provide half of the motors required as stand-by.

Conveyance and Pump Selection

Conveyance

There are two stages in the transportation of water:

- Conveyance of water from the source to the treatment plant.
- Conveyance of treated water from treatment plant to the distribution system.

In the first stage water is transported by gravity or by pumping or by the combined action of both, depending upon the relative elevations of the treatment plant and the source of supply.

In the second stage water transmission may be either by pumping into an overhead tank and then supplying by gravity or by pumping directly into the water-main for distribution.

Selection Of type of Pump:

Following Following consideration govern the choice of particular type of Pump in water supply project:

I. Capacity of Pumps

II. Importance of water supply scheme

III. Initial Cost

IV. Location of Pump

V. Maintenance cost

VI. Number of units required

VII. Quality of water to be pumped

VIII. Total head of water, variation in pumping head and pumping rate

IX. Type of Supply service

intermittent or continuous

X. Working or operating conditions

such as flexibility in operation, requirement of floor area etc.

Pipe Materials

The pipes used for plumbing installations in homes and businesses can be manufactured from many different materials. Like in any engineering decisions, the best option changes depending on the application and project conditions.

The most common piping materials used for plumbing are copper, PVC, CPVC and PEX (Cross-Linked Polyethylene Piping) etc.

1) Copper Pipes

Copper is very durable, and it has been the traditional plumbing material since the 1960s. Other materials have been introduced since then, but copper is still one of the best options. The main drawback of copper piping is its high price, and it requires soldering and additional fittings.

Merit

- Resistant to leaks
- Durable
- Heat tolerant
- Old pipes can be recycled
- Corrosion resistant

Demerit

- Expensive
- Old installations may contain lead
- Old copper pipes can be recycled, but copper mining and manufacturing cause environmental damage.

2. Polyvinyl Chloride Piping (PVC)

PVC is a plastic material that is commonly used in plumbing, and it comes in two sizes: Schedule 40 and Schedule 80.

Schedule 40 PVC is the most commonly used, having thinner walls and a lower price.

Schedule 80 PVC has thicker walls, making it more durable but also more expensive.

PVC is commonly used for the drain lines of sinks, toilets and bathtubs. Other common applications include indoor plumbing, underground plumbing.

Merit

- Resistant to rust and corrosion
- Resistant to high water pressure
- Low cost
- Easy installation, no welding or metalwork
- Versatile: multiple sizes and fittings
- Strong and durable
- Non-conductive

Demerit

- Cannot be used for hot water, since heat deforms PVC.
- PVC degrades with UV light, which means it cannot be exposed to sunlight.
- Not safe for drinking water.
- Not recyclable.

Other Pipe Materials

3. Galvanized Steel Piping

This materials was popular in the past, but no longer used due to its negative effects:

- Internal rusting in small diameter pipes, due to the zinc coating
- Can get clogged over time
- Lead can be released by corroded pipes
- Water discoloration

Galvanized steel is also a heavy material, which limits its applications in plumbing. These pipes were commonly used in greywater and non-potable water drains.

4. Cast Iron Pipes

Cast iron pipes are usually manufactured as a bell and spigot type, and they are the heaviest of all plumbing pipes.

common applications of cast iron pipes are water distribution systems and underground installations, such as the main pipes on drainage and sewer systems.

5. Asbestos Cement Pipe.

The asbestos pipe is made from asbestos, silica, and cement converted under pressure to a dense, homogeneous material possessing considerable strength.

The asbestos fiber is thoroughly mixed with the cement and serves as reinforcement. They are used to carry water under low pressure. The hydraulic efficiency of an asbestos pipe is high. These pipes are soft from the inside. That is why their performance is better. They are not rusted and are cheap as well.

6. Concrete Pipe.

- The Pre-cast Concrete pipe is available in sizes up to 72 inches diameter, and sizes up to 180 inches have been made on special order.
- The centrifugal force presses the mortar tightly against the forms and results in high-density watertight concrete.
- Because of the better control in its manufacture, a pre-cast concrete pipe is usually of higher quality and not need to be so thick as a cast-in-place pipe of the same size.
- Because of the need to move plant and forms over long distances, cast-in-place pipe is relatively expensive and is normally used only for pipe sizes not available in precast form or where transportation difficulties make use of precast pipe impossible.
- Concrete Pipes are generally used these days. They are used even in low as well as high pressure. Plain concrete pipes are made for low pressure, and R. C. C. (Reinforced Cement Concrete) pipes are made for high pressure.
- Less expenditure is required for their maintenance. Rust does not affect these pipe. Such pipes are heavy. So, their transportation is difficult. It is also difficult to repair them.

Pipe Joints

2.7 Pipe joints – necessity, types of joints, suitability, methods of jointing, Laying of pipes – method

What are Pipe Joints?

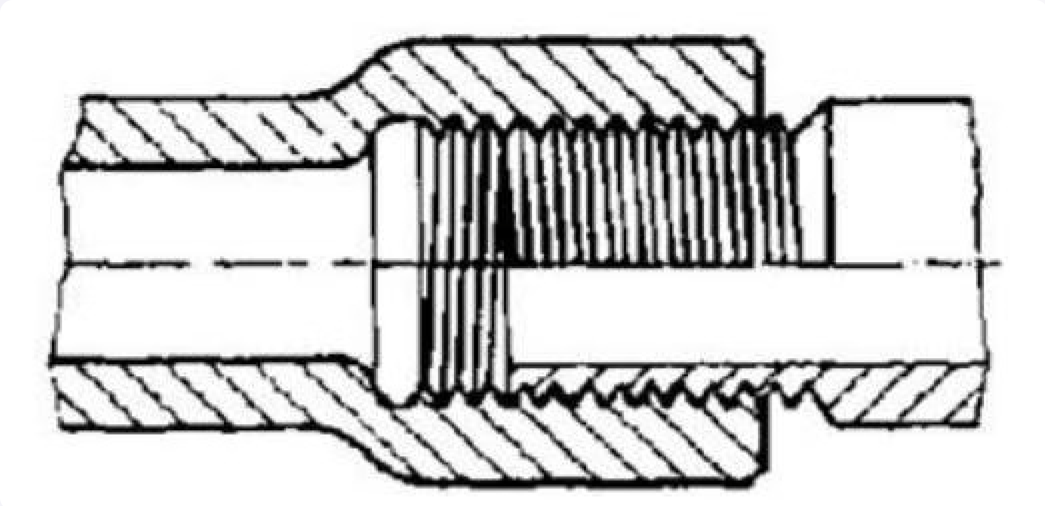
Pipe joints are connections used to join individual pipes together, creating a continuous flow path in plumbing and piping systems. These joints are designed to provide secure and leak-free connections, ensuring the efficient transfer of fluids or gases. Different types of pipe joints, such as threaded joints, soldered joints, welded joints, flanged joints, and compression joints, are used based on factors like the pipe material, application, and required strength and flexibility. Properly selected and installed pipe joints are vital for the integrity and functionality of piping systems.

Types of Pipe Joints

There are several types of pipe joints used in plumbing and piping systems. Here are some common types:

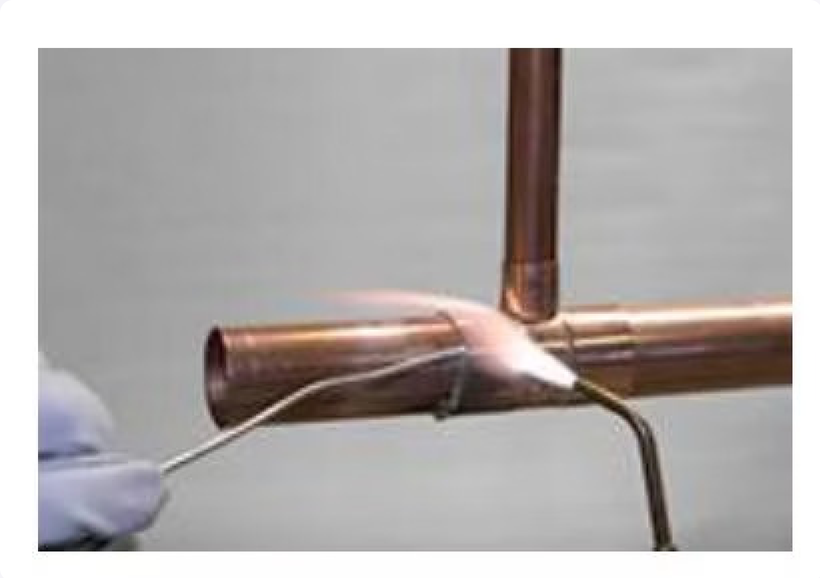
Threaded Joints

These joints screw the pipes together by using pipe threads and sealing material like Teflon tape or pipe dope. Threaded joints come in a range of sizes, from 6mm to 300mm diameter pipes, and are commonly used in low-temperature and low-pressure applications. However, in high-temperature environments, these joints may expand and lead to leakage caused by thermal expansion. While the installation of threaded joints is straightforward, proper maintenance is essential to ensure their optimal performance.



Soldered Joints

Also known as sweat joints, these joints are created by heating the pipe and applying solder to the joint, which melts and forms a bond as it cools, creating a watertight connection. These joints are used in low-temperature areas.

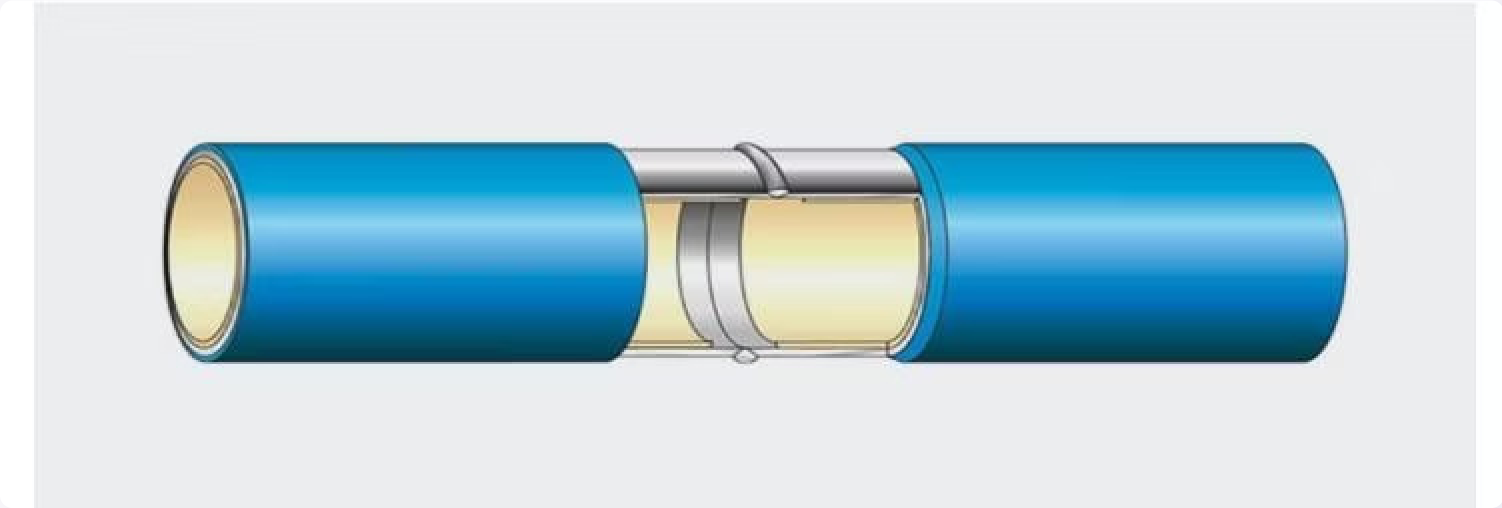


Welded Joints

Welded joints are created by fusing the ends of pipes together using heat and pressure, forming a strong and permanent connection. Welding methods include butt welding, socket welding, and fusion welding. These include **Butt Welded Joints** and **Socket Welded Joints.**

Butt Welded Joint

GIRIJA PRASAD DAS. 23 In pipe joints where the pipes have the same diameter, butt welding is employed as the method of connection. Butt welding is a widely used and commonly employed welding technique. It requires skilled workers for proper installation. These joints are predominantly used in large-scale commercial and industrial piping systems. The butt weld offers excellent joint strength, enabling it to withstand high pressure due to the smooth and uninterrupted surface inside the joint.



Collar Joint

Collar joints are mostly used in construction and woodworking to join two pieces of wood at right angles. They contain a round or rectangular piece called a collar that fits around the end of one piece, while the other piece is inserted inside the collar. Collar joints provide strength to structures, by making them a popular choice in various applications.

Expansion Joint

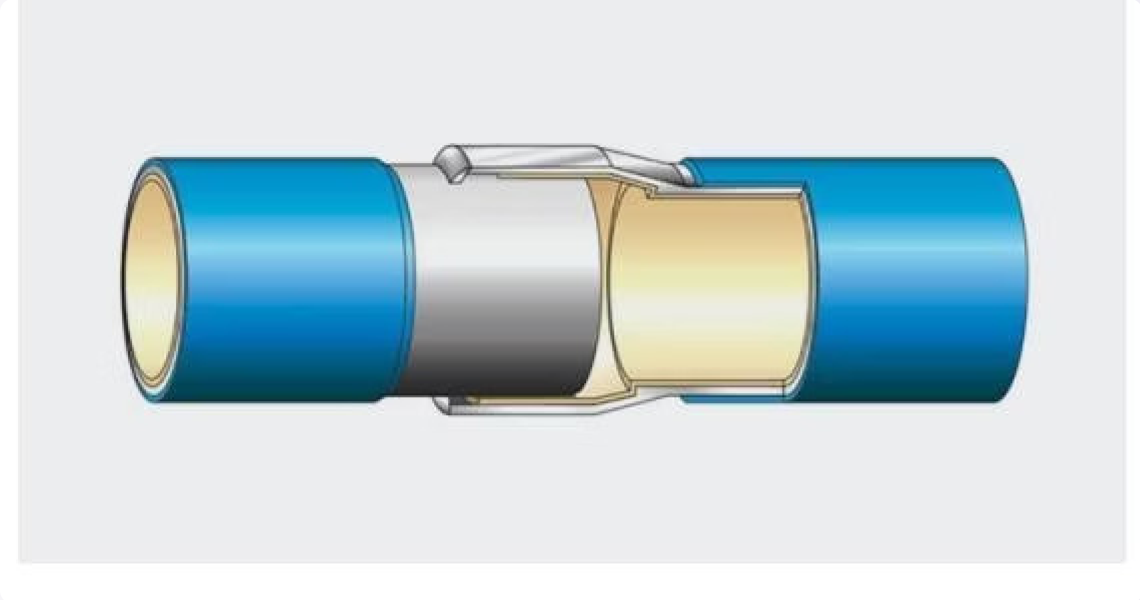
Expansion joints are crucial components used in construction to accommodate the movement of materials due to temperature changes, seismic activity, or settling. They are designed to absorb the expansion and contraction forces, preventing damage or stress to the structure. Expansion joints allow for flexibility and maintain the integrity of buildings, bridges, pipelines, and other infrastructure projects.

Hydraulic Joint

Hydraulic joints are essential in hydraulic systems, enabling the transfer of fluids under pressure. They connect various components such as pipes, hoses, valves, and cylinders, ensuring a leak-free and efficient flow of hydraulic fluid. These joints are designed to withstand high pressures and provide a secure connection, allowing for the smooth operation of hydraulic machinery and equipment

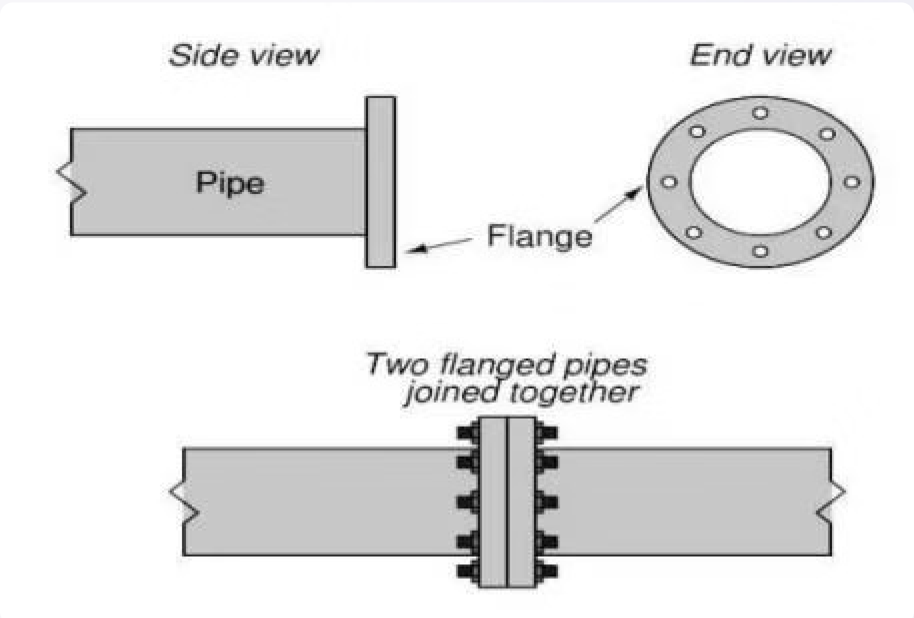
Socket Welded Joint

Socket welded joints in pipes are utilised in situations where the risk of leakage in joints is high. This type of joint involves inserting one pipe into another and welding around the joint. Socket welded joints are suitable for pipes with different diameters. In cases where the pipes have similar diameters, appropriate fittings are used. The cost of welding is typically lower compared to butt welding. It is important to note that socket welded joints exhibit lower fatigue resistance compared to butt weld joints. However, socket welded joints yield satisfactory results when compared to other mechanical joints.



Flanged Joints

GIRIJA PRASAD DAS. 23 Flanged joints consist of two pipes with flat mating surfaces and a gasket sandwiched between them. Bolts and nuts secure the flanges together, creating a strong and easily disassembled joint.



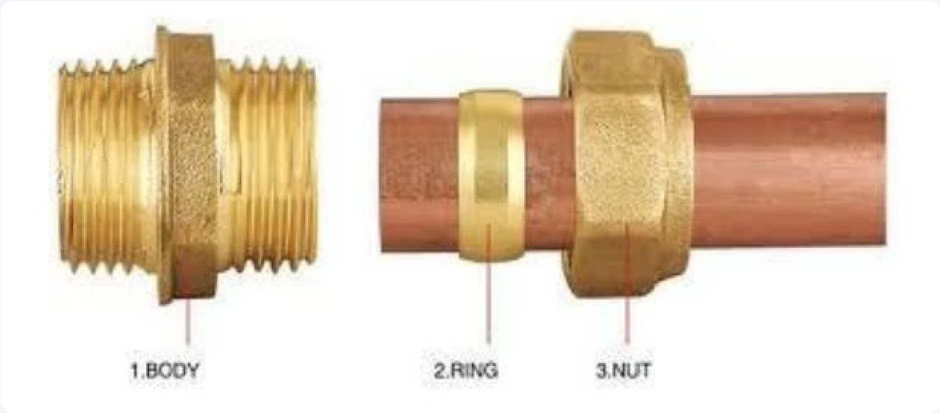
Pipe Joints: Types and Applications

Pipe joints are essential components in various systems, connecting pipes to create continuous flow paths. This document explores different types of pipe joints, their mechanisms, and their suitability for various applications.

Common Pipe Joint Types

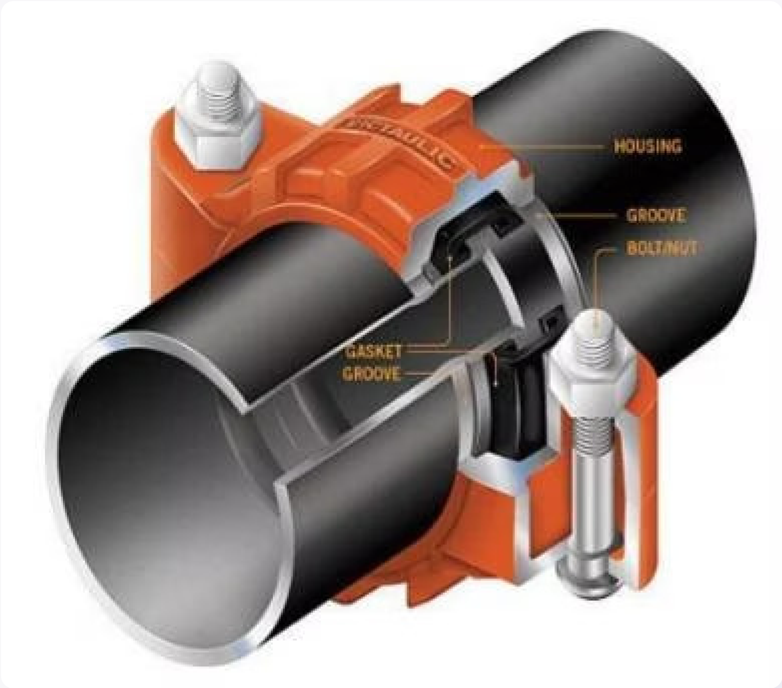
Compression Joints

Compression joints utilise a compression fitting that consists of a nut, a compression ring, and a fitting body. When the nut is tightened, it compresses the ring against the pipe, creating a tight seal.



Grooved Joints

Grooved joints feature pipes with grooves on the ends. Couplings with corresponding grooves are used to connect the pipes together, creating a secure joint without the need for welding or threading.



Mechanical Joints

Mechanical joints use mechanical components like couplings, clamps, or connectors to join pipes together. These joints are quick to install and allow for some flexibility and movement.

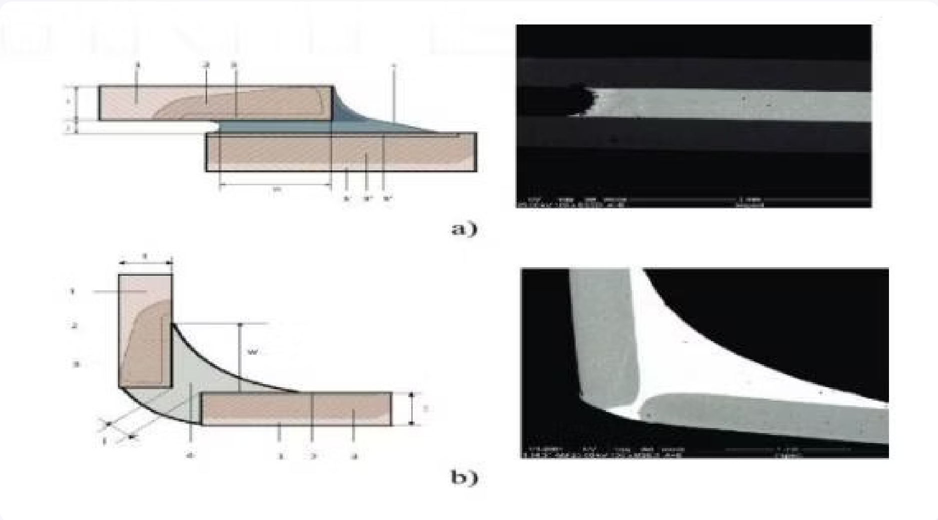
Push-Fit Joints

Push-fit joints, also known as push-to-connect or quick-connect joints, use specially designed fittings that can be easily pushed onto the pipe, creating a secure connection without the need for tools or additional materials.

Specialized Pipe Joints

Brazed Joints

A brazed joint is a type of metal joint formed by heating two or more metal pieces and melting a filler metal, known as brazing alloy, which flows into the gap between the pieces. The filler metal has a lower melting point than the base metals, allowing it to bond and create a strong, leak-proof connection when cooled. Brazing is commonly used in various industries, such as automotive, aerospace, and plumbing, due to its ability to join different metals, including dissimilar ones. It offers several advantages, including high joint strength, excellent heat and electrical conductivity, and the ability to create intricate and complex shapes.



Nipple Joints

A nipple joint is a type of pipe joint commonly used in plumbing and piping systems. It consists of a short length of pipe with male threads on both ends, allowing it to connect two female-threaded pipes or fittings. Nipple joints are typically made of metal, such as steel or brass, but can also be found in plastic materials. They provide a convenient and secure way to extend or connect pipes in a straight line, allowing for easy installation and disassembly.

Union Joints

A union joint, also known as a union fitting, is a type of pipe joint that allows for the convenient disconnection and reconnection of pipes or tubing. It consists of three main components: a nut, a male end, and a female end. The nut has internal threads that mate with the male end, which has external threads, while the female end has a smooth inner surface. To join pipes using a union joint, the nut is threaded onto the male end, compressing a gasket or O-ring between the male and female ends, creating a tight seal.

Where are Pipe Joints Used?

Pipe joints are used in various applications where pipes need to be connected to create a continuous flow path. Some common areas where pipe joints are used include:

Plumbing Systems

Pipe joints are extensively used in residential, commercial, and industrial plumbing systems to connect pipes for water supply engineering, drainage, and gas distribution.

HVAC Systems

Heating, ventilation, and air conditioning (HVAC) systems utilise pipe joints to connect pipes for the distribution of hot and cold water, as well as refrigerant lines.

Industrial Piping Systems

In industrial settings, pipe joints are employed in a wide range of applications, such as oil and gas pipelines, chemical processing plants, power plants, and manufacturing facilities.

Municipal Water and Sewage Systems

Pipe joints are essential in municipal water supply and sewage systems, connecting pipes that transport potable water, wastewater, and stormwater.

Irrigation Systems

Agricultural and landscaping irrigation systems utilise pipe joints to connect pipes and distribute water for different types of irrigation.

Fire Sprinkler Systems

Pipe joints play a crucial role in fire sprinkler systems, connecting pipes that distribute water for fire suppression in buildings and other structures.

Process Piping

Various industries, such as pharmaceutical, food and beverage, and petrochemical, rely on pipe joints to connect pipes in process piping systems for the transfer of fluids and gases.

Long Answer Questions – Chapter 2: Sources and Conveyance of Water

2.1 Surface Sources –Lake, Stream, River, and Impounded Reservoir

1. Compare lakes, streams, rivers, and impounded reservoirs as sources of water supply.
2. Discuss the merits and demerits of surface water sources with examples.
3. Explain the criteria for selecting a surface source for a water supply scheme.

2.2 Underground Sources –Aquifer Types & Occurrence, Infiltration Gallery, Infiltration Well, Springs, Well

1. Describe the different types of aquifers with neat sketches.
2. Explain the occurrence and movement of groundwater.
3. Describe the construction and working of an infiltration gallery.
4. Compare infiltration gallery and infiltration well in terms of construction and application.
5. Write a note on springs and their types with examples.
6. Differentiate between shallow well and deep well with respect to yield, depth, and construction.

2.3 Yield from Well – Methods of Determination

1. Explain the Constant Level Method and Recuperation Method for determining yield of a well with formulae.
2. List and explain the factors affecting the yield of a well.
3. Describe step-by-step procedure to determine well yield using the recuperation test.

2.4 Intakes – Types, Description of River Intake, Reservoir Intake, Canal Intake

1. Describe the construction and working of a river intake structure with a neat diagram.
2. Explain the features and suitability of a reservoir intake.
3. Compare canal intake and reservoir intake based on design, function, and use.
4. Explain the general criteria and requirements of a good intake structure.

2.5 Pumps for Conveyance and Distribution – Types, Selection, Installation

1. Differentiate between centrifugal and reciprocating pumps with diagrams.
2. Explain the working principle and components of a centrifugal pump.
3. List the factors to be considered while selecting a pump for water supply.
4. Describe the installation procedure of a pump in a water distribution system.

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2. Describe socket and spigot joint and flanged joint with neat sketches.
3. Explain the method of laying pipes and the precautions taken during jointing.
4. Compare different types of pipe joints in terms of application and durability.

Question Bank – Chapter 2: Sources and Conveyance of Water

2.1 Surface Sources –Lake, Stream, River, and Impounded Reservoir

Short Answer Questions:

1. Define surface sources of water.
2. Give two examples each of surface water sources.
3. What is an impounded reservoir?

Long/Descriptive Questions:

1. Compare rivers, lakes, and reservoirs as water sources.
2. Explain advantages and disadvantages of river and lake water as sources of supply.

2.2 Underground Sources –Aquifer Types & Occurrence, Infiltration Gallery, Infiltration Well, Springs, Well

Short Answer Questions:

1. What is an aquifer? Name its types.
2. Define infiltration gallery and infiltration well.
3. What is the difference between a spring and a well?

Long/Descriptive Questions:

1. Explain confined and unconfined aquifers with diagrams.
2. Describe the working and location suitability of infiltration galleries.
3. Compare shallow and deep wells.

2.3 Yield from Well – Methods of Determination, Numerical Problems

Short/Concept Questions:

1. Define yield of a well.
2. Name the methods used to determine well yield.

Long/Procedure Questions:

1. Explain the constant level method and recuperation method of yield estimation.
2. State the factors affecting yield from wells.

Numerical Questions:

1. Solve numerical using constant level method.
2. Solve numerical using recuperation test method.

2.4 Intakes – Types and Description of River, Reservoir, Canal Intakes

Short Questions:

1. What is an intake structure?
2. List types of water intakes.

Descriptive Questions:

1. Describe river intake with a neat sketch.
2. Explain reservoir intake structure and its working.
3. Compare canal and reservoir intake structures.

2.5 Pumps for Conveyance and Distribution – Types, Selection, Installation

Short Questions:

1. Define pump and its necessity in water supply.
2. What factors are considered for selecting a pump?

Long Questions:

1. Differentiate between centrifugal and reciprocating pumps.
2. Explain installation procedure of a centrifugal pump.
3. Describe the working of any one pump with a diagram.

2.6 Pipe Materials – Necessity, Suitability, Merits & Demerits

Short Questions:

1. Name commonly used pipe materials.
2. Why are CI and PVC pipes used in water supply?

Long Questions:

1. Compare Cast Iron, Steel, RCC, and HDPE pipes for water supply.
2. List the advantages and disadvantages of asbestos cement pipes.

2.7 Pipe Joints – Necessity, Types, Suitability, Methods of Jointing

Short Questions:

1. What is the purpose of pipe joints?
2. Name different types of pipe joints.

Descriptive Questions:

1. Explain socket and spigot joint with a sketch.
2. Discuss suitability of flanged and collar joints.
3. Describe the method of laying pipes in the field.

Water Treatment

Water treatment means the cleansing of water through various phases to be available for end-use by the people. The treated water is then used for various purposes like irrigation, industrial water supply, drinking, river flow maintenance, or any other such uses. The treatment of water removes harmful contaminants and compounds or the concentration of these is reduced for public use. This treatment is mandatory to promote human health and its uses for drinking and irrigation.

Necessity of Water Treatment

The water contaminated with feces of humans and animals pose a great threat to the public because of the presence of microbial elements in them that cause various diseases. Feces are the main source of viruses, pathogenic bacteria, protozoa, and helminths. The destruction or removal of such substances from the water is essential for it to be used by humans. Reactive chemical agents like suspended solids are used in the process of purification of water. These agents help in removing bacteria, viruses, algae, fungi, iron, and manganese.

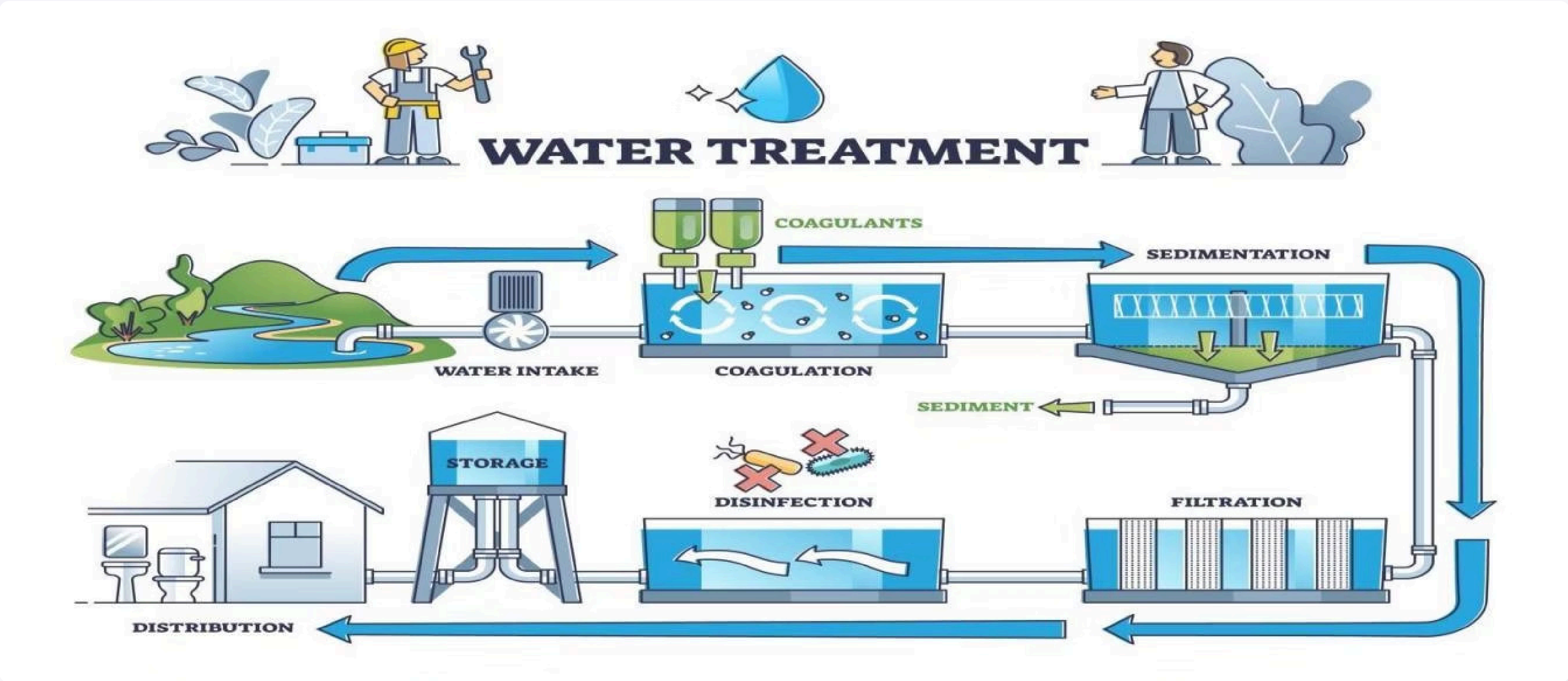
Note:

- Design of treatment units excluded.
- Students may be asked to prepare detailed sketches of units, preferably from working drawing, as home assignment
- Field visit to treatment plant, under practical should be arranged after covering this unit.

Methods Of Water Treatment

Water is naturally a pure substance containing hydrogen and oxygen. However, the distribution and supply of water come in contact with various organic minerals, man made pollutants, and chemicals. This makes water unfavorable for drinking purposes as it contains deadly viruses, bacteria, and other dangerous agents.

Different methods of water treatment are set up to make drinking water accessible. Below are some of the methods of water treatment.



Coagulation/ Flocculation

Coagulation is the process of adding alum, liquid sulfate, to untreated or raw water. After completion of the process, dirt particles coagulate in the water or stick together. Flocs are formed by large dirt particles and can be easily removed by filtration or setting. Coagulation methods include ionic layer compressions, surface complexation, and charge neutralization, sweep coagulation, and polymeric bridging.

Flocculation is what allows the coagulated water to mix with the particles that collide to form further flocs.

Sedimentation

During the treatment process, flocs and water make their way into the sedimentation basins. In these basins, water moves slowly allowing the flocs to settle at the bottom. The accumulated flocs are known as sludge and are carried to the drying lagoons. Storing such water for a couple of hours will allow the sedimentation of dense and large particles like silt and sands, microbes, and smaller particles. Settling time of 1 to 2 days will help remove larger particles and microbes like algae and clay.

Filtration

Filtration helps in removing the particles as the water passes through a filter. These filters are composed of sand and gravel or crushed anthracite. Filtration combines all the dangerous impurities and particles that float on the water. This helps boost the effectiveness of disinfection. Filters are regularly serviced by backwashing for better filtration.

Additional Water Treatment Methods

Disinfection

Water is disinfected before it makes its way to the distribution system. Disinfection removes disease-causing bacteria, viruses, and parasites. Chlorine is better known to help in the disinfection of water. It includes oxidizing agents that instantly remove all the bacteria in water.

Oxidation

Inorganic contaminants like iron, manganese are removed by the process of chemical oxidation and it further aids in the removal of coagulated particles to destroy odor causing and taste compounds. It is often used before coagulation, adsorption, and sedimentation for efficient removal of particulates, inorganics, taste, or odor. Oxidants are injected in the form of liquid or gas.

Adsorption

The adsorption process removes both organic and inorganic contaminants from water. Adsorption forms on the surface by the accumulation of a solid called adsorbents. They include stationary media like metal oxide, ion exchange, and activated carbon. Flocculation forms floc that can adsorb both inorganic and organic carbon like arsenic. Activated carbon helps in removing hundreds of organic contaminants.

Fluoridation

Fluoridation is used mainly in communities as it treats water supplies to bring a balance in the concentrated free fluoride ions. This is done till an optimal level is reached which helps avoid dental cavities.

Steps Of Water Treatment

Large scale water treatment plant follows the below steps for urban water supply. These are as follows: –

1

Screening

Screens are used to protect treatment plant units to help in the efficiency of operations. Screens remove large floating or suspended solids in the process of inflow. Materials like leaves, paper, twigs, and other debris are removed so as to avoid equipment or plant damage. There are two types of screens.

- **Coarse screens:** These are large and heavy screens used to minimize large materials like fish and logs from entering the water treatment plant. They help in the proper functioning of the mechanical equipment.
- **Fine screens:** These are used to avoid blockage in the pipes at the treatment plant. Solids that are caught in the pipes are removed by jet water and are taken for disposal.

2

Aeration

Aeration takes place after the screening process. Water becomes aerated after it has been exposed in order to take in oxygen from the air. Harmful soluble gases like CO2, hydrogen sulfide are expelled by aeration.

3

Coagulation And Flocculation

Coagulation is used after aeration to remove any remaining fine particles suspended in the water. Coagulant chemicals are mixed in the water for further cleansing.

4

Sedimentation

Large flocs which are spread on the floor of a tank are settled out by the process of sedimentation. The accumulated material is called sludge which is taken for proper disposal after the process.

5

Chlorination

To further disinfect the water after sedimentation a chemical called chlorine is used to help remove pathogenic microorganisms. The remaining chlorine is known as residual chlorine which gets through the process of the distribution system.

Aeration: Necessity

Aeration is the process of introducing air into a liquid or soil, and it's necessary for various reasons, primarily to improve oxygen levels and facilitate beneficial biological activity. In water, aeration increases dissolved oxygen, which is crucial for aquatic life and wastewater treatment. In soil, it enhances root health and microbial activity.

Here's a breakdown of why aeration is necessary:

1

Water Quality and Wastewater Treatment:

- **Increased Dissolved Oxygen:** Aeration increases the amount of oxygen dissolved in water, which is essential for the survival of aquatic organisms like fish and beneficial bacteria.
- **Removal of Undesirable Gases:** Aeration helps remove harmful gases like hydrogen sulfide and carbon dioxide, improving water's taste, odor, and safety.
- **Wastewater Treatment:** In wastewater treatment plants, aeration is vital for supporting the aerobic bacteria that break down organic matter and pollutants.
- **Prevention of Stratification:** Aeration helps prevent water layers from becoming stratified, which can lead to oxygen depletion in deeper layers.
- **Mosquito Control:** Aeration disrupts mosquito breeding habitats by preventing stagnant water.

2

Soil Health and Agriculture:

- **Root Respiration:** Soil aeration provides oxygen to plant roots, enabling them to respire and absorb nutrients effectively.
- **Microbial Activity:** Aeration supports the growth of beneficial aerobic microorganisms in the soil that decompose organic matter and improve soil health.
- **Nutrient Availability:** Aeration helps make nutrients more accessible to plants by promoting microbial activity and improving water infiltration.
- **Compaction Reduction:** Aeration can help reduce soil compaction, which can hinder root growth and water drainage.

3

Other Applications:

- **Industrial Water Conditioning:** Aeration is used to remove carbon dioxide and oxidize iron and manganese in industrial water treatment processes.
- **Drinking Water Treatment:** Aeration can remove volatile organic compounds and dissolved gases from drinking water.

In essence, aeration is a fundamental process that improves the quality of water and soil by enhancing oxygen levels and promoting beneficial biological activity.

What is Sedimentation?

A sedimentation tank, also known as a settling tank, is a structure used in water and wastewater treatment processes to remove suspended solids from liquids. It works by allowing heavier particles to settle at the bottom of the tank under the influence of gravity, resulting in the separation of solids from the liquid, which then flows out of the tank as clarified water.

Sedimentation involves settling suspended coarser particles in water to the tank's bottom, requiring a reduction in flow velocity, and is conducted in a structure known as a sedimentation tank or settling tank.

Necessity of plain sedimentation:

- **Reduces turbidity:** By removing suspended particles, plain sedimentation significantly reduces the turbidity (cloudiness) of the water, making it clearer and more visually appealing.
- **Decreases load on subsequent treatment:** The removal of settleable solids in the initial stage reduces the workload for subsequent treatment processes like filtration and disinfection, making them more efficient and cost-effective.
- **Cost-effective:** Plain sedimentation is a relatively low-cost method compared to other water treatment techniques, as it primarily relies on natural gravity and does not require the addition of chemicals or complex equipment in its basic form.
- **Improves water quality:** By removing a significant portion of suspended solids, plain sedimentation enhances the overall quality of the water, making it more suitable for various uses.
- **Pre-treatment for other methods:** Plain sedimentation often serves as a preliminary step before other water treatment methods like filtration and disinfection, making these subsequent processes more effective.

Working Principle of Sedimentation Tank

The fundamental principle of a sedimentation tank is to decrease the flow velocity of water, facilitating the settling of a significant portion of suspended particles. The rate at which particles settle is known as settling velocity. Design parameters for sedimentation tanks, such as the shape and size of the tank, particle size, water temperature, flow velocity, and detention period, influence the accumulation of suspended particles at the tank's bottom. The settling velocity of particles, denoted as "(Vs)" is calculated using Stoke's law.

$$(\vee_s = 43gCd(\rho_s - \rho)d\rho - - - - - - \vee)$$

Where,

- (Vs)= settling velocity of a particle
- g = acceleration due to gravity
- (ρs)and (ρ) are the Mass density of water and the Mass density of the particle respectively.
- d = diameter of particle
- (Cd) = Drag Coefficient

When the diameter of the particle is more than 0.1 mm then it is considered a turbulent flow the equation for settling velocity is

$$(Vs** = 1.8**g(s-1)d - - - - - - - \surd)$$

Importance Of Water Treatment

The availability of pure water is of utmost importance in society. The water treatment process caters to this by supplying suitable water for industries or individuals. Only when the contaminants are removed from the water can they be used and accessible to everyone. Several processes like filtration and disinfection are used to purify water.

Water is the key element to an individual's survival and without water survival is difficult. Recent global research conducted showed that many deaths take place mainly due to poor quality of water causing various types of diseases. Hence, it is vital to ensure the public has access to pure drinking water. Water treatment industries are being set up in large numbers to help in the purification of water thus saving the lives of the people.

Fatal diseases like typhoid and cholera are caused by impure water alone which can be life-threatening for individuals. Desalination helps in avoiding the scarcity of water faced by the people where they do not have access to water. The source of seawater is unlimited and can be utilized accordingly and be provided to the people after getting salt content removed and converted to safe drinking water.

Purposes Of Water Treatment

Water treatment's main objective is to remove the impure residuals of the water to make it accessible for drinking. These impurities are responsible for various types of diseases among humans.

The main purpose of water treatment is to ensure the public has safe access to drinking water devoid of any contaminants. At the community level, untreated or raw water is obtained through an underground aquifer or through lakes, or rivers. Once obtained, it is then taken for proper treatment and to remove harmful substances present in the water.

Water treatment plants are maintained to minimize high radiation levels in a facility. Impurities and corrosion may get highly radioactive and have to be removed in order to avoid these harmful substances from entering the water and disperse throughout.

Also, read more about Disposing of Sewage **Effluents,** here.

Raw Water Treatment

Raw water must be treated before use in utility processes. The treatment removes harmful substances like suspended and dissolved solids and other kinds of impurities that are present in large numbers. Treated raw water can be used for various purposes like cooling water, rinsing water, purified, and even drinking water. The process of raw water treatment includes:

- **Reverse osmosis:** Water flows at high speed across a membrane leaving only water and some unwanted residues behind. Major pollutants like iron, manganese, pesticides, can be expelled by reverse osmosis.
- **Turbidity:** Suspended particles cause turbidity in the water. Many suspended particles arise from turbidity which is used to measure the quality of water. Turbidity is present in large volumes mainly due to rainfall, bank erosion, and so on.
- **Ultrafiltration:** Water is treated with a screen filter before the actual high pressure filtration through a membrane. This method separates the contaminants from the water.

Types Of Water Treatment Plants

On the basis of the types of water industries, they can be divided into 3 major categories.

- **Water purification:** Natural water may not contain harmful elements still the water is sent for purification in order to become drinkable. Natural and purified water has a similar appearance but is different in taste and smell as there are plenty of bacteria present in the natural water. Water pollution is on a rise and thus purification of water is mandatory everywhere.
- **Wastewater treatment:** The wastewater treatment industry is set up to control the flow of wastewater in the society or community. Also, these industries help convert wastewater to become accessible to the public mainly for irrigation purposes, or fertilization.
- **Desalination:** Desalination implies converting salt or seawater into drinkable water or pure water. Seawater is easily accessible and available across giving a rise in the setting up of desalination industries.

Sedimentation Tanks in Water Treatment

Sedimentation tanks, also known as clarifiers or settling tanks, are essential components in water and wastewater treatment. They remove suspended solids from liquids by allowing them to settle under gravity. Common types include rectangular and circular tanks with horizontal, radial, or vertical flow patterns. Key aspects include flow control, surface skimming, and sludge withdrawal. Regular maintenance is crucial for optimal performance.

Types of Sedimentation Tanks

Rectangular Tanks:

Typically used in smaller to medium-sized plants, they feature horizontal flow and may include baffle walls to reduce flow velocity.

Circular Tanks:

Commonly used in larger plants, they can have radial or spiral flow patterns. Circular tanks are often preferred for continuous vertical flow.

Hopper Bottom Tanks:

These have a tapered bottom to collect settled solids, with water flowing vertically through the tank.

Horizontal Flow Tanks:

Water flows horizontally through the tank, with solids settling to the bottom.

Vertical Flow Tanks:

Water flows vertically upwards, with solids settling to the bottom.

Radial Flow Tanks:

Water flows outward from a central inlet, commonly found in circular tanks.

Essential Features of Sedimentation Tanks

Flow Control:

Maintaining a consistent flow rate is crucial to prevent turbulence and ensure efficient settling.

Detention Time:

The time water spends in the tank must be sufficient for particles to settle.

Surface Skimming:

Removing floating debris and scum from the surface prevents contamination of the treated water.

Sludge Removal:

Regular removal of settled sludge is necessary to maintain tank capacity and prevent interference with the settling process.

Inlet and Outlet Structures:

Proper design of inlet and outlet structures is essential to minimize turbulence and ensure even flow distribution.

Operation and Maintenance of Sedimentation Tanks

- **Flow Rate Monitoring:** Operators must monitor flow rates to ensure they are within design parameters.
- **Water Level Control:** Maintaining appropriate water levels is important for efficient settling and sludge removal.
- **Sludge Level Monitoring:** Regular monitoring of sludge depth helps determine the frequency of sludge removal.
- **Surface Skimming:** Regularly skim the surface to remove floating debris and scum.
- **Sludge Removal:** Sludge should be removed according to a schedule based on sludge depth and composition.
- **Tank Cleaning:** Regular cleaning is necessary to remove accumulated solids and debris.
- **Equipment Maintenance:** Regular inspection and maintenance of mechanical equipment (scrapers, pumps, etc.) are essential.

Sedimentation with Coagulation

Sedimentation with coagulation is a crucial water treatment process that removes suspended particles and impurities. Coagulation destabilizes these particles, causing them to clump together into larger flocs, which then settle out during sedimentation. This process is necessary because plain sedimentation struggles to remove fine particles and colloids due to their small size and charge. Common coagulants include aluminum sulfate, ferric sulfate, and ferric chloride.

Necessity of Coagulation:

- **Removing fine particles and colloids:** Plain sedimentation relies on gravity to settle particles, but very fine suspended solids and colloids (particles that don't settle easily) can remain in the water.
- **Improving sedimentation efficiency:** Coagulation makes these fine particles clump together into larger, heavier flocs, which settle much faster during sedimentation.
- **Enhancing overall treatment:** Coagulation-flocculation is often a pre-treatment step before filtration, significantly improving the efficiency of the entire water treatment process.

Principle and Types of Coagulation

Principle of Coagulation:

- **Charge neutralization:** Most suspended particles in water carry a negative electrical charge, which causes them to repel each other and remain dispersed.
- **Coagulant action:** Coagulants, typically positively charged chemicals like alum (aluminum sulfate), are added to the water.
- **Floc formation:** The positive ions from the coagulant neutralize the negative charges on the particles, allowing them to collide and stick together, forming larger, heavier flocs.

Types of Coagulation:

Inorganic Coagulants:

- **Aluminum salts:** Aluminum sulfate (alum) is a widely used coagulant.
- **Iron salts:** Ferric sulfate and ferric chloride are also common.
- **Sodium aluminate:** Another option for coagulation.

Organic Coagulants:

- **Polyelectrolytes:** These polymers can be used as coagulants and flocculants, often with minimal impact on pH.
- **Melamine Formaldehydes and Tannins:** These can act as sweep-floc coagulants, capturing additional materials like oil and grease.

Flocculation and Flash Mixer

Flocculation:

Gentle mixing: After coagulation, flocculation involves gently mixing the water to encourage the flocs to collide and grow larger, improving their settling rate.

. Flash Mixer:

Purpose:

To rapidly and uniformly disperse coagulant chemicals (like alum or ferric chloride) into the raw water or wastewater.

Process:

High-speed mixing ensures that the coagulant is evenly distributed, neutralizing the charges on suspended particles and initiating the coagulation process.

Key factor:

The duration of flash mixing is critical; too short a time may result in uneven mixing, while too long a time can lead to overdosing of chemicals.

Example:

In a flash mixer, coagulants are introduced and mixed vigorously with the incoming water stream using a high-speed impeller.

Flocculator and Clarifier

2. Flocculator:

Purpose:

To provide a gentle mixing environment that allows the destabilized particles (from the coagulation process) to collide and adhere to each other, forming larger, heavier flocs.

Process:

Flocculation occurs after flash mixing, where the water is gently agitated to encourage the formation of larger, settleable flocs.

Key factor:

The speed and duration of mixing in the flocculator are crucial for optimal floc formation. Too much mixing can break down the flocs, while too little can prevent proper aggregation.

Example:

Flocculators use slower-moving agitators to gently stir the water, allowing the tiny particles formed during coagulation to clump together.

3. Clarifier (Sedimentation Basin):

Purpose:

To provide a quiet environment where the larger, heavier flocs can settle out of the water due to gravity.

Process:

The water flows slowly through the clarifier, allowing the flocs to settle to the bottom, forming a sludge layer that is periodically removed.

Key factor:

The design of the clarifier (size, shape, and flow rate) is crucial for efficient separation of the flocs from the water.

Example:

Clarifiers are large tanks, either circular or rectangular, where the water velocity is reduced to allow gravity to separate the flocs.

Water Filtration Overview

Water filtration is essential for removing impurities and ensuring water is safe for consumption. Different types of filters, based on principles like mechanical straining, adsorption, and ion exchange, are employed to target specific contaminants. Common types include sand filters, activated carbon filters, reverse osmosis filters, and UV filters.

Necessity of Water Filtration:

- **Removes contaminants:** Filtration removes a wide range of impurities, including sediment, bacteria, viruses, chlorine, heavy metals, and dissolved solids, which can be harmful to human health.
- **Improves taste and odor:** Filtration can eliminate unpleasant tastes and odors caused by certain contaminants, making water more palatable.
- **Protects plumbing and appliances:** By removing sediment and other debris, filtration can prevent damage to pipes, faucets, and other water-using appliances.
- **Essential for various applications:** Filtration is crucial for drinking water, industrial processes, and even wastewater treatment.

Principles of Water Filtration

Mechanical Filtration:

This involves using a physical barrier (like a screen or membrane) to trap particles based on their size.

Adsorption:

This principle uses materials with a large surface area (like activated carbon) to attract and hold onto certain contaminants through chemical interactions.

Ion Exchange: This process exchanges undesirable ions (like calcium and magnesium in hard water) with other, less problematic ions (like sodium).

Reverse Osmosis:

This method forces water through a semipermeable membrane, leaving behind dissolved salts and other contaminants.

UV Disinfection: While not a filtration method in the traditional sense, UV light deactivates harmful microorganisms, making the water safe to drink.

Water Purification: Filtration, Disinfection, and Softening

Slow sand filters, rapid sand filters, and pressure filters all serve to purify water, but their essential features and mechanisms differ. Slow sand filters rely on a biological layer called the "schmutzdecke" for filtration, whereas rapid sand filters primarily use physical filtration and require backwashing for cleaning. Pressure filters are enclosed systems that utilize various media to remove contaminants under pressure, often used as a pre-treatment for other processes.

Essential Features of Water Filters

Here's a breakdown of their essential features:

Slow Sand Filters:

- **Biological Filtration:** The core of slow sand filtration is the biological layer (schmutzdecke) that develops on the sand surface, removing pathogens and organic matter.
- **Low Filtration Rate:** They operate at a very slow rate, typically 0.1 to 0.4 cubic meters per hour per square meter, allowing for biological activity.
- **Long Run Times:** Due to the biological process, slow sand filters can run for extended periods (months) without needing cleaning.
- **Simple Design:** They have a simple design with a sand bed and gravel layer, making them suitable for small-scale and remote applications.
- **Limited Turbidity Removal:** They are not ideal for highly turbid waters, as the biological layer can be easily clogged.
- **No Chemical Additives:** They can remove pathogens and impurities without the need for chemical coagulants.

Rapid Sand Filters and Pressure Filters

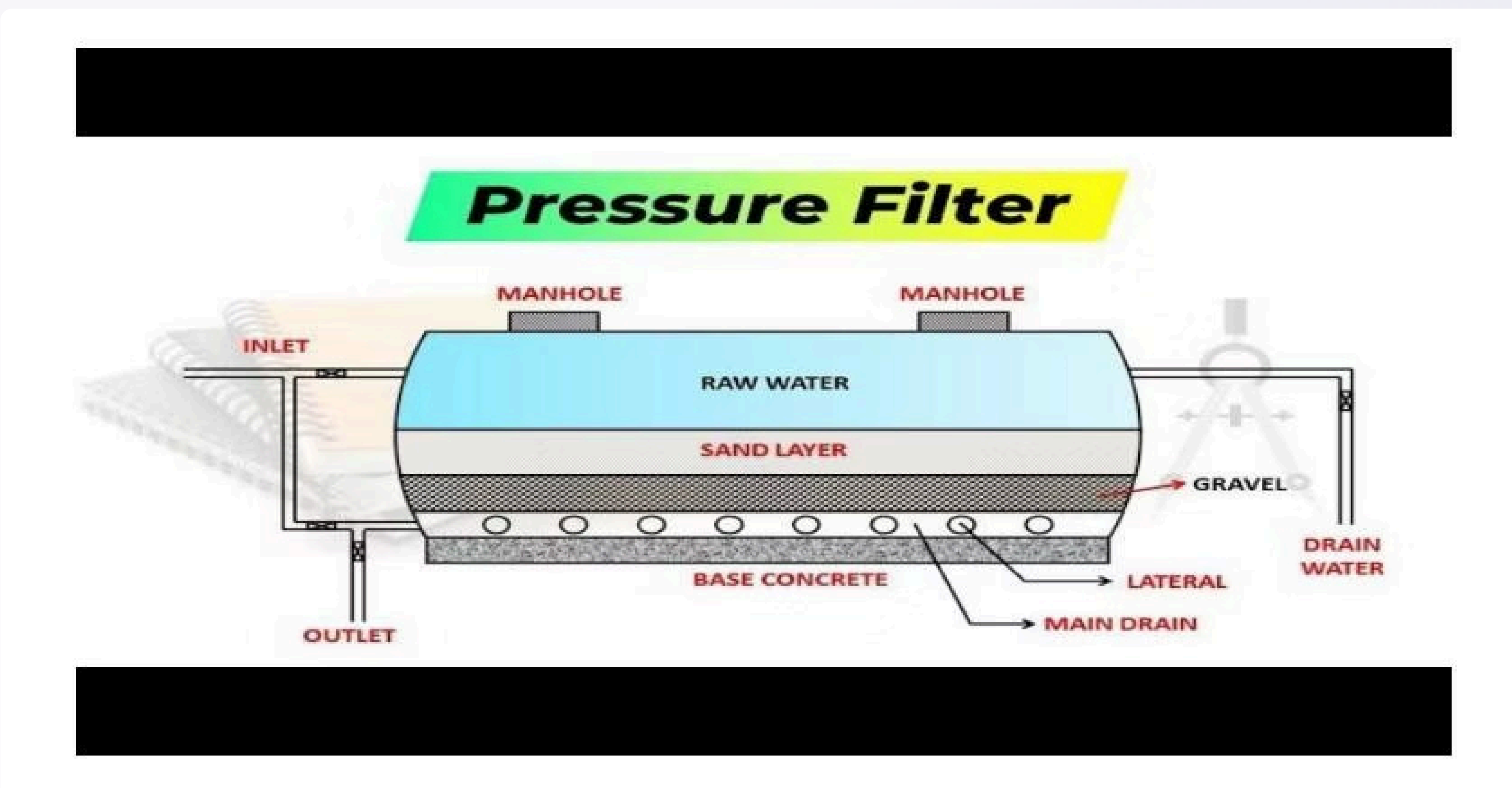
Rapid Sand Filters:

- **Physical Filtration:** They rely on the physical entrapment of particles in the sand bed.
- **High Filtration Rate:** They operate at a much faster rate than slow sand filters.
- **Backwashing:** They require regular backwashing to remove accumulated debris and maintain filtration efficiency.
- **Pre-treatment:** They often require pre-treatment like flocculation and sedimentation to remove larger particles.
- **Effective Turbidity Removal:** They are highly effective in removing turbidity and other suspended solids.
- **Chemical Usage:** They typically require the use of coagulants like alum to aid in particle removal.

Pressure Filters:

- **Enclosed System:** They are enclosed tanks that operate under pressure.
- **Multiple Media:** They can utilize a variety of filter media, such as sand, activated carbon, or specific resins, to target different contaminants.
- **Pre-treatment:** They can serve as pre-treatment for other filtration systems like ultrafiltration or as a standalone treatment method.
- **High Pressure Operation:** Their pressurized operation allows for higher flow rates and efficient removal of contaminants.
- **Versatile Applications:** They can be used to remove iron, manganese, turbidity, and other contaminants.
- **Compact Design:** Their enclosed design makes them suitable for space-constrained applications.

In essence, the choice between these filter types depends on factors such as the water quality, the required flow rate, the desired level of treatment, and the available resources and expertise



Disinfection in Water Treatment

Disinfection

Disinfection is a crucial step in water treatment to eliminate harmful microorganisms and ensure safe drinking water. It involves using various methods to kill or inactivate pathogens like bacteria, viruses, and parasites, preventing waterborne diseases. Common methods include chlorination, ozonation, and ultraviolet (UV) light treatment.

Necessity of Disinfection:

Preventing waterborne diseases:

Pathogens in water can cause serious illnesses such as cholera, typhoid, and dysentery.

Ensuring safe drinking water:

Disinfection is essential for making water safe for consumption, even if it appears clear.

Protecting public health:

By eliminating harmful microorganisms, disinfection safeguards the health of individuals and communities.

Environmental protection:

Disinfection prevents the spread of waterborne diseases through wastewater discharge, protecting aquatic life and ecosystems.

Methods of Disinfection

Methods of Disinfection:

Chlorination:

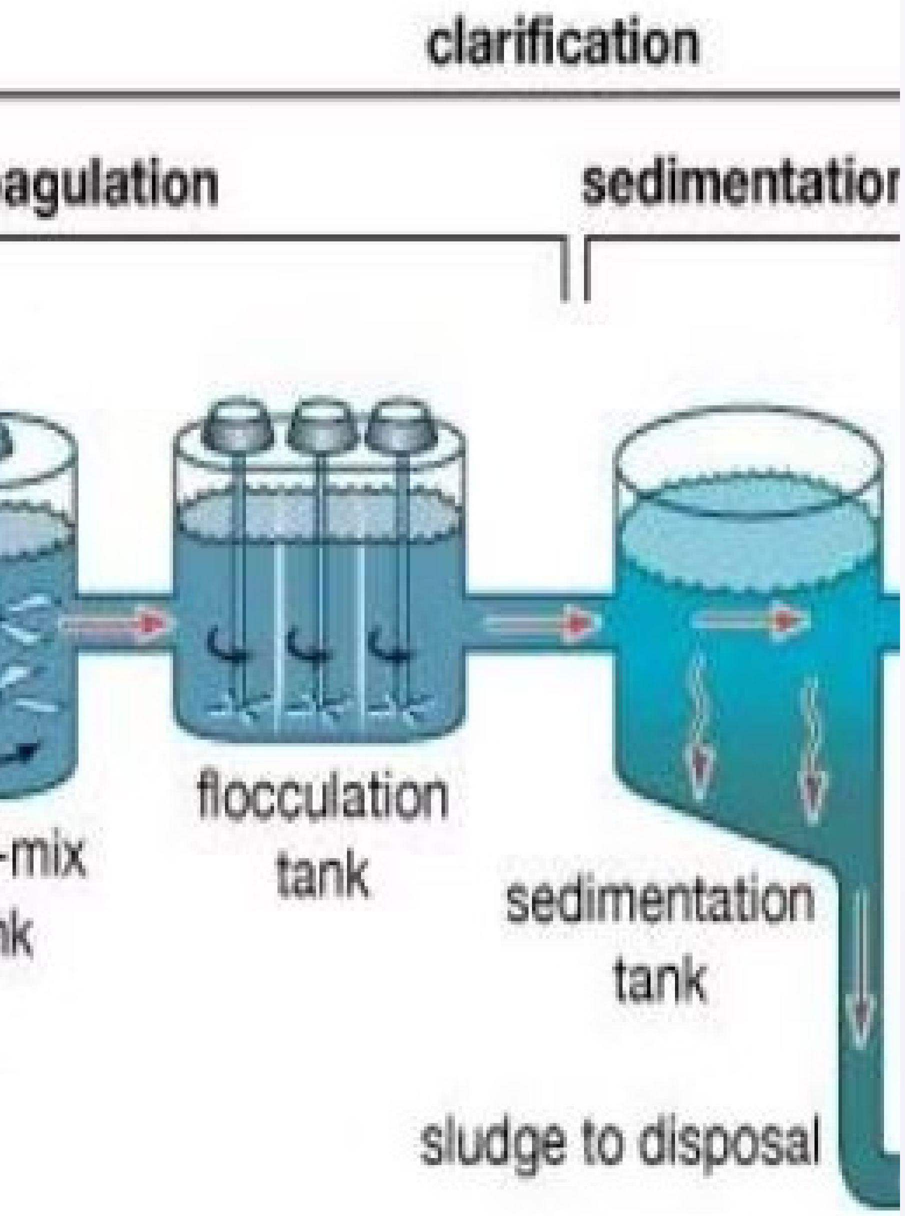
- Chlorine or its compounds (like chloramines) are widely used due to their effectiveness and residual disinfection properties.
- Chlorine kills or inactivates pathogens by disrupting their cellular processes.
- Chlorination is effective against a wide range of microorganisms.
- It also provides a residual disinfectant that can prevent regrowth of pathogens in the distribution system.

Ozonation:

- Ozone (O3) is a powerful oxidant that effectively kills microorganisms.
- It is more reactive than chlorine and leaves no chemical residuals in the water.
- Ozonation is also effective in removing taste and odor compounds.

UV Radiation:

- UV light inactivates microorganisms by damaging their DNA, preventing them from reproducing.
- UV disinfection is a chemical-free method.
- It is effective against a wide range of pathogens, including bacteria, viruses, and protozoa.



Other Disinfection Methods

Other methods:

- **Chlorine dioxide:** Another chlorine-based disinfectant that is effective against a wide range of pathogens.
- **Iodine and bromine:** Used as disinfectants, particularly in emergency situations.
- **Heat:** Boiling water is a simple method of disinfection used in emergencies.
- **Electrochemical membrane technology:** Emerging technology that utilizes electrochemical processes for disinfection.

Chlorination: Key Concepts

Chlorination is a common water treatment process that uses chlorine to disinfect water by killing harmful bacteria and viruses. Different types of chlorination, like pre-chlorination, breakpoint chlorination, and super-chlorination, are used to manage chlorine's effectiveness and ensure safe water. Chlorine demand refers to the amount of chlorine needed to react with impurities before a disinfectant effect is achieved, while residual chlorine is the amount remaining after this demand is met. Key Concepts:

Chlorine Demand:

The amount of chlorine that reacts with impurities in the water (like organic matter, iron, manganese, etc.) before it can act as a disinfectant.It represents the chlorine's consumption by these substances.

Free Chlorine:

Chlorine that is available to disinfect water, including forms like hypochlorous acid (HOCl), hypochlorite ions (OCl-), and dissolved chlorine gas (Cl2).

Combined Chlorine:

Chlorine that has combined with other compounds, like ammonia, to form chloramines.

Residual Chlorine:

The amount of chlorine remaining in the waterafter the chlorine demand has been satisfied. It's the active disinfectant that provides ongoing protection against microbial contamination.

Chlorination Processes

Breakpoint Chlorination:

A process where chlorine is added to water until the chlorine demand is met, and any additional chlorine results in a free chlorine residual.

Super Chlorination:

The process of adding chlorine beyond the breakpoint, often used to disinfect water during epidemics or when dealing with specific contaminants like amoebic cysts.

Pre-chlorination:

Chlorination applied early in the watertreatment process, often before filtration, to help control microbial growth and aid in coagulation.

Double or Multiple Chlorination:

Involves both pre-chlorination and post-chlorination, where chlorine is added at multiple points in the treatment process.

How it works:

1. **Chlorine Addition:** Chlorine is added to the waterin the form of chlorine gas, sodium hypochlorite, or calcium hypochlorite.
2. **Chlorine Demand:** The chlorine reacts with impurities and organic matter in the water, consuming the chlorine and reducing its concentration.
3. **Breakpoint:** When enough chlorine has been added to satisfy the chlorine demand, breakpoint is reached, and any further addition of chlorine will result in a free chlorine residual.
4. **Residual Chlorine:** The free chlorine residual is the active disinfectant that continues to kill bacteria and viruses in the water.

Importance of Residual Chlorine and Specific Chlorination Types

Importance of Residual Chlorine:

- **Disinfection:** Residual chlorine ensures that the water remains disinfected during distribution and storage, preventing re-contamination.
- **Public Health:** It's crucial for public health, as it protects against waterborne diseases.

Break-point Chlorination:

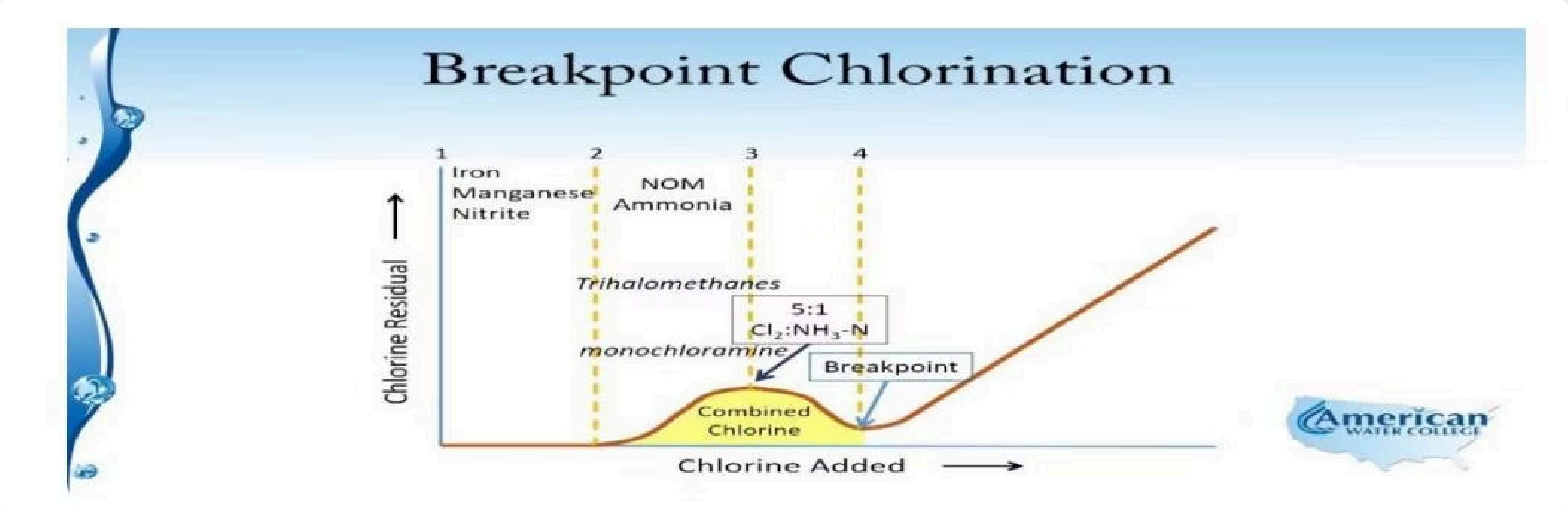
- **Purpose:** To ensure a sufficient free chlorine residual for effective disinfection.
- **Process:** Adding chlorine until the chlorine demand is met, and any further addition results in free chlorine.
- **Significance:** It ensures that the water is properly disinfected and that there is enough residual chlorine to provide ongoing protection.

Super Chlorination:

- **Purpose:** To add excess chlorine beyond the breakpoint, often used for emergency situations or to address specific contaminants.
- **Process:** Adding chlorine in higher doses than breakpoint chlorination.
- **Significance:** It can be used to disinfect water during outbreaks of waterborne diseases or when dealing with difficult-to-remove contaminants.

Pre-chlorination:

- **Purpose:** To disinfect water early in the treatment process, often before filtration.
- **Process:** Adding chlorine at the beginning of the treatment process.
- **Significance:** Helps to control microbial growth and aids in coagulation and flocculation processes.



Water Softening: Necessity and Methods

Water softening is the process of reducing the mineral content in water, specifically calcium and magnesium ions, which cause hardness. It's necessary to prevent scale buildup in pipes and appliances, improve soap lathering, and enhance water taste. The main methods for water softening are lime-soda process and ion exchange.

Necessity of Water Softening:

Scale Formation:

Hard water forms scale (calcium and magnesium deposits) inside pipes, water heaters, and appliances, reducing efficiency and potentially causing damage.

Soap Inefficiency:

Hard water reduces the effectiveness of soap, requiring more soap for cleaning and leaving behind soap scum.

Taste and Appearance:

Hard water can have a metallic taste and may cause spots on dishes and fixtures.

Health Concerns:

While not a direct health hazard, some people prefer softened water for drinking and hygiene.

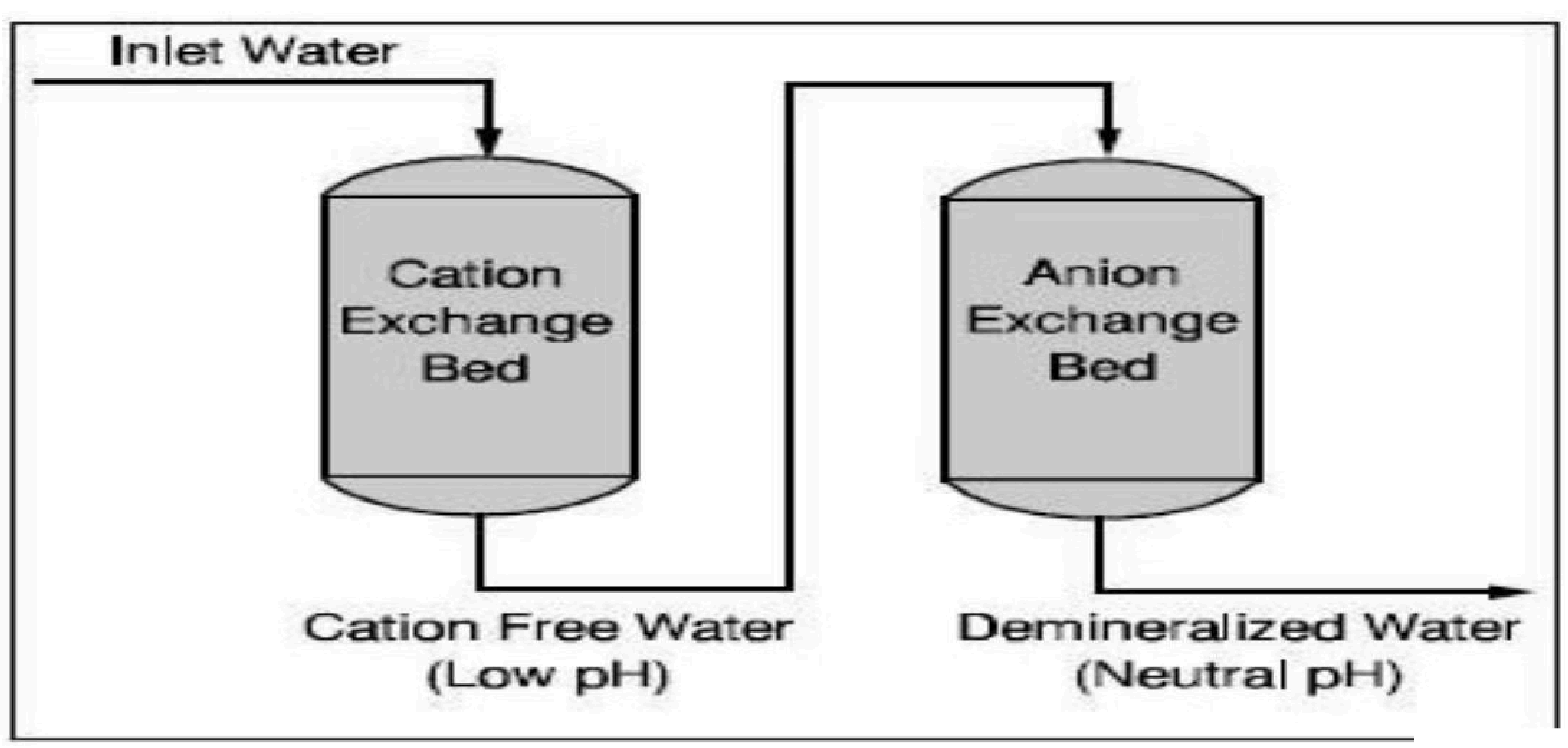
Methods of Water Softening:

1. Lime-Soda Process:

- This chemical process involves adding lime (calcium hydroxide) and soda ash (sodium carbonate) to the water.
- Lime reacts with temporary hardness (bicarbonates) and magnesium, precipitating them out as calcium carbonate and magnesium hydroxide, respectively.
- Soda ash is added to remove non-carbonate hardness (sulfates and chlorides of calcium and magnesium).
- The precipitates are then removed through sedimentation and filtration.
- This method can be done hotor cold, with hot process being more efficient.

2. Ion Exchange Method:

- This method utilizes a resin bed containing sodium or potassium ions.
- Hard water is passed through the resin, and the resin exchanges its sodium or potassium ions for calcium and magnesium ions in the water.
- The water exiting the resin bed is softened,while the resin becomes depleted of sodium/potassium.
- The resin is then regenerated by flushing it with a concentrated salt solution (brine), which replaces the calcium and magnesium ions with sodium/potassium.
- This process is widely used in both residential and industrial settings due to its efficiency and ease of operation.



Question Bank – Chapter 3: Treatment of Water

3.1 Flow Diagram of Conventional Water Treatment System

Short Questions:

- What is a conventional water treatment system?
- Draw a neat flow diagram of a conventional water treatment plant.

Long Questions:

- Describe the various units involved in a conventional water treatment plant with a flow diagram.
- Explain the step-by-step watertreatment process as per conventional layout.

Key Processes in Water Treatment

3.2.1 Aeration

Short Questions:

- What is aeration?
- State the necessity of aeration in watertreatment.

Long Questions:

- Explain the process of aeration and its role in removing dissolved gases and impurities from water.

3.2.2 Plain Sedimentation

Short Questions:

- What is plain sedimentation?
- Name different types of sedimentation tanks.

Long Questions:

- Describe the working principle and design considerations of sedimentation tanks.
- Discuss the operation and maintenance of sedimentation tanks.
- Explain the necessity and essential features of plain sedimentation tanks with sketches.

3.2.3 Sedimentation with Coagulation

Short Questions:

- What is coagulation?
- List any two types of coagulants.
- Define flocculator and flash mixer.

Long Questions:

- Explain the need for coagulation in watertreatment.
- Describe the principle and process of sedimentation with coagulation.
- Write notes on:

Flash Mixer

Flocculator

Clarifier (definition and working)

Advanced Water Treatment Methods

3.2.4 Filtration

Short Questions:

- What is filtration?
- Name any two types of filters used in watertreatment.
- Write any two features of a slow sand filter.

Long Questions:

- Explain the necessity and working principle of water filtration.
- Compare slow sand filter, rapid sand filter, and pressure filter.
- Describe essential features and working of rapid sand filters with a diagram.

3.2.5 Disinfection

Short Questions:

- What is disinfection?
- What do you mean by residual chlorine?
- Define free and combined chlorine.

Long Questions:

- Describe the necessity and methods of disinfection of water.
- Explain the process of chlorination and its types:

1	2	3
Pre-chlorination	**Breakpoint chlorination**	**Super-chlorination**

- Discuss chlorine demand and residual chlorine with examples.

3.2.6 Softening of Water

Short Questions:

- What is water softening?
- Name any one method of water softening.

Long Questions:

- Explain the necessity of water softening in treatment.
- Describe the Lime Soda process of water softening with reactions (concept level).
- Write a short note on ion-exchange method of water softening (concept only).

Distribution System And Appurtenance in Distribution System

A water distribution system delivers water to consumers with adequate quantity, quality, and pressure. It includes pipes, storage reservoirs, pumps, and various appurtenances like valves, hydrants, and meters. Key requirements include ensuring reliable and adequate water supply, maintaining water quality throughout the system, and providing sufficient pressure and storage for fire protection.

General Requirements of a Water Distribution System

Adequate Quantity and Pressure:

The system must deliver the required amount of water to each consumer, and the pressure should be sufficient (typically not less than 20 psi) to meet their needs.

Water Quality:

The water delivered should be of acceptable quality, meaning it should meet drinking water standards and not deteriorate during its transit through the distribution system.

Reliability:

The system should be designed to ensure a continuous and reliable supply of water, even during peak demand or emergencies.

Fire Protection:

Adequate storage and flow capacity should be available to meet fire flow demands.

Accessibility and Maintainability:

The system should be designed for ease of maintenance and repair, with readily accessible valves, hydrants, and other appurtenances.

Economy:

The system should be designed and operated in an economical manner, balancing capital costs, operating costs, and energy consumption.

Flexibility and Adaptability:

The system should be able to adapt to changing water demands and future growth of the community.

Appurtenances in a Water Distribution System

Appurtenances are miscellaneous components that facilitate the efficient operation and maintenance of the distribution system. Some common examples include:

- **Valves:** Used to control the flow of water, isolate sections for maintenance, regulate pressure, and release or admit air.
- **Fire Hydrants:** Provide a readily available source of water for firefighting.
- **Water Meters:** Measure the amount of water used by individual consumers.
- **Service Lines:** Connect the main distribution pipes to individual buildings.
- **Air Valves:** Release trapped air from the pipelines.
- **Pressure Relief Valves:** Protect the system from excessive pressure.
- **Manholes:** Allow access to underground pipes for inspection and maintenance.

Water distribution systems can be broadly categorized into gravity, direct pumping, and combined systems, each utilizing different methods to deliver water to consumers. Appurtenances, such as pipes, valves, and storage tanks, are essential components that control, regulate, and maintain the flow of water within these systems.

Types of Distribution Systems

1. Gravity System:

- In a gravity system, water is distributed solely by the force of gravity.
- Water is typically sourced from a high-elevation location (like a reservoir on a hill) and flows downhill to lower-lying areas.
- This method is cost-effective where the source naturally sits at a higher elevation than the distribution area.

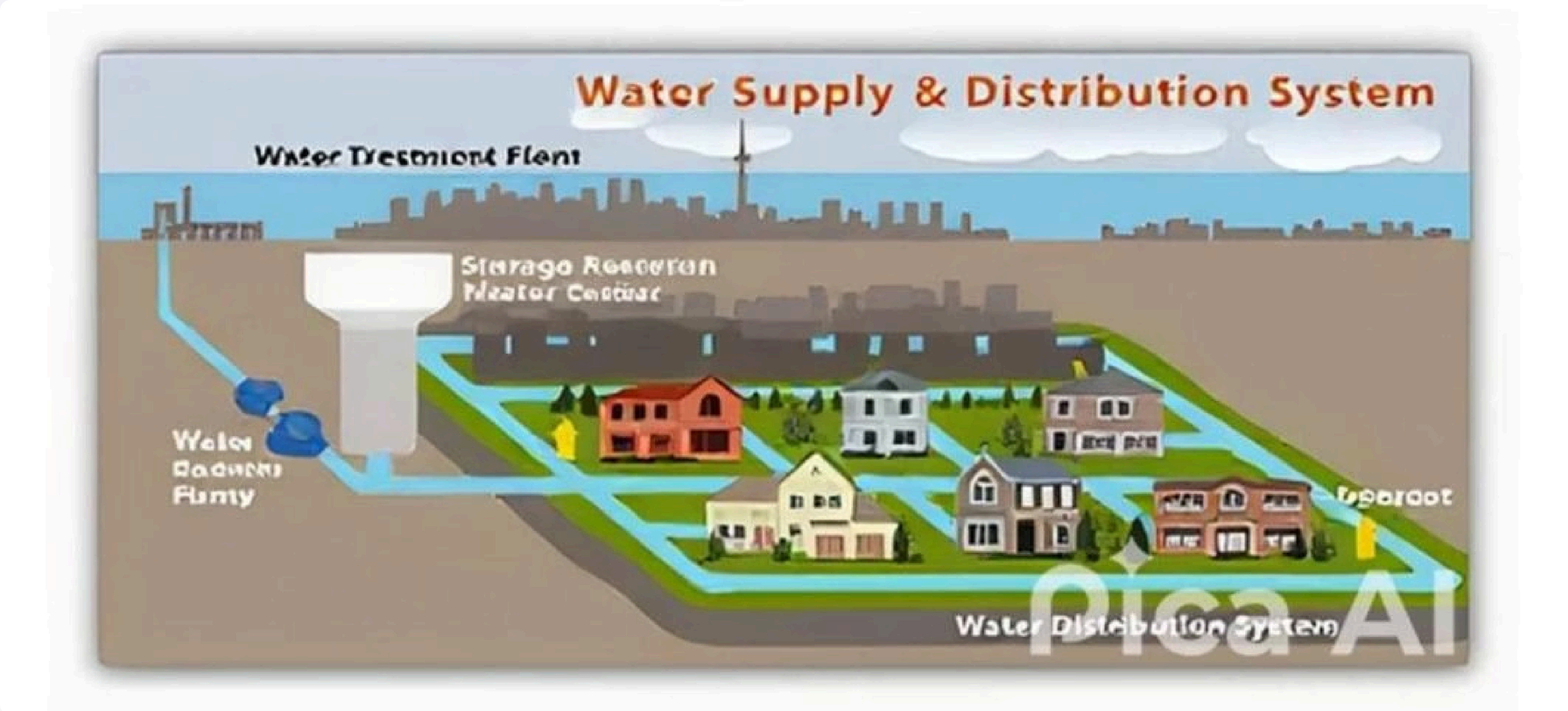
2. Direct Pumping System:

- In a direct pumping system, water is pumped directly from the source (or after treatment) into the distribution network without any intermediate storage.
- High-lift pumps are required to overcome friction and maintain pressure at the points of use.
- This system is less reliant on natural elevation and can be used in diverse terrains.

3. Combined Gravity and Pumping System:

- This system combines both gravity and pumping to deliver water.
- Water is pumped to an elevated storage reservoir (like an overhead tank).
- From the reservoir, water is distributed to consumers by gravity.
- This method allows for efficient storage of excess water during low demand periods for use during high demand.
- It also ensures a more reliable water supply, even during power outages, as the reservoir provides a backup source.

Appurtenances in Distribution Systems



- **Pipes:** The network of pipes carries water throughout the system.
- **Valves:** Valves control the flow of water, allowing for isolation of sections for maintenance or repairs.
- **Storage Tanks/Reservoirs:** These store water for distribution and help regulate pressure.
- **Hydrants:** Used for firefighting and other emergency purposes.
- **Water Meters:** Measure water usage by individual consumers.
- **Pumps:** Used to lift water to higher elevations or increase pressure in the system.
- **Pressure Regulating Valves:** Control and maintain water pressure.
- **Air Valves:** Release trapped air from the system.

Methods of Water Supply: Continuous vs. Intermittent

In a water distribution system, the two primary methods of supply are continuous and intermittent. Continuous supply delivers water 24 hours a day, while intermittent supply provides water for a limited time each day.

Continuous Water Supply:

Description:

Water is supplied 24 hours a day, every day of the year, through a pressurized network.

Advantages:

- Fresh water is always available.
- Meets fire demands quickly.
- No need for storage tanks.

Disadvantages:

- Can waste more water due to leaks.
- Requires more infrastructure.
- Can be expensive to maintain.

Intermittent Water Supply:

Description:

- Water is supplied for a limited number of hours per day, often divided into zones.

Advantages:

- Manages water scarcity.
- Can be cheaper to implement initially.

Disadvantages:

- Water may not be available during emergencies.
- Requires storage tanks, which can lead to contamination and mosquito breeding.
- Negative pressure in pipes during off-supply periods can cause contamination.
- Supply times may not be convenient for all consumers.

Distribution System Layouts in Water Supply

Introduction

A water distribution system delivers treated water from the treatment plant or storage reservoir to individual consumers through a network of pipes, pumps, and storage tanks.

Types of Distribution System Layouts

1

Dead-End System (Tree System)

Description: Branching layout with isolated ends.

Advantages:

- Easy to design and construct.
- Fewer valves.

Disadvantages:

- Stagnant water at ends.
- Poor circulation.

Suitability: Small towns and rural areas.

2

Grid System (Loop System)

Description: Water flows in multiple directions; resembles a network.

Advantages:

- Good pressure.
- Continuous circulation.

Disadvantages:

- Costlier and complex.

Suitability: Urban areas and planned cities.

3

Radial System

Description: Water flows outward from a central point.

Advantages:

- Equal pressure.
- Simple design.

Disadvantages:

- Failure affects whole sector.

Suitability: Modern radial townships.

4

Ring or Circular System

Description: Main pipelines form a closed loop.

Advantages:

- Reliable supply.
- Easy isolation.

Disadvantages:

- Expensive due to more piping.

Suitability: Large cities.

Valves in Water Distribution System

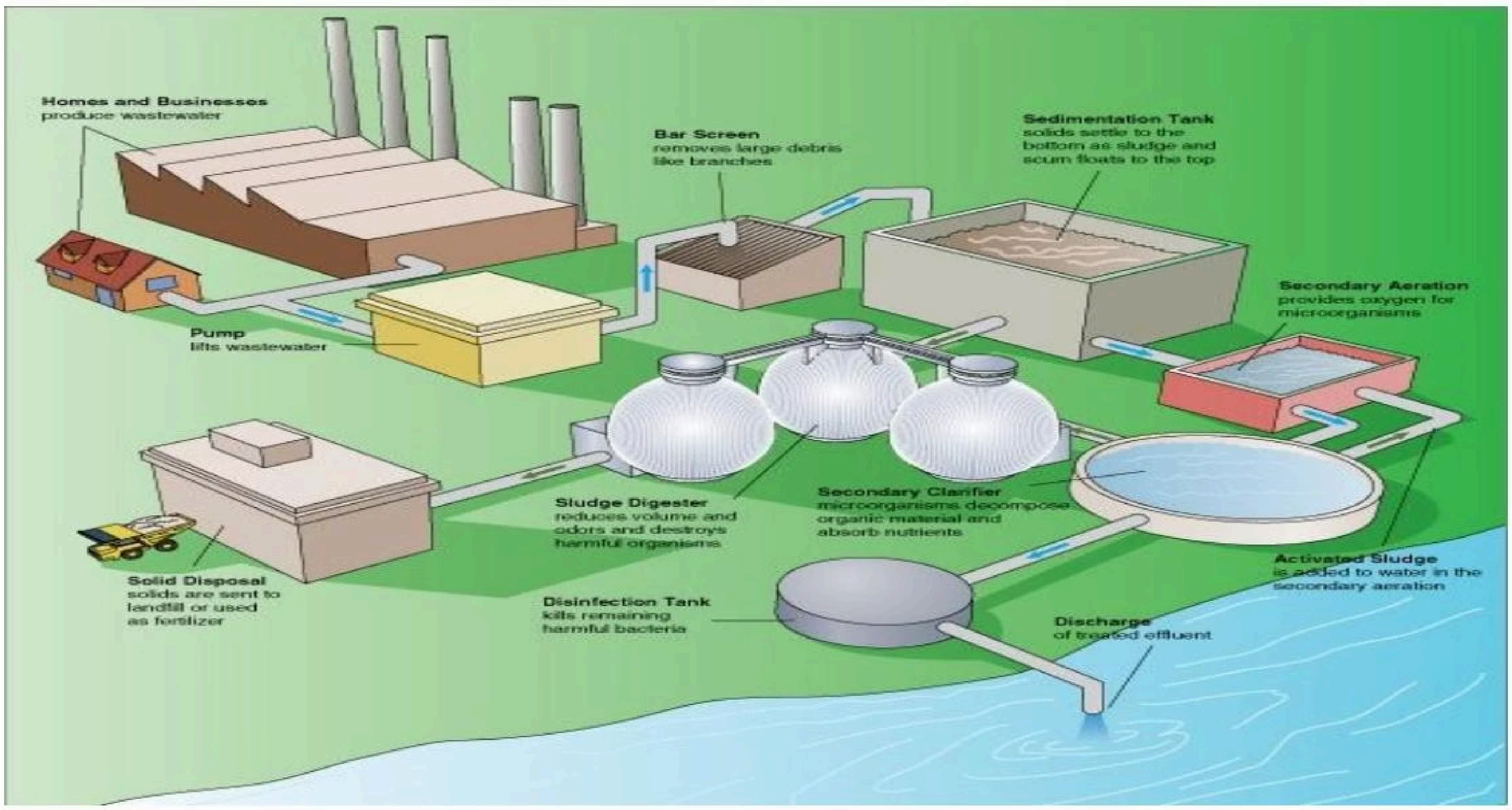
Introduction

Valves are important control devices in a water distribution system used to regulate, direct, stop or monitor water.

Types of Valves and Their Uses

- **1. Sluice Valve (Gate Valve)**
  - **Purpose:** Used to isolate a section of the pipeline for maintenance or repairs.
  - **Feature:** Operates by raising or lowering a gate inside the valve.
  - **Use:** Installed at regular intervals, on branch lines, and near critical installations.
- **2. Check Valve (Non-return Valve)**
  - **Purpose:** Prevents backflow of water.
  - **Feature:** Allows flow in only one direction.
  - **Use:** Installed on pump delivery lines and rising mains.
- **3. Air Valve**
  - **Purpose:** Removes trapped air in water mains.
  - **Feature:** Automatically releases air pockets.
  - **Use:** Installed at high points of pipelines.
- **4. Scour Valve (Drain Valve or Blow-off Valve)**
  - **Purpose:** Drains out sediment and cleans the pipeline.
  - **Feature:** Fitted at the lowest point in a pipe system.
  - **Use:** Used during maintenance or flushing operations.
- **5. Fire Hydrant**
  - **Purpose:** Provides water for firefighting purposes.
  - **Feature:** Vertical pipe with a nozzle connection.
  - **Use:** Installed at road junctions or near public buildings.
- **6. Water Meter**
  - **Purpose:** Measures the amount of water supplied to consumers.
  - **Feature:** Records flow rate and total usage.
  - **Use:** Installed at individual house or commercial service connections.

Sanitary Engineering: Main Aim and Objectives



The main aim of sanitary engineering is to protect public health and the environment by managing water resources, wastewater, and solid waste effectively. Its objectives include disease prevention, environmental protection, and promoting sustainable practices through efficient resource use and waste management.

Elaboration:

Sanitary engineering is a specialized branch of engineering focused on improving the overall sanitation of human communities. It achieves this by addressing the safe and efficient removal and disposal of human waste, as well as providing safe drinking water. The core objectives of sanitary engineering can be further broken down as follows:

- **Disease Prevention:** A primary goal is to prevent the spread of diseases by ensuring proper sanitation practices, including safe water supply and effective wastewater and solid waste management.
- **Environmental Protection:** Sanitary engineering aims to minimize the negative impacts of human activities on the environment. This includes preventing pollution of water sources, soil, and air from waste materials.
- **Sustainable Practices:** It promotes the efficient use of resources and the implementation of sustainable waste management strategies to reduce environmental impact and promote long-term ecological balance.
- **Public Health Protection:** By addressing sanitation issues, sanitary engineering contributes to the overall well-being of individuals and communities by creating healthier living environments.
- **Regulatory Compliance:** Sanitary engineering involves adhering to local, national, and international regulations related to sanitation and waste management to ensure safety and health standards are met.

Key Terms in Sanitary Engineering

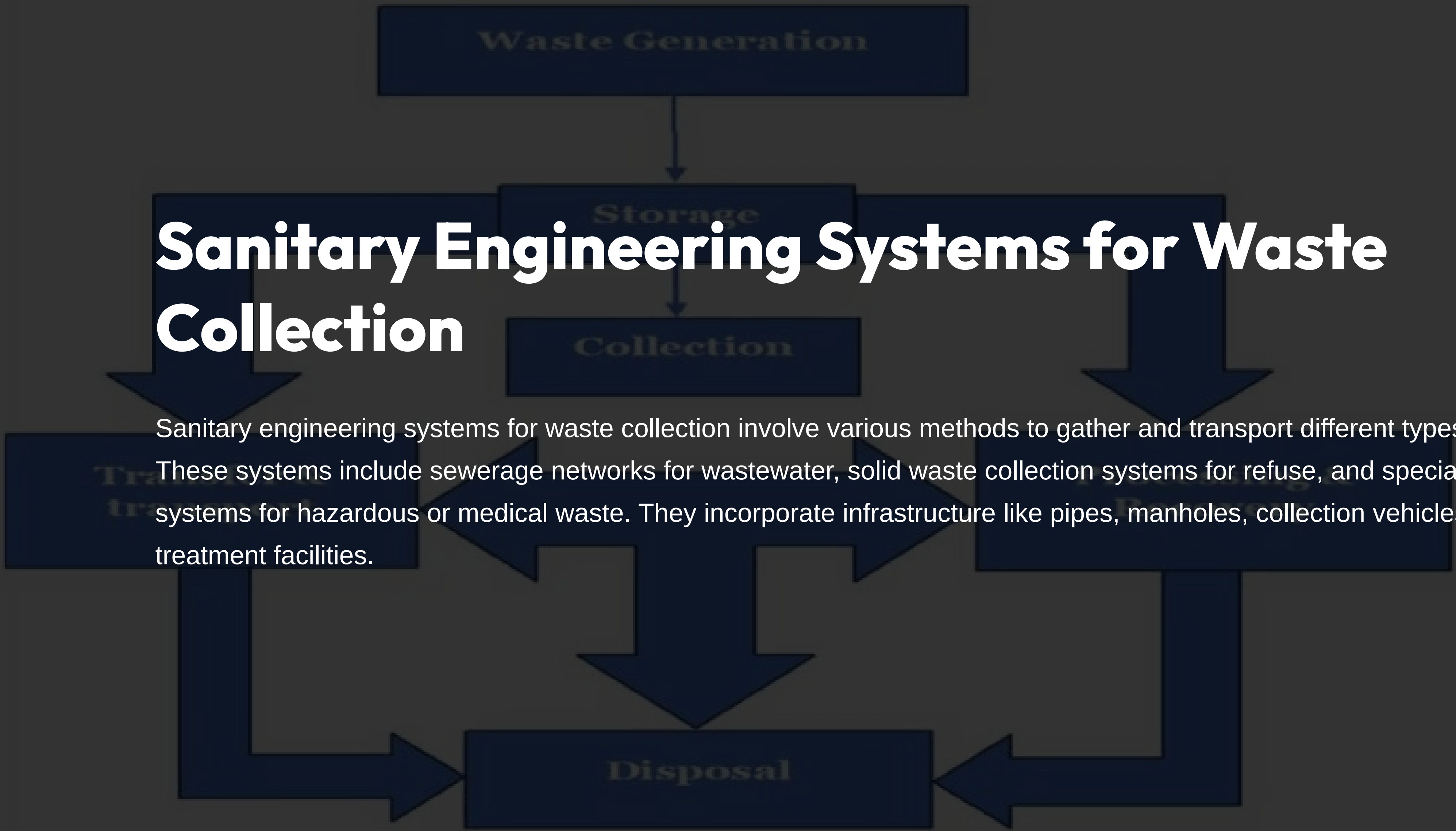
Sanitary engineering encompasses the design, construction, and maintenance of systems that ensure public health through waste management and safe water supply. Key terms include sewage, which is wastewater from various sources; sullage, which is wastewater from baths, kitchens, etc., excluding toilet waste; and sewerage, the system of sewers for waste transport. Sanitary engineering also involves storm water management and solid waste management.

Elaboration:

- **Sanitary Engineering:** A branch of engineering focused on public health through the design and management of systems for waste removal and safe water supply.
- **Sewage:** Liquid waste from various sources like residences, industries, and public spaces, including sullage and toilet waste.
- **Sullage:** Wastewater from sources like bathrooms, kitchens, and washbasins, excluding toilet waste.
- **Sewerage:** The network of underground pipes (sewers) and associated infrastructure that collects and conveys sewage.
- **Storm Water:** Runoff from rainfall that enters the sewer system.
- **Solid Waste Management:** The process of collecting, transporting, and disposing of solid waste materials.
- **Refuse:** A general term encompassing all types of waste, including garbage, rubbish, and sewage.
- **Garbage:** Wet, easily decomposable waste, like food scraps.
- **Rubbish:** Dry waste like paper, plastics, and other discarded materials.
- **Sanitary Sewage:** Sewage from residential, commercial, and industrial sources that is treated before disposal.
- **Domestic Sewage:** Sewage generated from household activities like toilet use, washing, and bathing.
- **Industrial Sewage:** Sewage generated from industrial processes.
- **Sewer:** An underground pipe or conduit used to transport sewage.
- **Storm Sewer:** A sewer specifically designed to carry storm water runoff.
- **Combined Sewer:** A sewer system that carries both sewage and storm water.
- **Wastewater Treatment:** The process of removing contaminants from wastewater to make it safe for discharge or reuse.
- **Sludge:** The solid or semi-solid material that is a byproduct of wastewater treatment.
- **Infiltration:** The process of groundwater entering sewers through cracks or leaks.
- **Dry Weather Flow (DWF):** The normal, continuous flow of sewage in a sewer system, excluding storm water.
- **Peak Flow:** The maximum rate of flow in a sewer system, typically occurring during peak usage or storm events.

Sanitary Engineering Systems for Waste Collection

Sanitary engineering systems for waste collection involve various methods to gather and transport different types of waste. These systems include sewerage networks for wastewater, solid waste collection systems for refuse, and specialized systems for hazardous or medical waste. They incorporate infrastructure like pipes, manholes, collection vehicles, and treatment facilities.



Wastewater Collection

Sewerage Systems:

These systems use a network of underground pipes (sewers) to collect and transport wastewater (sewage) from residential, commercial, and industrial sources.

Types of Sewers:

Sanitary sewers carry only wastewater, while storm sewers handle stormwater runoff. Combined sewers carry both, but this can lead to overflows during heavy rainfall.

Components:

Key components include inlets, catch basins, manholes, cleanouts, and pumping stations.

Collection Methods:

Gravity systems, low-pressure systems, and vacuum systems are used to move wastewater through the network.

Treatment:

Collected wastewater is typically treated at a wastewater treatment plant to remove pollutants before being discharged or reused.

Solid Waste Collection and Disposal

Source Separation:

Waste is often separated at the source (homes, businesses) into different categories like recyclables, organic waste, and general waste.

Collection Methods:

Waste collection can involve curbside pickup, drop-off centers, and strategically placed waste bins.

Transportation:

Waste is transported by specialized vehicles to processing and disposal facilities.

Disposal Options:

Solid waste is managed through recycling, composting, incineration, and landfilling.

Sanitary Landfills:

These are designed to minimize environmental impact by using liners, covering waste with soil, and controlling leachate.

Other Waste Systems and Smart Sanitary Engineering

Hazardous Waste:

Specialized collection and disposal methods are needed for hazardous and medical waste, often involving incineration or secure landfills.

Industrial Waste:

Industrial waste management involves specific regulations and treatment processes depending on the type of waste.

E-waste:

Electronic waste requires specialized collection and recycling to prevent environmental contamination.

Smart Sanitary Engineering:

Smart Bins:

Sensors in waste bins can optimize collection routes and reduce fuel consumption.

Wastewater Reuse:

Advanced treatment technologies allow for the reuse of treated wastewater for irrigation and other non-potable purposes.

Conservancy vs. Water Carriage Systems

The conservancy and water carriage systems represent contrasting approaches to sewage and waste management. The conservancy system, a traditional method, relies on manual collection and disposal of waste, often involving human contact with sewage. Conversely, the water carriage system utilizes a network of pipes and water flow to transport sewage away from the source, minimizing human interaction. While the conservancy system is cheaper to implement, it poses significant hygiene and health risks. The water carriage system, despite its higher initial cost, offers greater sanitation, safety, and is generally preferred in modern urban settings.

Comparison of Features:

Waste Collection	Manual, using containers or pits	Water-based, using sewers
Waste Removal	Manual transport (carts, buckets)	Piped conveyance, water flow
Hygiene	Low, potential for disease transmission	High, minimal human contact with sewage
Cost	Low initial cost	Higher initial cost
Aesthetics	Can be unsightly	Generally cleaner and more aesthetically pleasing

Suitability of Waste Management Systems

The conservancy system is generally more suitable for rural areas or places with limited access to water and where the population density is low. Its low initial cost can be a significant advantage in such settings. However, the health risks associated with manual handling of waste make it less desirable in most situations.

The water carriage system is the preferred method for urban areas and places with higher population densities. The advantages of improved sanitation, reduced health risks, and minimal manual labor make it a more sustainable and hygienic option for modern living. The higher initial cost is often offset by the long-term benefits and reduced health burden.

Quantity of Sanitary Sewage :

The determination of sanitary sewage is necessary because of the following factors which depend on this:

1. To design the sewerage schemes as well as to dispose a treated sewage efficiently.
2. The size, shape and depth of sewers depend on quantity of sewage.
3. The size of pumping unit depends on the quantity of sewage.

Estimating Sanitary Sewage Quantity

Sanitary sewage is mostly the spent water of the community into sewer system with some groundwater and a fraction of the storm runoff from the area, draining into it. Before designing the sewerage system, it is essential to know the quantity of sewage that will flow through the sewer. The sewage may be classified under two heads:

1. The sanitary sewage, and
2. Storm water

Sanitary sewage is also called as the Dry Weather Flow (D.W.F), which includes the domestic sewage obtained from residential and residential and industrials etc., and the industrial sewage or trade waste coming from manufacturing units and other concerns.

Quantity of Sewage:

It is usual to assume that the rate of sewage flow, including a moderate allowance for infiltration equals to average rate of water consumption which is 135 litre/ head /day according to Indian Standards. It varies widely depending on size of the town etc.this quantity is known as Dry Weather Flow (D.W.F). It is the quantity of water that flows through sewer in dry weather when no storm water is in the sewer. Rate of flow varies throughout 24 hours and is usually the greatest in the fore-noon and very small from midnight to early morning. For determining the size of sewer, the maximum flow should be taken as three times the D.W.F.

Design Discharge and Factors Affecting Sanitary Sewage

Design Discharge of Sanitary Sewage

The total quantity of sewage generated per day is estimated as product of forecasted population at the end of design period considering per capita sewage generation and appropriate peak factor. The per capita sewage generation can be considered as 75 to 80% of the per capita water supplied per day. The increase in population also result in increase in per capita water demand and hence, per capita production of sewage. This increase in water demand occurs due to increase in living standards, betterment in economic condition, changes in habit of people, and enhanced demand for public utilities.

Factors affecting the quantity of sewage flow: - The quantity of sanitary sewage is mainly affected by the following factors:

- Population
- Type of area
- Rate of water supply
- Infiltration and exfiltration

In addition to above, it may also be affected by habits of people, number of industries and water pressure etc.

The quantity of sanitary sewage directly depends on the population. As the population increases the quantity of sanitary sewage also increases. The quantity of water supply is equal to the rate of water supply multiplied by the population. There are several methods used for forecasting the population of a community.

The quantity of sanitary sewage also depends on the type of area as residential, industrial or commercial. The quantity of sewage developed from residential areas depend on the rate of water supply to that area, which is expressed a litres/ capita/ day and this quantity is obtained by multiplying the population with this factor.

The quantity of sewage produced by various industries depends on their various industrial processes, which is different for each industry.

Similarly, the quantity of sewage obtained from commercial and public places can be determined by studying the development of other such places.

Water Rate, Infiltration, and Exfiltration

Rate of water

Truly speaking the quantity of used water discharged into a sewer system should be a little less than the amount of water originally supplied to the community. This is because of the fact that all the water supplied does not reach sewers owing to such losses as leakage in pipes or such deductions as lawn sprinkling, manufacturing processes etc.

However, these losses may be largely be made up by such additions as surface drainage, groundwater infiltration, water supply from private wells etc. On an average, therefore, the quantity of sewage may be considered to be nearly equal to the quantity of water supplied. Ground water infiltration and exfiltration.

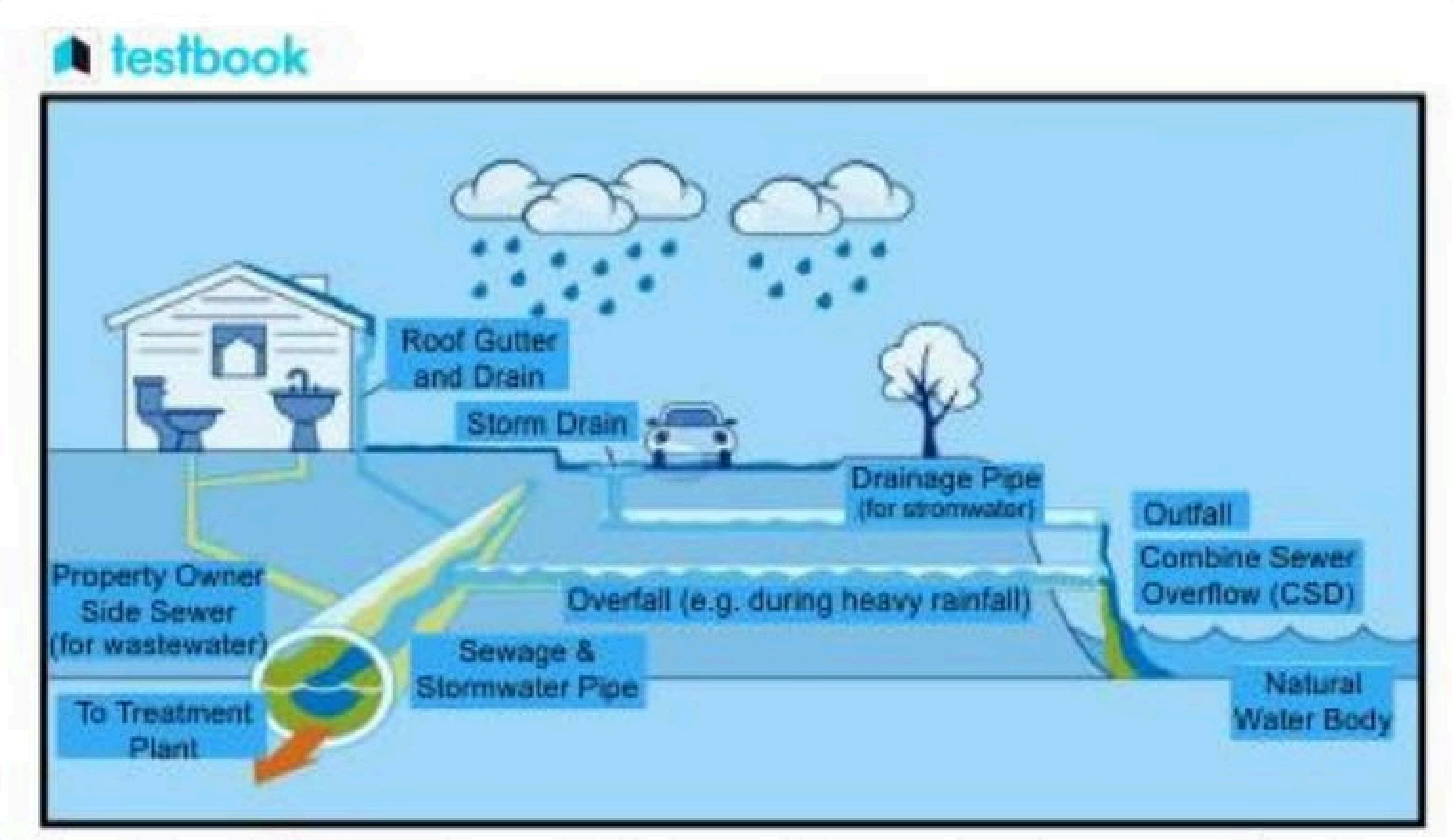
The quantity of sanitary sewage is also affected by groundwater infiltration through joints. The quantity will depend on, the nature of soil, materials of sewers, type of joints in sewer line, workmanship in laying sewers and position of underground water table.

> **Infiltration** causes increase to the ―legitimate‖ flows in urban sewerage systems. Infiltration represents a slow response process resulting in increased flows mainly due to seasonally elevated groundwater entering the drainage system, and primarily occurring through defects in the pipe network.
>
> **Exfiltration** represents losses from the sewer pipe, resulting in reduced conveyance flow rate is due to leaks from defects in the sewer pipe walls as well as overflow discharge into manholes, chambers and connecting surface water pipes. The physical defects are due to a combination of factors including poor construction and pipe joint fittings, root penetration, illicit connections, biochemical corrosion, soil conditions and traffic loadings as well as aggressive groundwater.

It is clear that Infiltration and Exfiltration involve flows passing through physical defects in the sewer fabric and they will often occur concurrently during fluctuations in groundwater levels, and particularly in association with wet weather events; both of which can generate locally high hydraulic gradients. Exfiltration losses are much less obvious and modest than infiltration gains, and are therefore much more difficult to identify and quantify. However, being dispersed in terms of their spatial distribution in the sewer pipe, exfiltration losses can have potentially significant risks for groundwater quality.

Sewerage System Types and Wastewater Classification

Sewerage system refers to the infrastructure which conveys sewage or surface runoff using sewers. Some of the components of the sewerage system includes inlets, catch basins, clean outs, manholes, lampholes, flushing tanks, grease and oil traps, inverted syphons and storm regulators.



What is Sewerage System?

A network of pipes, pumping stations, and other interconnected components constitute the sewerage system, also known as sewage system, which is designed to transfer wastewater including sewage and stormwater runoff. The infrastructure collects wastewater from various sources such as homes, industries, and commercial areas, and moves it through sewers. The system primarily utilizes gravity to facilitate the movement of wastewater and often employs natural stormwater drainage as well.

Sewerage System Types

Depending upon the mode of collection of sewage the sewerage system can be classified into following three categories:-

Combined Sewerage System

Storm run-off and domestic sewage are carried through the same sewerage system conduit in a combined system. In a country such as India, where actual rainy days are sparse, this sewerage system will have difficulty in maintaining the self-cleansing velocity of the sewers in the dry season as the sewage discharge in the dry season would be far less than the design discharge after including stormwater. Due to this problem, the sewers might get choked, which could decrease the discharge-carrying capacity of the sewers.

Separate Sewerage System

Separate conduits are used in a separate system, one for sewage and the other for stormwater run-off. Because stormwater is not as foul as sewage and no treatment is generally provided, it can be discharged directly into the water body. To meet desired standards, sewage collected from the city is adequately treated before it is discharged into a water body or used for irrigation. For large cities, a separate system is advantageous and cost-effective.

Partially Separate Sewerage System

In this system, stormwater, particularly collected from building roofs and paved courtyards, is admitted into the same drain as sewage from residences and institutions, etc. Stormwater from other locations is collected separately via separate stormwater conduits.

Wastewater Types in Sewerage Systems

Mixture of water and liquid waste generated due to different activities in the community is termed as sewage. It includes the water from urinals, toilets, discharge from residential areas, commercial areas, institutional buildings, and stormwater or groundwater entering the sewers. Its decomposition produces a considerable amount of foul-smelling fumes, and it contains numerous pathogenic or disease-causing germs, as well as a high concentration of organic materials and suspended particles.

The wastewater or the sewage can be classified on the basis of its origin and composition. Some of the types of wastewater are:-

Domestic Sewage

If the sewage is generated due to various domestic activities such as washing, bathing etc. from residential buildings, restaurants, public buildings etc. and carries lots of waterborne wastes, then this type of sewage is termed as domestic sewage. Domestic sewage is free from the wastes generated from the industrial effluents. Domestic sewage can also be referred to as sanitary sewage.

Industrial Sewage

Industrial sewage refers to the wastewater generated from various industrial activities in the form of effluents. Its decomposition produces a considerable amount of foul-smelling fumes, and it contains numerous pathogenic or disease-causing germs, as well as a high concentration of organic materials and suspended particles.

Stormwater Sewage

Stormwater is sewage runoff from the atmosphere that collects as water particles in open channels. Rain, drizzle, snow, and other types of precipitation are examples of this.

Sewer Shapes and Their Applications

Sewer shapes are categorized into circular, rectangular each with specific advantages and disadvantages for different flow conditions and system requirements. Circular sewers are generally preferred due to their efficiency and self-cleansing properties, while egg shaped sewers offer better hydraulic performance during low flow. Rectangular sewers are typically used for stormwater or large sewage flows. Features like sharp corners or angles in sewer shapes should be avoided as they can hinder maintenance and cleaning.

Circular Sewers

Advantages:

Circular sewers are the most common and are considered the most efficient shape for carrying sewage. They have a smaller perimeter for a given area, which minimizes friction and allows for higher flow velocities, aiding in self cleaning.

Suitability:

They are suitable for all types of sewage and are often used in separate sewer systems.

Disadvantages:

While efficient, circular sewers may not perform as well as egg-shaped sewers during low flow conditions, where they can experience reduced flow velocity and potential for sediment deposition.

Rectangular Sewers

Advantages:

Rectangular sewers are suitable for conveying stormwater or large volumes of sewage. They can handle significant flow rates, especially when designed with a trapezoidal or U-shaped profile.

Suitability:

They are often used for stormwater management and in situations where large volumes of sewage need to be conveyed, especially in open-cut construction.

Disadvantages:

Rectangular shapes are more prone to sediment build-up and require more frequent cleaning compared to circular sewers. The corners can also pose challenges for maintenance and cleaning.

Laying Sewers: The Process

Laying sewers involves carefully planning and executing the installation of underground pipes to transport wastewater. This process includes marking the sewer line, excavating trenches, laying the pipes, jointing them, testing for leaks, and finally back filling the trenches.

Here's a more detailed breakdown of the process:

Planning and Marking:

The sewer line's route is mapped out, and the center line and offset lines are marked on the ground to guide trench excavation.

Depth and Gradient:

The depth and gradient (slope) of the sewer line are determined based on the terrain and the desired flow rate.

Trench Excavation:

Excavation:

Trenches are excavated to the specified depth and width, considering the pipe diameter and soil conditions.

Timbering and Dewatering:

If the trench is deep or the soil is unstable, timber supports or other shoring methods may be used to prevent collapse. If there is groundwater, dewatering techniques like underdrains or sump pumps may be necessary.

Pipe Laying and Jointing:

Pipe Installation:

Pipes are typically laid starting from the lowest point, ensuring proper alignment and a consistent slope.

Jointing:

Pipes are joined using appropriate methods like lead caulking or cement mortar, ensuring watertight seals.

Testing:

- **Leak Testing:** The installed sewer line is tested for leaks, typically by filling it with water and observing for any signs of leakage or sweating.
- **Obstruction Testing:** The line is also tested to ensure there are no obstructions to flow.

Backfilling:

Once the sewer line has been tested and approved, the trench is carefully backfilled with soil, compacted in layers to avoid settling.

Other Considerations in Sewer Installation

Manholes:

Manholes are strategically placed along the sewer line to allow for access, maintenance, and cleaning.

Materials:

The type of sewer pipe used (e.g., PVC, concrete) and the jointing methods depend on the specific project requirements and local regulations.

Laying Out a Sewer Alignment

Laying out a sewer alignment involves precisely marking the sewer's path on the ground, ensuring it follows the desired gradient and horizontal direction for proper flow. This process typically includes establishing a center line, marking points where manholes will be located, and using tools like boning rods and sight rails to maintain the correct slope and alignment during pipe laying.

1

Setting the Center Line and Offsets:

- The sewer's center line is marked on the ground, often with pegs placed at regular intervals (e.g., 7.5m or 15m).
- Offset lines are established a few meters away from the center line to help locate the sewer's position during excavation and pipe laying.

2

Determining Alignment and Gradient:

L-Section Drawing:

The longitudinal section (L-section) of the sewer, found on the design drawings, is crucial for understanding the ground level, excavation depth, and the desired slope (gradient) of the sewer.

Bench Marks:

Bench marks (permanent and temporary) are established to provide reference points for maintaining accurate levels.

Tools:

Dumpy levels, boning rods, and sight rails are used to ensure the sewer is laid at the correct gradient and horizontal alignment.

Excavation, Pipe Laying, and Testing

Excavation:

Trenches are excavated according to the design specifications, ensuring sufficient width for pipe installation and safe working conditions.

Pipe Laying:

Sewers are typically laid from the tail end (outfall) towards the starting point, ensuring proper jointing and alignment of pipes.

Bedding:

Depending on the soil conditions, a concrete bedding layer may be provided to support the sewer pipe.

Backfilling:

Once the sewer is laid and tested, the trench is carefully backfilled with soil, ensuring proper compaction.

Maintaining Alignment and Gradient:

Boning Rods and Sight Rails:

These tools are used to visually check the alignment and gradient of the sewer as it's being laid.

Theodolite:

In more complex situations, a theodolite may be used to accurately measure angles and distances for setting out curves and grades.

Testing:

After installation, the sewer line is tested for leakage and proper alignment.

Manholes and Lampholes

Manholes:

Purpose:

Provide access for personnel to enter the sewer for inspection, cleaning, repairs, and maintenance.

Size:

Larger openings, often circular or rectangular, with a cover that can be removed.

Frequency:

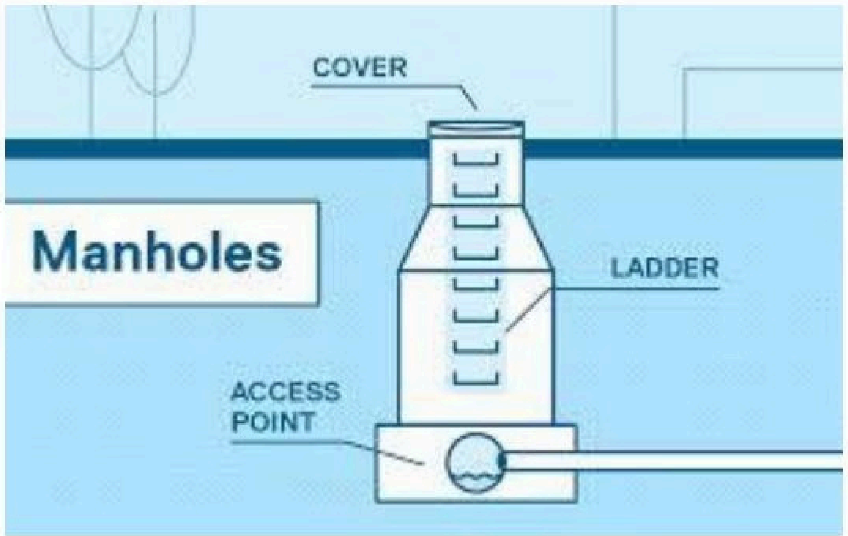
Typically placed at regular intervals along the sewer line, especially at changes in direction or elevation.

Features:

May include ladders, platforms, and other features to facilitate entry and work within the sewer.

Examples:

Used for tasks like removing blockages, inspecting pipe condition, and performing repairs.



Lampholes:

Purpose:

Allow for visual inspection of the sewer line by inserting a light source (lamp or flashlight) and observing the light from adjacent manholes or other access points.

Size:

Smaller openings, often just a pipe extending vertically from the sewer line to the surface.

Frequency:

Placed between manholes, especially where the distance between manholes is significant or where there are curves or changes in direction.

Features:

May have a cover that can be removed to insert a light.

Examples:

Used to detect obstructions, such as debris or collapsed sections of the sewer, by observing how the light is blocked or distorted.

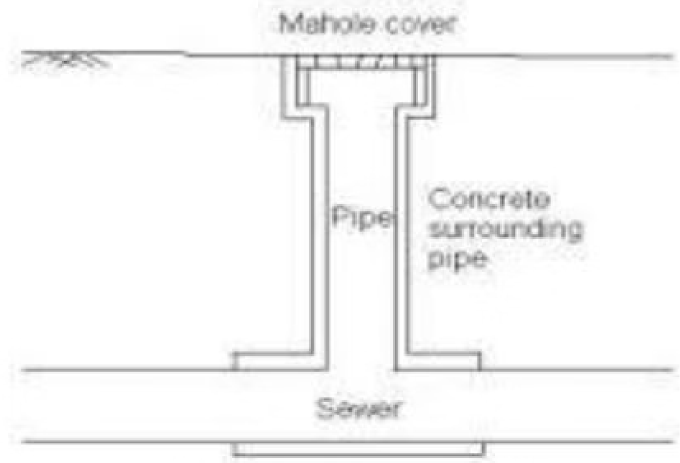


Figure 8.12 Lamp hole

Sewage Treatment: Key Processes

Sewage treatment is the process of removing contaminants from wastewater, primarily from household sewage, to produce an effluent that can be safely discharged into the environment or reused. It involves a series of physical, chemical, and biological processes to eliminate pollutants and make the water suitable for release.

Key Processes in Sewage Treatment:

1

Preliminary Treatment:

This stage removes large debris like rags and grit through screening and grit removal.

2

Primary Treatment:

Involves sedimentation to remove suspended solids and some organic matter.

3

Secondary Treatment:

Focuses on removing dissolved and suspended organic matter, often using biological processes like activated sludge or trickling filters.

4

Tertiary Treatment:

An advanced stage that may include nutrient removal (like nitrogen and phosphorus) and further polishing of the water to meet specific discharge or reuse requirements.

5

Sludge Treatment:

The solid waste (sludge) generated during the treatment process is treated separately through stabilization, dewatering, and disposal or reuse.

Why is Sewage Treatment Important?

Environmental Protection:

Prevents water pollution by removing harmful contaminants that can harm aquatic life and contaminate water sources.

Public Health:

Protects public health by removing pathogens and other harmful substances from wastewater.

Water Resource Management:

Enables the safe reuse of treated wastewater for irrigation, industrial processes, and other non-potable purposes.

Types of Sewage Treatment Plants (STPs)

STPs can be categorized based on the level of treatment provided:

- **Conventional STPs:** Include primary, secondary, and sometimes tertiary treatment stages.
- **Advanced STPs:** Incorporate tertiary treatment for advanced nutrient removal and polishing.
- **Decentralized STPs:** Smaller, localized treatment systems for individual buildings or communities.

Chapter 4: Distribution System and Appurtenances

Long Questions (Theory-Based – Diploma Level)

1. Explain the different types of water distribution systems. Describe gravity, pumping, and combined systems along with their advantages and disadvantages.
2. Discuss the requirements of a good water distribution system. What factors make a distribution system effective and reliable?
3. Compare intermittent and continuous water supply systems. Explain their features, advantages, disadvantages, and suitability for Indian conditions.

Distribution System Layouts and Valves

1

Distribution Layouts

With neat sketches, explain the different types of distribution layouts. Describe dead end, grid iron, radial, and ring layouts along with suitability.

2

Valves in Distribution Systems

Write short notes on various valves used in a distribution system. Include sluice valve, check valve, air valve, scour valve, fire hydrant, and water meter.

3

Water Meter Purpose and Working

Describe the purpose and working of a water meter. Where is it installed and why is it important?

Short Questions: Water Distribution Systems

- What is a gravity distribution system?
- Name any two requirements of a good water distribution system.
- What is the main disadvantage of an intermittent water supply?
- Which layout of the distribution system is most suitable for a well-planned city?
- What is the function of a sluice valve?
- Write two uses of a fire hydrant.
- What is a check valve? Where is it used?
- What is the difference between a grid iron and radial distribution system?
- Define water meter.
- Why are air valves provided in water distribution systems?

CHAPTER-5: Sanitary Plumbing for Building

11.1 Requirements of Building Drainage

Layout of lavatory blocks in residential buildings, layout of building drainage

11.2 Plumbing Arrangement

Plumbing arrangement of single storied & multi storied building as per I.S. code practice

11.3 Sanitary Fixtures

Features, function, and maintenance and fixing of the fixtures – water closets, flushing cisterns, urinals, inspection chambers, traps, antisyphonage pipe

Chapter 5: Water Supply Plumbing in Buildings

5.1 Connection from Water Mains to Building Water Supply

The connection between municipal water mains and a building involves:

- **Ferrule:** Small fitting inserted into the main to take supply
- **Service Pipe:** Pipe carrying water from main to building
- **Stopcock:** Valve to control entry into the premises
- **Water Meter:** Measures water usage
- **Storage Tank:** Usually placed on roof or underground
- **Pipes and Fittings:** GI, PVC, CPVC, PEX pipes are used

Diagram showing connection from water main to building included.

General Layout of Plumbing for Water Supply in Building (as per IS Code)

Key Components of Internal Plumbing:

- **Rising Main:** Pipe carrying water upwards from ground tank
- **Overhead Tank:** Storage at roof level for gravity supply
- **Distribution Pipes:** Supply water to different fixtures
- **Valves:** Gate, check, air valves for control and maintenance
- **Taps, Faucets, Shower:** End user fixtures

Plumbing Layouts

Single-Storied Building:

- Simple layout
- Direct supply or via small tank
- Less pressure management required

Multi-Storied Building:

- Uses zonal distribution
- Requires high head pumps and pressure reducing valves
- More complex piping and safety measures

IS Codes followed:

- **IS 1172:** Code of Basic Requirements for Water Supply
- **IS 2065:** Code of Practice for Water Supply in Buildings

Diagrams included for both single and multi-storied layouts.

Long Questions: Water Supply Plumbing

1

Connection from Water Mains

Describe the method of connection from water mains to the building water supply system. Explain the necessary fittings and materials used in the connection.

2

General Plumbing Layout

With the help of neat sketches, explain the general plumbing layout for water supply in a single storied and multi-storied building as per I.S. code provisions.

3

Key Components and Guidelines

Write a note on the key components and standard guidelines of internal plumbing design for residential buildings.

Short Questions: Building Plumbing

- What is the purpose of a plumbing system in a building?
- Name the main connection point between water mains and building supply.
- What is the use of a down-take pipe?
- Mention any two IS codes related to plumbing.
- What is the difference between single-storied and multi-storied plumbing systems?