V V COLLEGE OF ENGINEERING,
TISAIYANVILAI.

DEPARTMENT OF CIVIL ENGINEERING

SUBJECT NOTES ON

EN8491- WATER SUPPLY ENGINEERING

Prepared By

P.Muthuraman,
AP/Civil .

EN8491- WATER SUPPLY ENGINEERING

OBJECTIVE

- To equip the students with the principles and design of water treatment units and distribution system.

UNIT I SOURCES OF WATER 9

Public water supply system – Planning, Objectives, Design period, Population forecasting; Water demand – Sources of water and their characteristics, Surface and Groundwater – Impounding Reservoir – Development and selection of source – Source Water quality – Characterization – Significance – Drinking Water quality standards.

UNIT II CONVEYANCE FROM THE SOURCE 9

Water supply – intake structures – Functions; Pipes and conduits for water – Pipe materials – Hydraulics of flow in pipes – Transmission main design – Laying, jointing and testing of pipes – appurtenances – Types and capacity of pumps – Selection of pumps and pipe materials.

UNIT III WATER TREATMENT 9

Objectives – Unit operations and processes – Principles, functions, and design of water treatment plant units, aerators of flash mixers, Coagulation and flocculation –Clarifloccuator-Plate and tube settlers - Pulsator clarifier - sand filters - Disinfection - Residue Management – Construction, Operation and Maintenance aspects.

UNIT IV ADVANCED WATER TREATMENT 9

Water softening – Desalination- R.O. Plant – demineralization – Adsorption - Ion exchange– Membrane Systems – RO Reject Management - Iron and Manganese removal - Defluoridation - Construction and Operation & Maintenance aspects – Recent advances - MBR process

UNIT V WATER DISTRIBUTION AND SUPPLY 9

Requirements of water distribution – Components – Selection of pipe material – Service reservoirs – Functions – Network design – Economics – Analysis of distribution networks - Computer applications – Appurtenances – Leak detection. Principles of design of water supply in buildings – House service connection – Fixtures and fittings, systems of plumbing and types of plumbing.

TOTAL: 45 PERIODS

OUTCOMES:

The students completing the course will have

- an insight into the structure of drinking water supply systems, including water transport, treatment and distribution

- the knowledge in various unit operations and processes in water treatment
- an ability to design the various functional units in water treatment
- an understanding of water quality criteria and standards, and their relation to public health
- the ability to design and evaluate water supply project alternatives on basis of chosen criteria.

TEXTBOOKS:

1. Garg, S.K. Environmental Engineering, Vol.IKhanna Publishers, New Delhi, 2010.

2. Modi, P.N., Water Supply Engineering, Vol.I Standard Book House, New Delhi, 2010.

3. Punmia, B.C.,Ashok Jain and Arun Jain, Water Supply Engineering, Laxmi Publications (P) Ltd., New Delhi, 2014.

REFERENCES:

1. Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.

2. Syed R. Qasim and Edward M. Motley Guang Zhu, Water Works Engineering Planning, Design and Operation, Prentice Hall of India Learning Private Limited, New Delhi, 2009.

UNIT – 1. PLANNING FOR WATERSUPPLY SYSTEM

Public water supply system -Planning -Objectives -Design period -Population forecasting -Water demand -Sources of water and their characteristics -Surface and Groundwater-Impounding Reservoir Well hydraulics -Development and selection of source – Water quality - Characterization and standards – Impact of climate change

PUBLIC WATER SUPPLY SYSTEM

Supplying safe and wholesome water to the public from the large water resources by treating and bringing it in an efficient manner to public is known as Public water supply system.

ACTIVITIES

1. Taking water from the large water sources (reservoir)
2. Bringing it to treatment plant by pumping or without pumping through the proper pipeline networks
3. Ensuring the quality standards of water
4. Supplying water to the Municipality and then to the local
5. Running ,Maintenance & Operation of pipeline network
6. Governing council for water supply system
7. Establishing new pipeline & other service connections
8. Collecting charges or financial fund from the public & Industries.

PLANNING OF WATER SUPPLY SYSTEM

- Financial aspect
- Population growth
- Quality of water
- Quantity of water
- Rate of consumption
- Usage of water

- Sanitary survey of area
- Source of water supply
- Service connection

OBJECTIVE OF WATER SUPPLY SYSTEM

1. To provide safe and wholesome water to the public

   WHOLESOME WATER: The water which is safe and potent for drinking to human health is referred to as wholesome water.

2. To supply water in adequate quantity and good quality
3. To make water easily available to consumer so as to encourage personal and household cleanliness

NEED FOR PROTECTED WATER SUPPLY

1. Manmade Pollution
2. Industrial Pollution
3. Surface run off
4. Water Scarcity
5. Climatic change
6. Sea water Intrusion
7. Ground water depletion
8. Unhygienic condition

DESIGN PERIOD

The future period or the number of years for which a provision is made in designing the capacities of the reservoirs and various components of the water supply system is known as Design Period

Factors affecting design period

- Life period of component structures

- ❖ Making changes in the system
- ❖ Financial condition of current situations
- ❖ Population Growth
- ❖ Developmental Works
- ❖ Living styles of public

Design period values

- Under normal condition – 30 years (after completion of the project)
- As per GOI Manual on water supply the following values for Design period are suggested.

S.No	COMPONENTS	D.P in Years
1	Storage Dams	50
2	Intake Towers	30
3	Plumping • Pump House • Electrical Works	30 15
4	Water treatment units	15
5	Pipe connections materials	30
6	Water conveying units	30
7	Clear water storage	15
8	Distribution System	30

Water Demand

The amount of water needed or demanded by the public for the smooth conductance of day today activities is called water demand.

<u>Types of water Demand</u>:-

1. Domestic water Demand
2. Industrial water Demand
3. Institution and commercial water demand
4. Demand for public uses
5. Fire Demand

6. Water required to compensate losses in wastes and thefts

1. Domestic water Demand

- Water required for Drinking, Cooking, Bathing, Lawn sprinkling, Gardening and sanitary purposes etc.
- As per IS 1172-1993 , the minimum domestic consumption for a town (or) a city is 200 litres/ head / day.
- For LIG (Low Income Groups) it will be 135 litres/ head / day.
- The total domestic water consumption usually amounts to 50 to 60 % of the total water consumptions
- The total domestic water demand shall be equal to the total design population multiplied by per capita domestic consumptions.

USES	**CONSUMPTIONS IN Litres / Head/ Day**	
	Metropolitan City	**Small City**
Drinking	5	5
Cooking	5	5
Bathing	75	55
Washing of clothes	25	20
Washing of Utensils	15	10
Washing & Cleaning of Houses and Residences	15	10
Lawn watering &Gardening	15	-
Flushing of water closets	45	30
Total	200	135

2. Industrial Water Demand

- Water demand for Industries (Existing or Future Planned)
- The ordinary per capita consumption on account of industrial need of a city is generally taken as 50 litres/ head/day

3. Institutional & Commercial Water Demand

- Water demand for Hospital, Hotel, Restaurants, Schools & Colleges, Railway stations, offices , Small factories et.
- On average per capita consumption is 20 litres/ person/day

4. Demand for Public Uses

- Water required for public utility purposes watering of public parks, gardening, Washing and Sprinkling on roads etc.
- An average per capita demand is 10 litres/ person/day

5. Fire Demand

- Water required for Fire fighting
- Rate of fire demand is treated as the function of population

1. Kuichling's Formula
2. Freeman's Formula
3. NBF Formula
4. Buston's Formula

i) Kuichling's Formula

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

Where

Q = Amount of water required in litres / minute

P = population in Thousands

ii) Freeman's Formula

$$Q = 1136\left(\frac{P}{10} + 10\right)$$

Where Q & P as same as in the previous

iii) National Board of Fire Under writer's Formula

For a central congested high valued city

1. When population is less than or equal to 2,00,000

$$Q = 4637\sqrt{P}\left(1 - 0.01\sqrt{P}\right)$$

Where

Q = Amount of water required in litres / minute

P = population in Thousands

2. When population is more than 2,00,000 a provision of 54600 l/min may be made with an extra additional provision of 9100 to 36400 l/min for fire

For A Residential Area

I. Small or Low buildings = 2,200 litres/min
II. Large or Higher buildings = 4500 litres/min
III. High value residence & Apartment = 7650 to 13500 litres/ min
IV. Three storey buildings in densly populated area = 27,000 litres/min

iv) Buston's Formula

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

Where

Q = Amount of water required in litres / minute

P = population in Thousands

6. Water Required for Compensate Loss in thefts and Wastes

- ❖ Loss due to leakage, bad plumbing, damaged meter & stolen meter.
- ❖ It may be 15% of the total Consumption.

Factors affecting losses & thefts

Water tight joints, Pressure in the Distribution system, System of supply, Metering, Unauthorized connections

PER CAPITA DEMAND

- It is the annual average amount of daily water required by one person and it includes the domestic use, industrial & commercial uses, Public use, wastes, thefts etc.

Mathematically

$$\text{Per capita demand(q)} = \frac{\text{Total yearly water requirement of the city in litres (V)}}{\text{365 X Design Population}}$$

Break up for Per capita Demand for an average Indian City

Sl. No	**Uses**	**Demand in l/h/d**
1	Domestic Uses	200
2	Industrial Uses	50
3	Commercial Uses	20
4	Civic or public uses	10
5	Wastes & Thefts etc	55
	Total	335

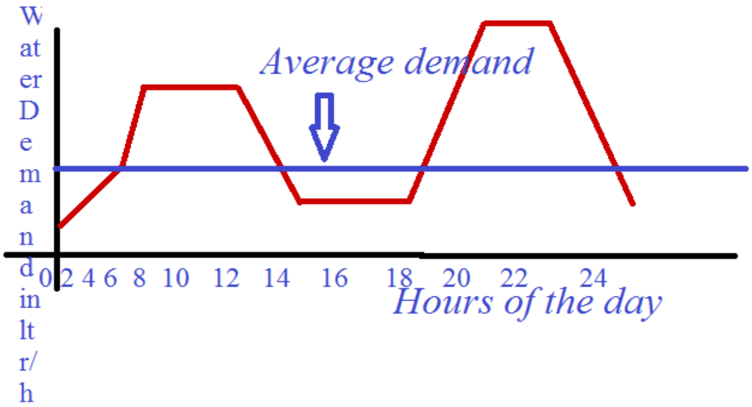
Factors affecting per capita Demand

1. Size of the city
2. Climatic conditions
3. Types of Gentry & Habits of people
4. Industrial & Commercial Activities
5. Quality of water supplies
6. Pressure in the Distribution system
7. Development of sewerage system
8. System of supply
9. Cost of water
10. Policy of metering & method of charges

Variations in Demand

1. Hourly variation
2. Daily variation
3. Monthly variation
4. Seasonal variation

Hourly variations of water Demand



PEAK DEMAND

It can be determined by Goodrich formula

$$\% P = 180(t)^{-0.1}$$

Where, P = Percentage of average annual rate, t = Time in days

For Example *if t is one hour* then,

$$\% P = 180(1/24)^{-0.1}$$

= 247%

If t is 1 da y	**% P**	**= 180%**
If t is 7 days	**% P**	**= 148%**
If t is 365 days	**% P**	**= 100%**

Hourly variations of water Demand

- Maximum daily consumption is generally taken as 180% of average daily consumption
- Maximum hourly consumption is generally taken as 150% of its average hourly consumption.
- Maximum hourly consumption of the maximum day is Peak Demand
- Maximum weekly demand is 148% of average weekly demand
- Maximum monthly demand is 128% of average monthly demand
- Hence Peak demand = 2.7 times the average demand
- Maximum hourly consumption of the maximum day= 1.5 X (Max. Daily demand)

= 1.5 X (1.8 q)

= 2.7q

= 2.7 times average hourly demand

COINCIDENTAL DEMAND

It is the summation of maximum daily demand and fire demand.

= Max. daily demand + Fire Demand

= 1.8 X Avg. daily demand + $4637\sqrt{P}\left(1-0.01\sqrt{P}\right)$

Points to be Remember

- Pipeline carrying water from reservoir to the treatment plant is designed on the basis of Maximum daily peak demand
- Treatment plant is designed on the basis of future population of 30 years.
- Water distribution system (pipe network) is governed by peak hourly demand (Prof. Hardy Cross method)
- In India the water supply rate will be

Chennai -115 l/day, Calcutta – 226 l/ day, Delhi- 244 lpcd, Mumbai-296 lpcd

FORECASTING OF POPULATION

Predicting (or) Estimating the future population of a particular city by using different techniques and current population data is known as Population Forecasting.

Factors affecting Population:

1. Birth rate
2. Death rate
3. Migration

Methods of Population Forecasting

1. Arithmetical Increase Method
2. Geometrical Increase Method
3. Incremental Increase Method
4. Decreasing rate Method
5. Simple graphical Method
6. Comparative graphical Method
7. Master Plan Method
8. The Apportionment Method
9. The logistic curve Method

1. ARITHMATIC MEAN (INCREASE) METHOD

- Here the assumption is that the rate of change of population is constant.

  ie $$\frac{dp}{dt} = K(\text{constant})$$

- It analogous to simple rate of interest
- It is applicable for well-developed old town and the places wherein there is no growth etc.

  $$dp = k.dt$$

  $\int ing$ both the sides

$$\int_{p_1}^{p_2} dp = \int_{t_1}^{t_2} k.dt$$

$$(p_2 - p_1) = k(t_2 - t_1)$$

$$(p_2 - p_1) = k\Delta t$$

$$p_2 = p_1 + k\Delta t$$

in terms of n

$$p_n = p_0 + k\Delta t$$

$$p_n = p_0 + n\bar{x}$$

where

n - no of decades

$\bar{x}$ – population increases per decades

p_0 – population at present

2. GEOMETRIC INCREASE METHOD

- Here percentage growth of population rate is assumed to be CONSTANT.
- It is analogous to compound rate of interest
- Applicable for young town and for future expansion
- @ time "t" = 0 ; Population $P = P_0$
- @ time "t" = 1 ; Population $P = P_1$

$= P_0 + r \times P_0$

$= P_0 (1+ r)$

@ time "t" = 2 ; Population $P = P_2$

$= P_0 (1+r) + r P_0 (r+1)$

$= P_0 (r+1) (r+1)$

$= P_0 (r+1)^2$

@ time "t"= n $P = P_n$ $= P_0 (r+1)^n$

$P_n = P_0 (r+1)^n$

Where

P_0 = Initial population ie (population at the end of the last known census)

P_n = Future population after n years

r = Assumed growth rate,

$$r = \sqrt[t]{r_1, r_2, r_3 \ldots\ldots r_n}$$

$$Where \quad r_1 = \frac{Increase \text{ in Population}}{Original \text{ Population}}$$

3. INCREMENTAL INCREASE METHOD

- This method lies in between the arithmetic mean and geometric mean method.
- Here the growth rate is assumed to be varying.
- Applicable for town having increase and decrease in population.

$$P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2} . \bar{y}$$

Where P_n = Population after n decades from present

$\bar{x}$ = Average increase of population of known decades

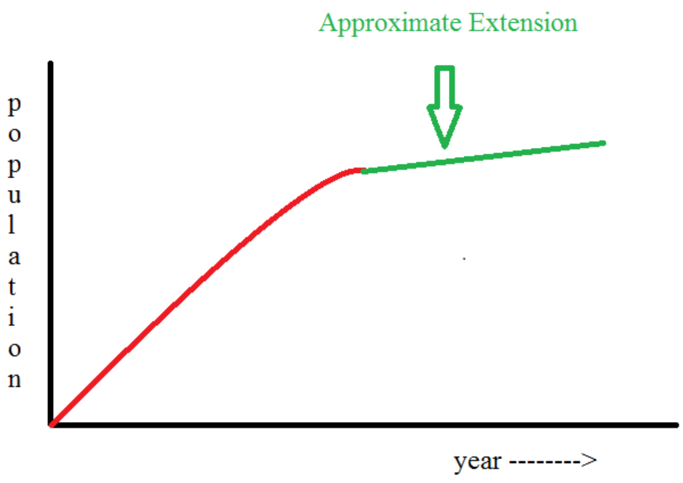
$\bar{y}$ = *Average* of incremental increase of the known decades (increment over the increase)

4. DECREASING RATE METHOD

- Here the average decrease in the percentage increase is calculated .
- This is applicable only in case where the rate of growth shows a downward trend.

5. Simple Graphical Method

- In this method a graph is plotted from the available data between time & population then the curve is smoothly extended up to the desired year.



6. COMPARATIVE GRAPHICAL METHOD

- Population of similar cities
- Logical Background
- Comparing a city with already developed city having identical properties in a graphical format.

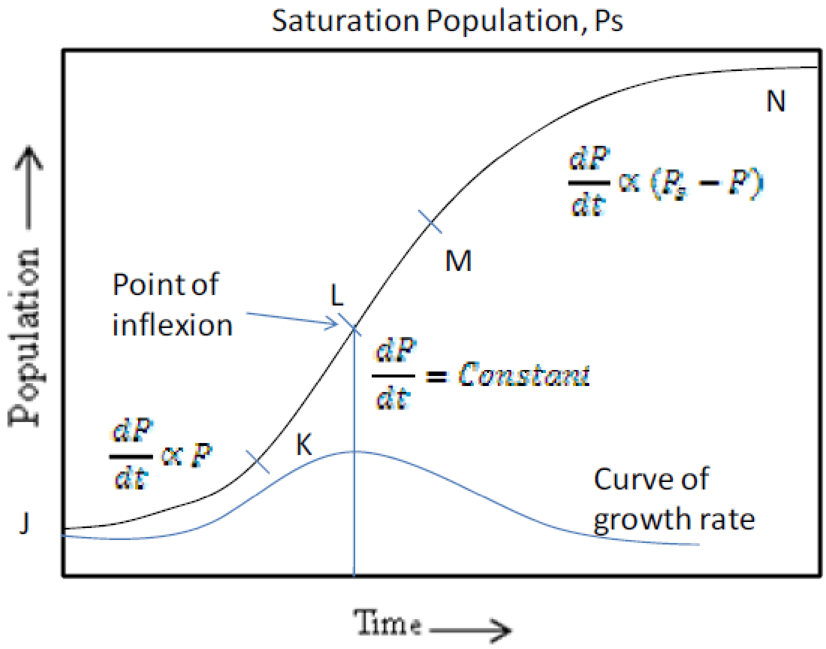
7. MASTER PLAN METHOD (ZONING METHOD)

- By using this method, the total area is divided into no. of zones with respects to types of building and then finally the population is predicted based on the Zones.

8. RATIO METHOD (The Apportionment Method)

- Based on the ratio of percentage of whole city or the country the future population will be predicted
- It is the ratio of national population to the local population.

9. THE LOGISTIC CURVE METHOD



- The "S" shaped curve plotted between time in x axis and population in y axis by obtaining the population of a particular city is known as the logistic curve.
- The curve represents early growth AB at an increasing rate ie, geometric or log growth, $\frac{dp}{dt} \infty P$
- The last growth DE at a decreasing rate ie first order curve $\frac{dp}{dt} \infty (P_s - P)$ as the saturation value is obtained.
- The transitional middle curve BD follows arithmetical increase ie, $\frac{dp}{dt} = K(constant)$
- By using this logistics curve we can forecast the population depends upon as to where the point lies on the growth curve at a given time.
- According to P.F Verhulst the entire curve AD can be represented by an autocatalytic first order equation

$$\log_e\left[\frac{P_s - P}{P}\right] - \log_e\left[\frac{P_s - P_o}{P_o}\right] = K.P_s.t$$

where

P_o = The population at the start point of curve A

P_s = Saturation population

P = Population at any time t from the origin A

K = Constant

$$\log_e\left[\left(\frac{P_s - P}{P}\right) X \left(\frac{P_o}{P_s - P_o}\right)\right] = -K.P_s.t$$

$$\left(\frac{P_s - P}{P}\right) X \left(\frac{P_o}{P_s - P_o}\right) = \log_e{}^{-1}(-K.P_s.t)$$

$$\left(\frac{P_s - P}{P}\right) = \left(\frac{P_s - P_o}{P_o}\right) \log_e{}^{-1}(-K.P_s.t)$$

$$\frac{P_s}{P} - 1 = \left(\frac{P_s - P_o}{P_o}\right) \log_e{}^{-1}(-K.P_s.t)$$

$$\frac{P_s}{P} = 1 + \left(\frac{P_s - P_o}{P_o}\right) \log_e{}^{-1}(-K.P_s.t)$$

$$P = \frac{P_s}{1 + \left(\frac{P_s - P_o}{P_o}\right) \log_e{}^{-1}(-K.P_s.t)}$$

$$substitute \frac{P_s - P_o}{P_o} = m\ (cons\tan t)$$

$$-K.P_s = n(another\ cons\tan t)$$

$$P = \frac{P_s}{1 + m \log_e{}^{-1}(n.t)}$$

- According to Prof. Mc.Lean, if only three pairs of characteristics values P_0,P_1&P_2 at times $t=t_0$,t_1&t_2 ie $t_2=2t_1$ then the value of

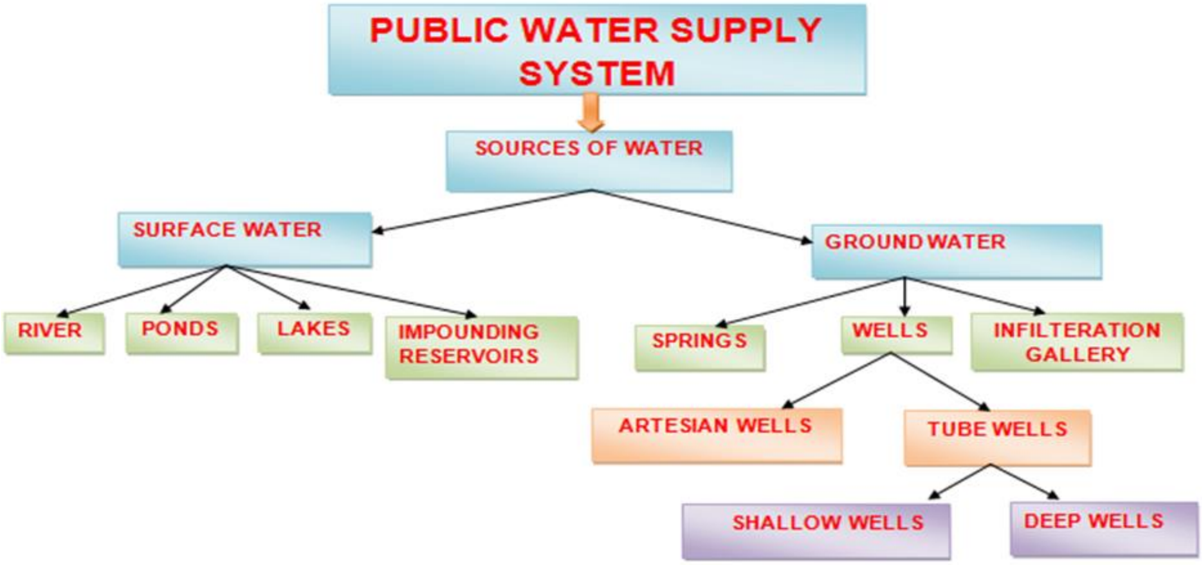
$$P_s = \frac{-2P_0P_1P_2 - P_1^2(P_0 + P_2)}{P_0P_2 - P_1^2}$$

$$m = \frac{P_s - P_o}{P_o}$$

$$n = \frac{1}{t_1} \log_e \left[\frac{P_0(P_s - P_1)}{P_1(P_s - P_0)}\right]$$

$$= \frac{2.3}{t_1} \log_{10} \left[\frac{P_0(P_s - P_1)}{P_1(P_s - P_0)}\right]$$

SOURCES OF WATER



1. Surface water sources
2. Sub surface water sources

Surface Sources

1. Ponds & Lakes
2. Streams & Rivers
3. Storage reservoirs
4. Oceans (Generally not used for water supply at present)

Sub surface source

1. Springs
2. Infiltration Gallery
3. Infiltration wells
4. Wells and Tube wells

SURFACE SOURCES

Surface sources are those sources of water in which the water flows over the surface of the earth and is directly available for water supplies.

1. **Ponds & Lakes:**

- A natural large sized depression formed within the surface of the earth, when gets filled up with water is known as pond or lake.
- If the depression size is small then it is Pond
- If the depression size is bigger than it is lake.
- Quality of water-generally good and not needed that much purification
- Quantity of water – generally small and sometimes may be used for main source.

2. Streams and Rivers:-

- Small stream channels feed their water to the lakes or rivers
- Quantity will be very small
- Larger and perennial stream may be used as water sources
- Rivers are the most important source of water for public water supply system.
- Rivers may be
  - ✓ Perennial – water available throughout the year
  - ✓ Quantity of water will be more
  - ✓ Quality of water is not reliable
  - ✓ The river water must therefore be properly analyzed and well treated before supplying to the public.

3. Storage Reservoirs:-

- A barrier in the form of a dam may be constructed across the river so as to form a pool of water on the upstream side of the barrier. This pool or artificial lake formed on the upstream side of a dam is known as Storage reservoir.
- We can have optimum benefits
- Covering irrigation needs
- Quantity and Quality will be more and good.

Factors affecting the Selection of Dam Site:

1. Suitable foundation
2. Length of the Dam
3. Bed level of the dam higher than reservoir basin

4. Suitable for site spillway
5. Availability of materials
6. Water tight basin
7. Value of land and property
8. Easily accessible
9. Establish labour colony and healthy environment etc.

STORAGE CAPACITY OF DAM

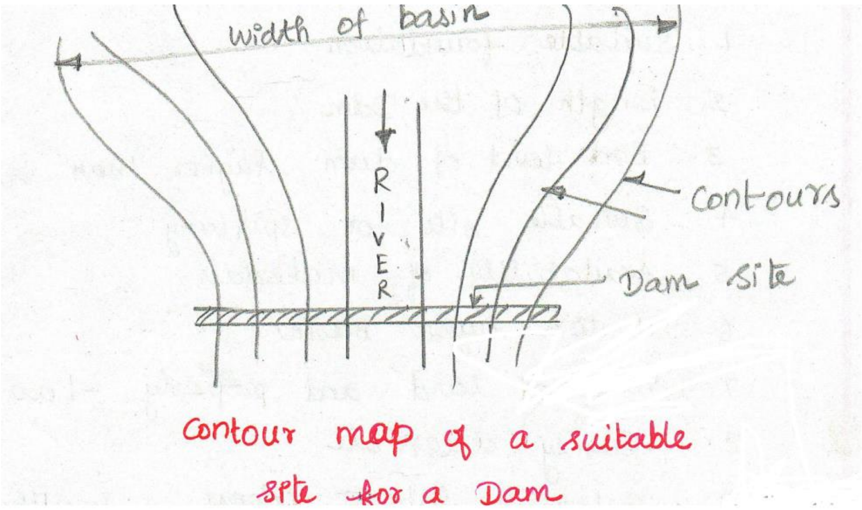
- Reservoir design capacity
- Reservoir sedimentation
- Reservoir losses

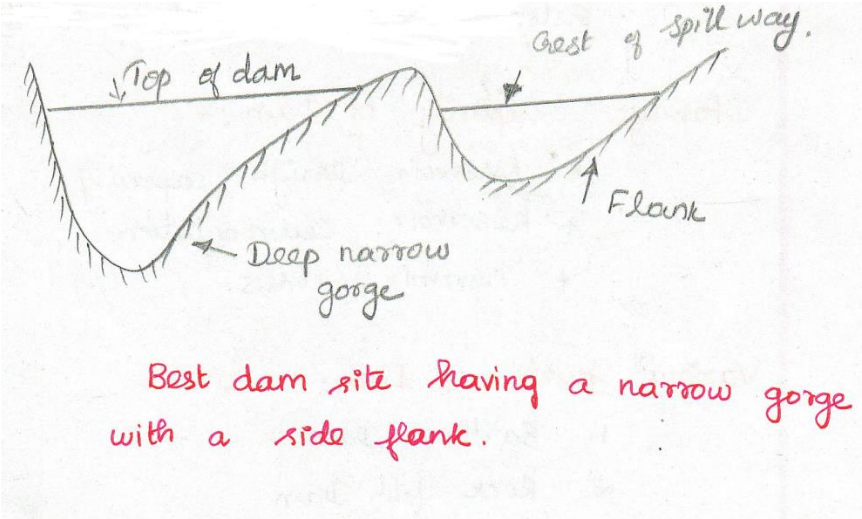
VARIOUS KINDS OF DAM

1. Earthen Dam
2. Rock fill dam
3. Solid masonry gravity dam
4. Concrete Dam
5. Agricultural Dam

VARIOUS TYPES OF DAM

1. Hollow masonry gravity dam
2. Timber dam
3. Steel dam
4. Arch dam





SUB SURFACE WATER SOURCES

GROUNDWATER

Groundwater may be defined as that portion of the total precipitation which has percolated downward into the porous space in the soil and rock where it remains, or from which it finds its way out to the surface.

It is the most important source of supply for most rural communities of the world.

Advantages of groundwater:

- ✓ It is comparatively likely to be free from disease causing micro-organism
- ✓ It can be used without further treatment if properly protected and treated immediately after the completion of construction work on the well or other source where groundwater is available.
- ✓ It is not exposed for evaporation and is used as natural storage in underground.
- ✓ It is most practical and economical to obtain and distribute.
- ✓ Groundwater can be found near a family or a community.

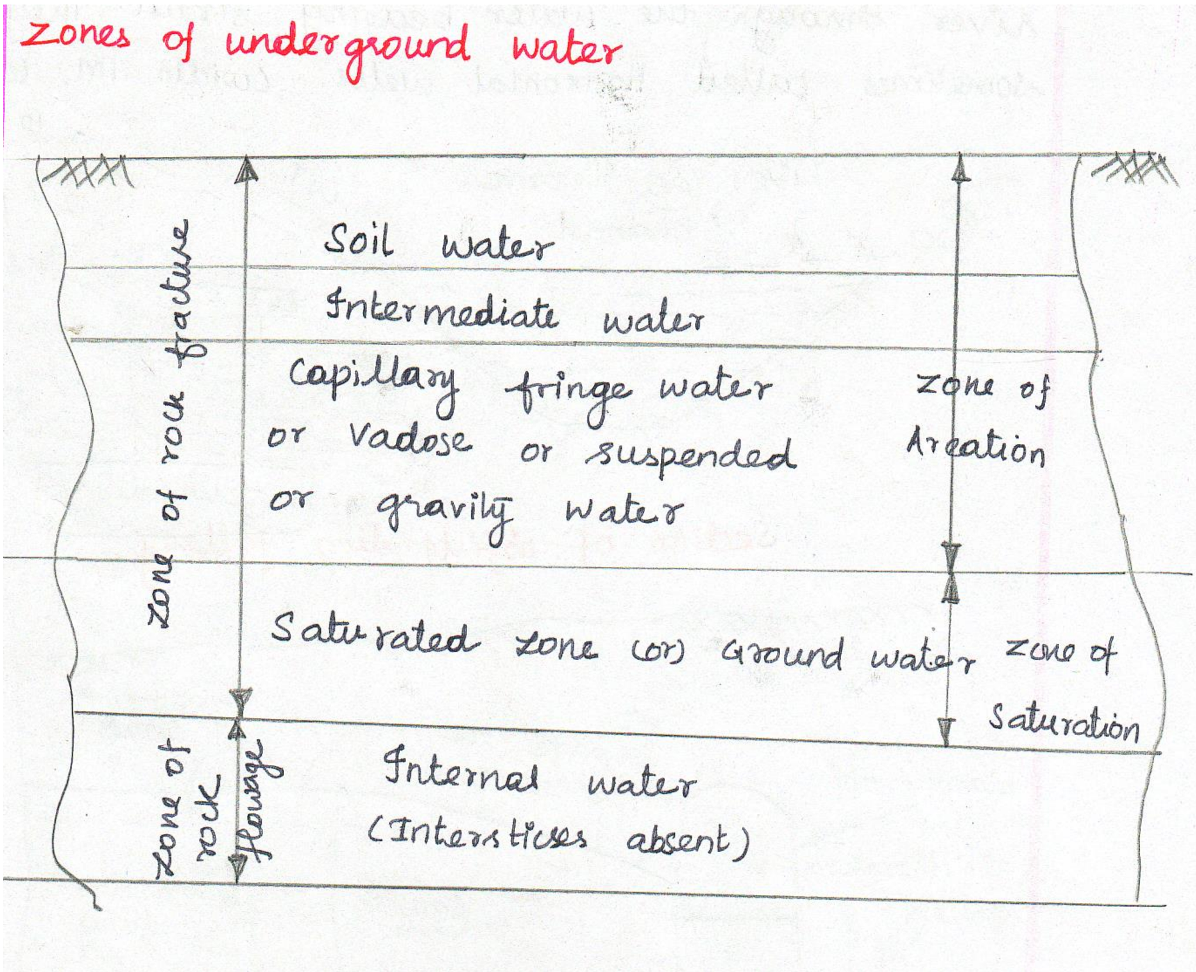
Disadvantages of groundwater

- ✓ It needs pumping unless it comes from a spring
- ✓ It may contain excess amounts of dissolved minerals.
- ✓ It is poor in oxygen content.

The water storage capacity of the ground water depends upon

1. The porosity and permeability of the soil
2. The rate at which the water is added to it by infiltration
3. The rate at which the water is lost from it by evaporation, transpiration, seepage to the surface course and withdrawal by man.

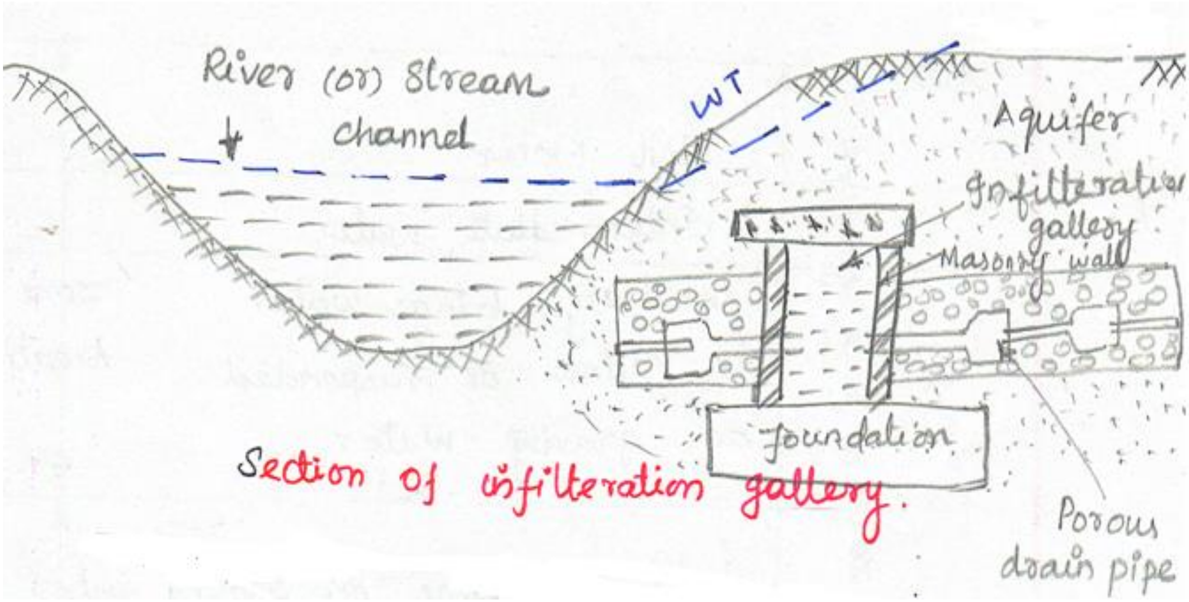
Zones of Underground Water

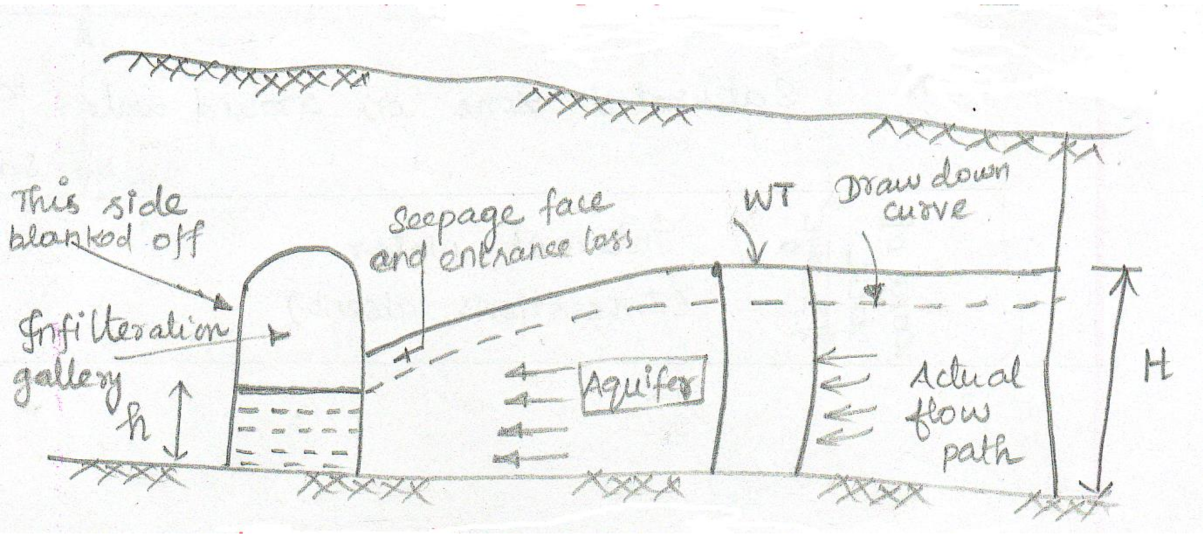


Various Forms of Underground Water

1. Infiltration Galleries
2. Infiltration wells
3. Springs and
4. Wells including tube wells

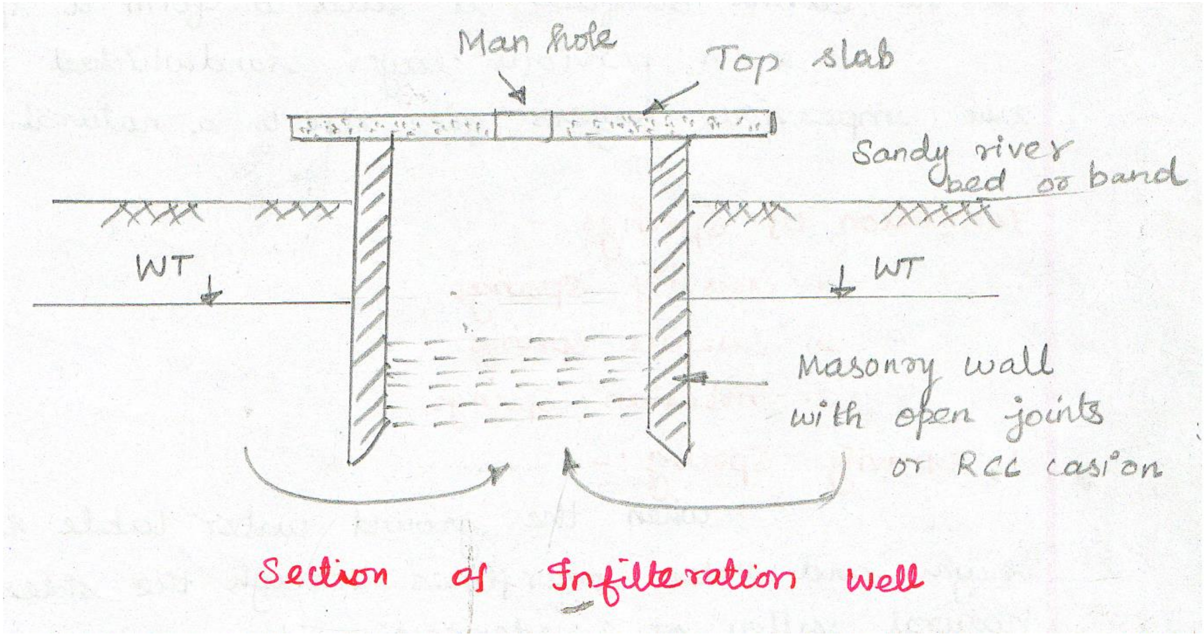
1. Infiltration Galleries





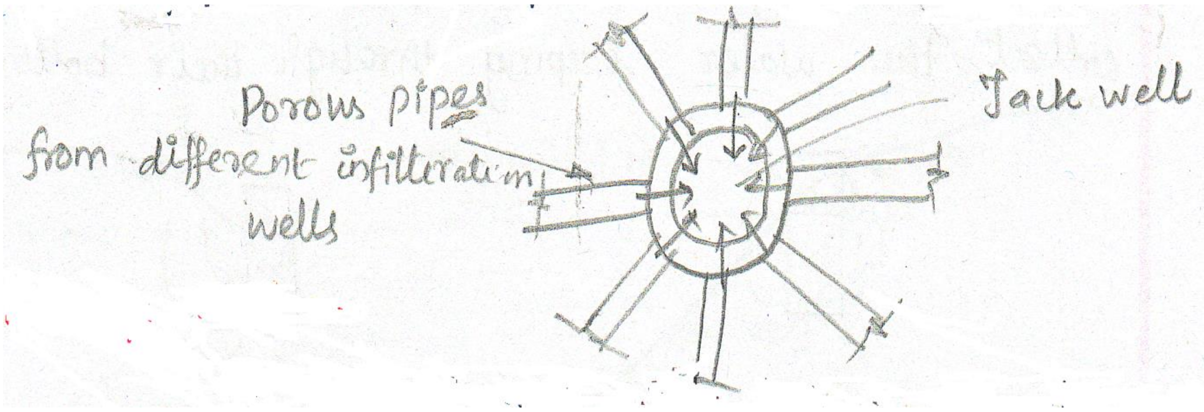
Flow pattern in an infiltration gallery

2. Infiltration Wells



Jack Well

- Various infiltration wells are connected porous pipe to a sump well called Jack well.



Ranney Well

A vertical well 3 to 6 m in diameter with horizontal radial collector is known as ranney wells.

3. Springs

- ✓ Springs are occurrences of groundwater naturally issuing at points where the water table reaches the surface, or where the top confining layer over the water – bearing strata is broken.
- ✓ Springs are normally found at the foot of mountains and hills, in lower slopes of valleys, and near the banks of major rivers.

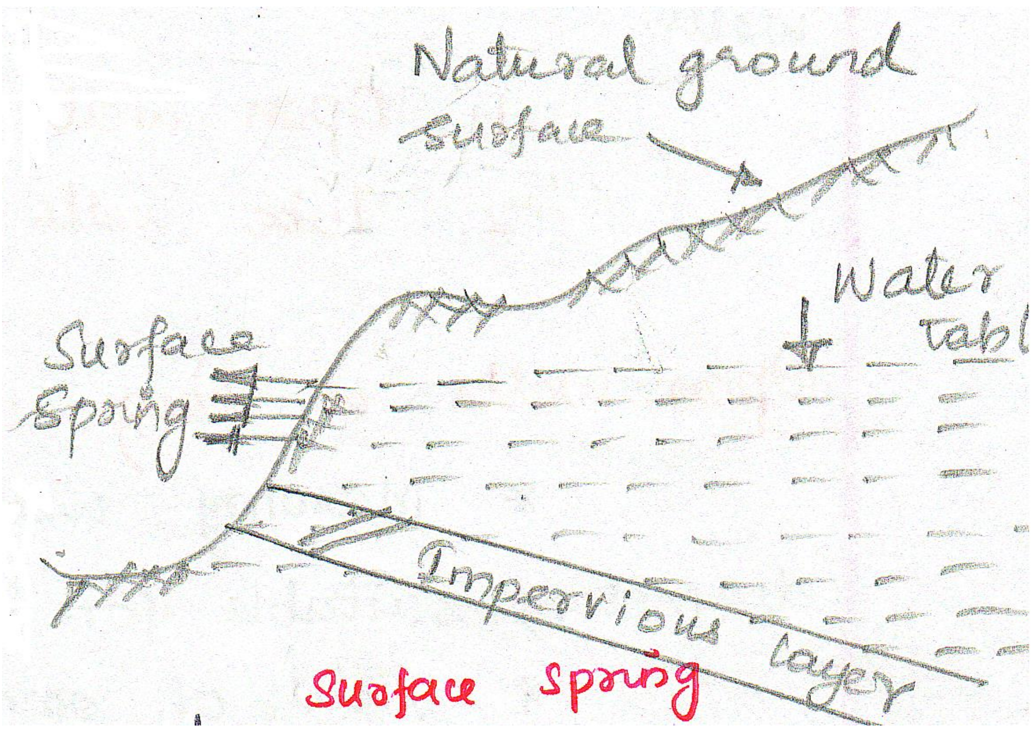
- ✓ The yield (flow rate) of a spring varies with the position of the water table, which in turn varies with the rainfall amount at that locality and season.

Classification of Springs

1. Surface, intermittent or seasonal spring
2. Main springs
3. Thermal or hot springs
4. Artesian springs

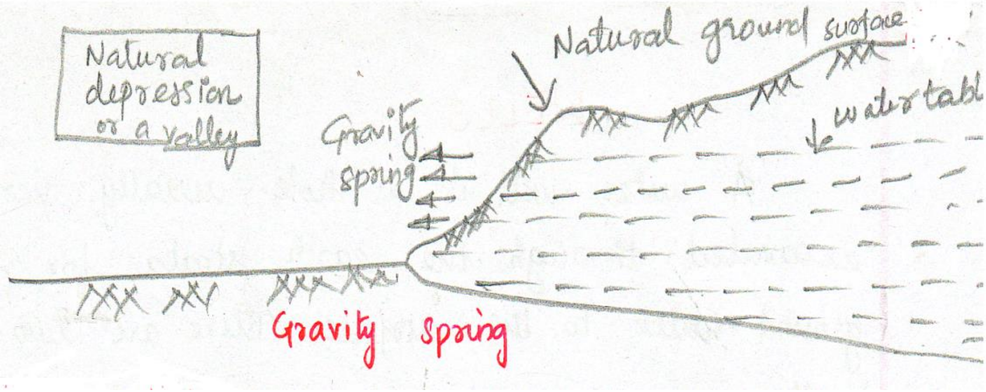
Surface, intermittent or seasonal spring

- ✓ These are springs which outcrop at a point higher in the groundwater body than the impermeable stratum in the ground formation.
- ✓ These are in fact seepages from the subsoil or through cracks or faults in the rock formation.
- ✓ These springs are usually not reliable, drying up during drier seasons and appearing again during or after the rainy seasons.
- ✓ They should not be developed as water supply sources unless observed throughout the year for their reliability.



Mainsprings or Gravity Spring

- ✓ These flow out of the ground after the infiltration water has reached an impermeable stratum in the rock layers.
- ✓ Such springs are sometimes known as gravity springs because the force of gravity makes them flows in the direction of the hydraulic gradient.



Thermal or hot springs

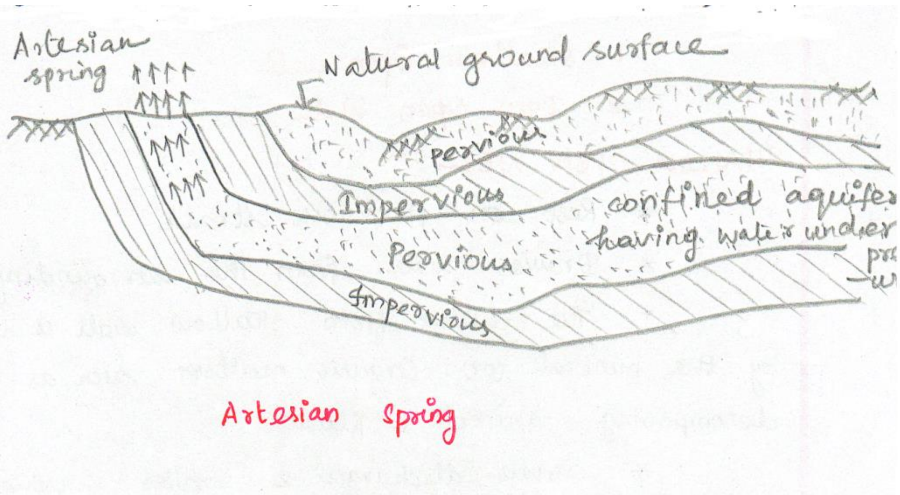
These are springs of water which have been heated before they reach the surface of the ground.

There are at least two explanations for the occurrence of thermal springs:

a) Heat escaping from hot lower levels of the earth's crust towards ground level may heat groundwater.

b) The strata of certain regions contain radioactive elements, and heat emitted by this process may heat groundwater and produce hot springs.

Artesian Spring



4. Wells

A water well is a hole usually vertical excavated through the earth strata for lifting ground water to the surface.

Generally there are three types of well,

1. Open wells or Dug wells
2. Tube wells

1. Open well or Dug well

- Masonry well having comparatively bigger diameter and suitable for low discharge
- Yield of open well is limited because of limited depth
- Higher velocity cannot be obtained

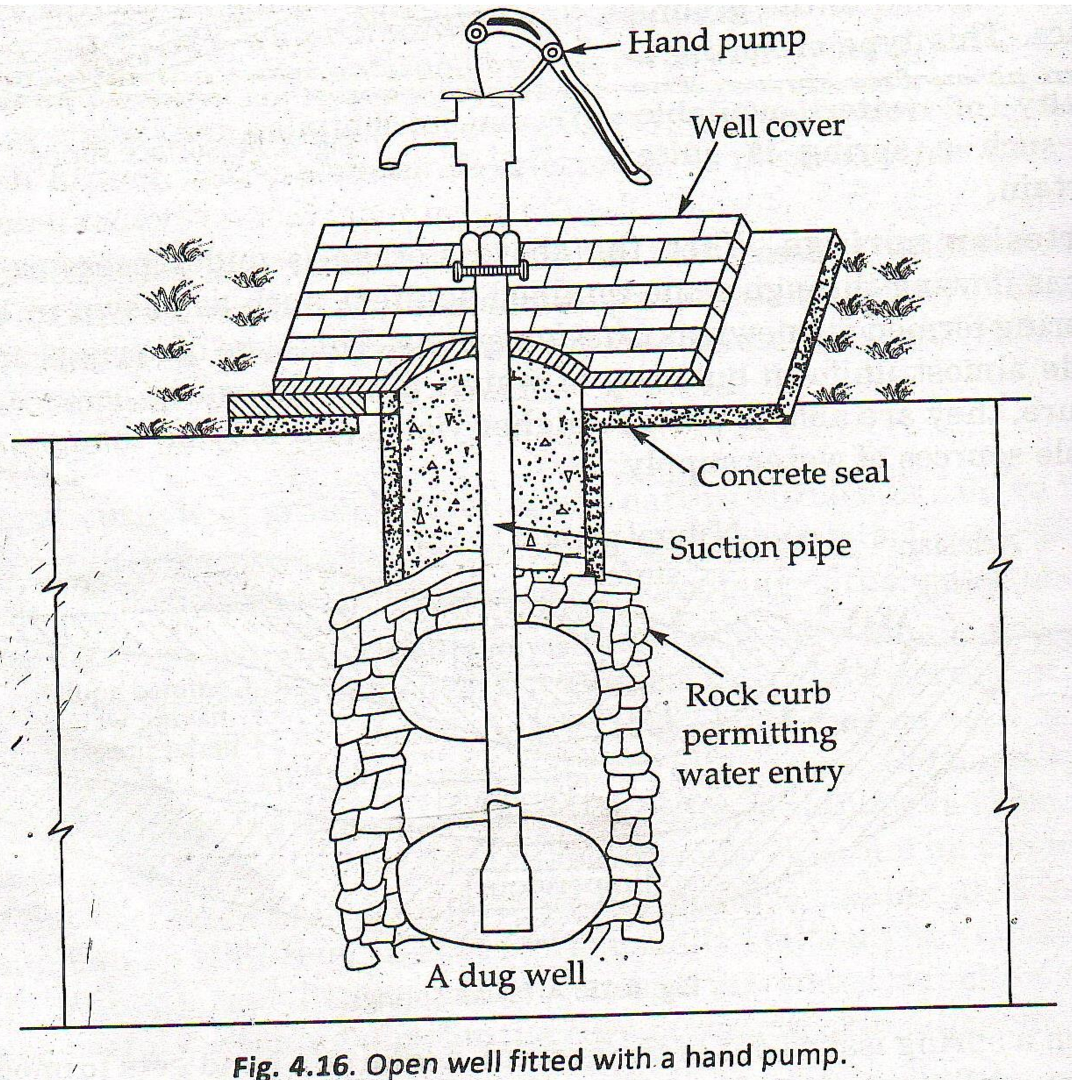


Fig. 4.16. Open well fitted with a hand pump.

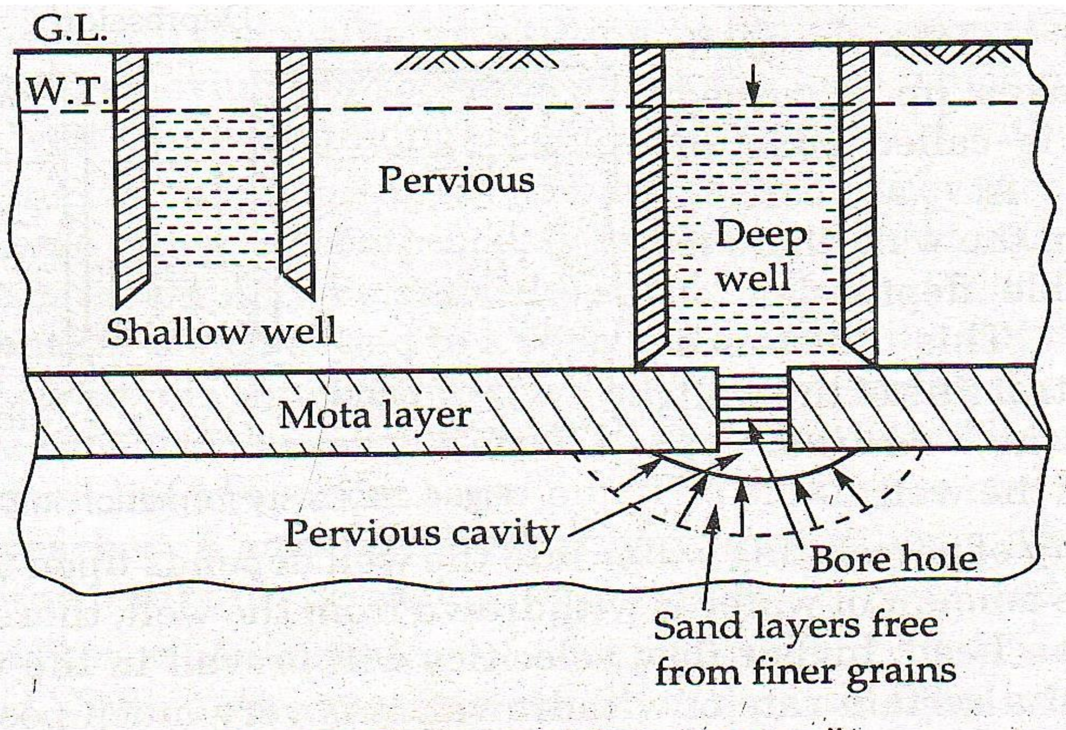


Fig. 4.17. Shallow and Deep open wells.

Deep well

- Rest on an impervious strata
- It draws water from the pervious layer lying below the mota layer.
- Mota layer give structural supports to an open deep well
- The water is in the deep well is not liable to get such impurities.
- Large supply and larger discharge
- Higher specific yield.

2. Tube Well

- Tube well is a long pipe or a tube board or drilled deep into the ground intercepting one or more water bearing strata.
- In the tube wells larger discharge can be obtained by getting a larger velocity and larger cross sectional area of the water bearing strata.
- Tube wells are used for irrigation purposes.

Types of tube wells

1. Cavity type tube well; 2. Screen type tube well

Cavity type tube well

- These wells are draw water from the bottom of the well and not from the sides.
- The flow in a cavity well is in the form spherical.
- In the initial stage of pumping fine sand comes out with water and consequently a hollow or a cavity is formed.
- As the spherical area of the cavity increases outwards, the radial critical velocity decreases for the same discharge, thus reducing the flow velocity and consequently stopping the entry of sand.
- The cavity of a tube well developed carefully and slowly by using a centrifugal pump rather than a compressor or turbine.
- When the discharging water becomes clear the draw down may be increased slightly which may be result in further sand being drawn out.

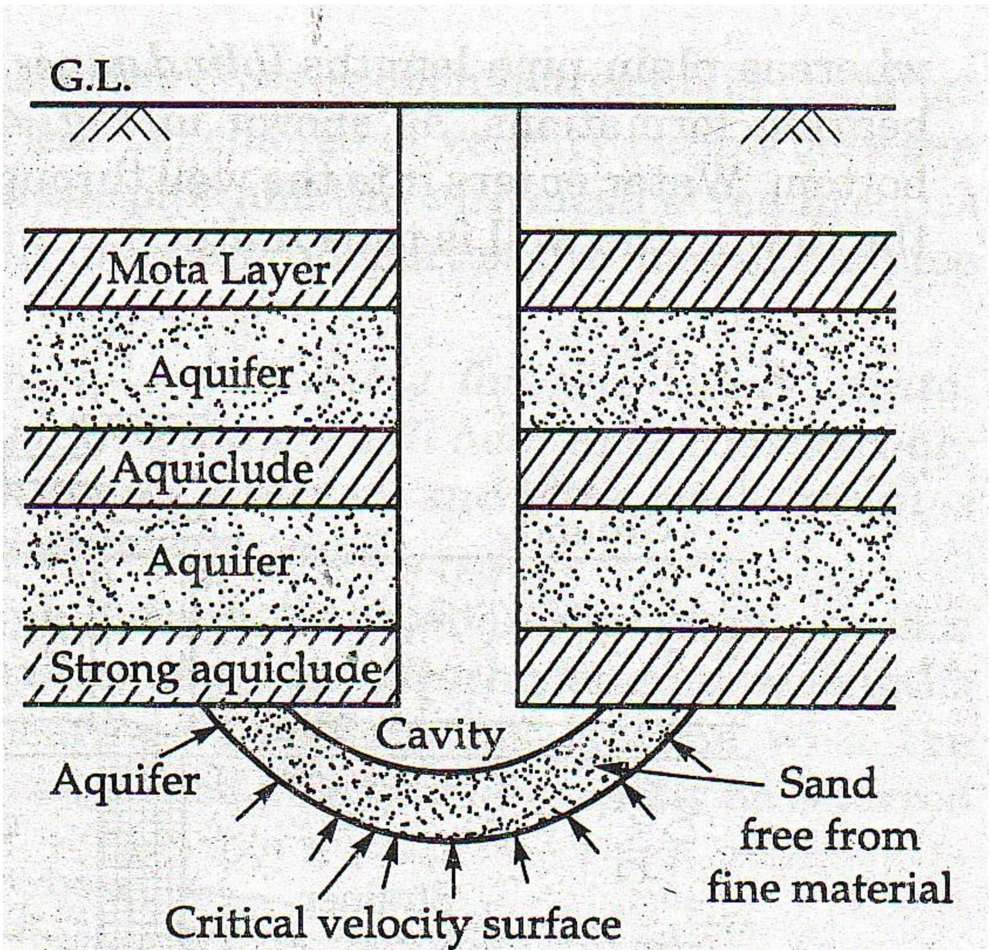


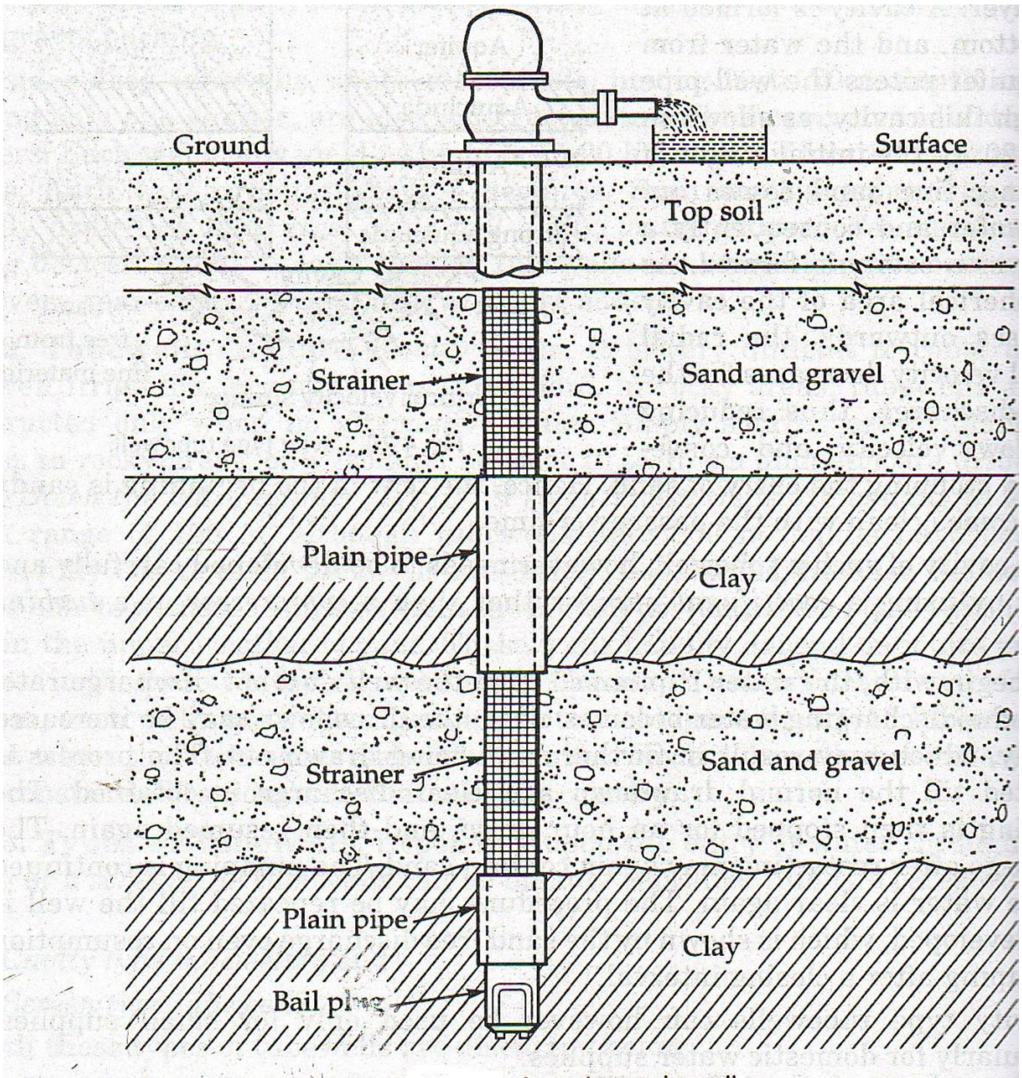
Fig. 4.20. Cavity type tubewell.

Screen type tube well

1. Strainer tube well
2. Slotted pipe graved –pack tube well

Strainer tube well

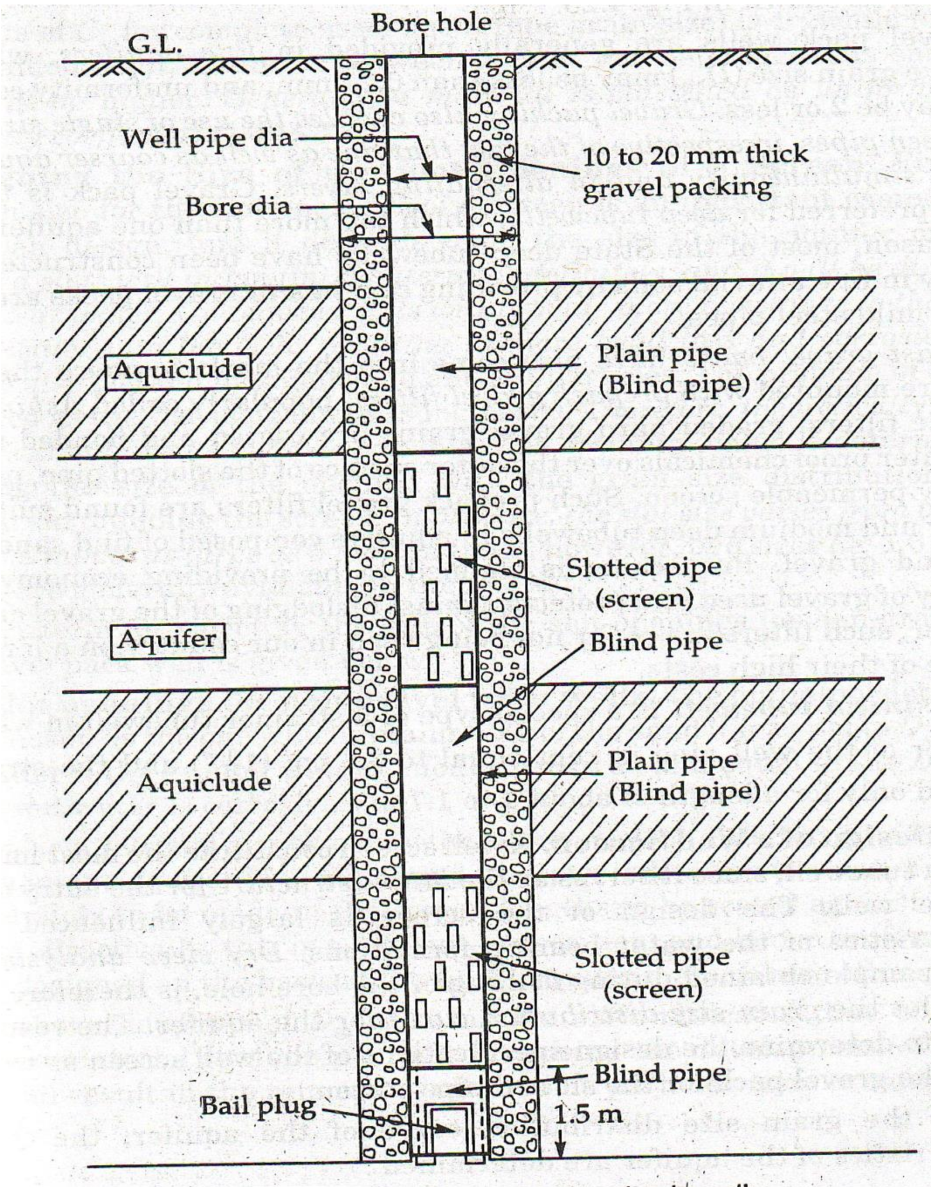
- It consists of a perforated pipe with wire mesh wrapped around the pipe with a small annular space between the two.
- The wire screen prevent the sand particles from entering the well
- This reduces the danger of sand removal and hence higher how velocity is permitted.
- The strainer type tube well is unsuitable for fine sandy strata because the size of the mesh opening will have to be considerably reduced which may result in choking of the strainer.



A strainer tubewell.

A gravel pack slotted pipe tube well

- Slotted pipe is a pipe without being covered by any wire mesh
- After placing the assembly of plain and slotted pips in the hole , a grave and bajric (called gravel shroudig) is poured in to the bore hole between the well pipe assembly and the casing pipe.
- Thickness of the gravel pack is 10-to 20 mm
- Effective size may be D10 less than 0.25mm
- Uniformity co0efficient 2 or less
- Gravel pack acts as an aquifer
- Precast gravel packs are used.



Slotted pipe gravel pack tubewell.

CHARACTERISTICS OF WATER

- Physical characteristics
- Chemical Characteristics
- Biological or Microscopial or Bacterial Characteristics

Physical characteristics

1. Turbidity
2. Colour
3. Taste and Odours
4. Temperature
5. Specific conductivity

Chemical Characteristics

1. Total and suspended solids
2. pH value
3. Hardness
4. Chloride content
5. Nitrogen content
6. Iron content
7. Manganese content
8. Metal content
9. Dissolved gases

Bacterial Characteristics

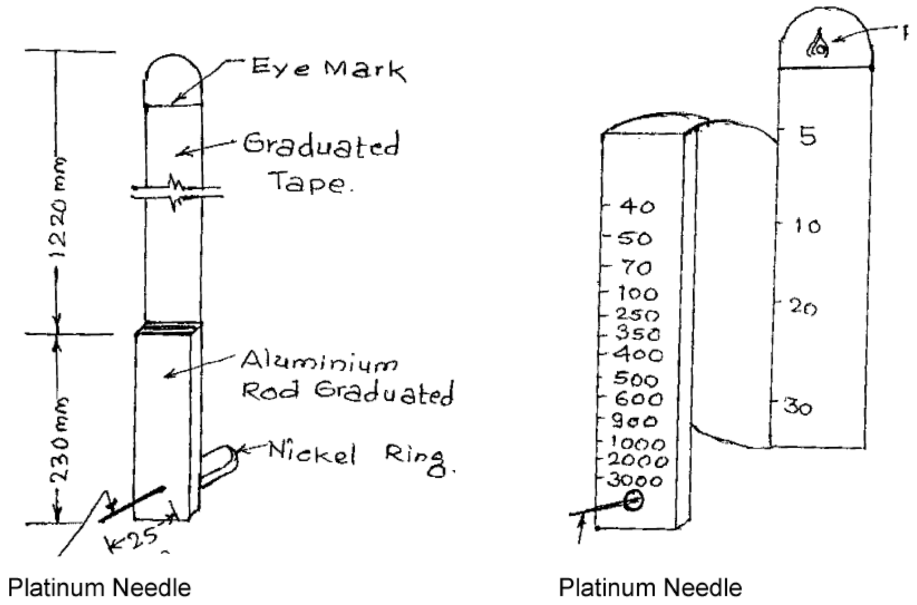
1. Non Pathogenic bacteria
2. Pathogenic bacteria
    1. Aerobic Bacteria
    2. Anerobic Bacteria
    3. Facultative Bacteria

I. PHYSICAL CHARACTERISTICS

1. TURBIDITY

Turbidity is the measure of interference by the suspended matter present in water to the passage of light.

- Large amount of suspended particles present in the water (e.g clay and silt)
- It is in the form of muddy or cloudy or turbid in appearance
- It depends upon the fineness and concentration of particles present in it.
- High level turbidity shield and protect bacteria from the action of disinfecting agents
- It is measured by turbidity rod or turbidity meter. Desirable limit-5NTU
- Should be below 1 NTU when disinfection is practiced
- Permissible limit-10NTU



Turbidity Rod.

i) Turbidity rod-Procedure

a) The graduated aluminum rod is lowered in water and the image of the platinum needle ceases to be seen (Keeping the eye at the eye mark) under standard light conditions.

b) Note the depth at which the platinum needle ceases to be seen (keeping the eye at the eye mark) under standard light conditions.

c) Note the corresponding reading on graduated rod at this stage which directly gives the turbidity in ppm.

ii) Jackson Turbidimeter - Procedure:

Turbidity can be measured in the laboratory using Jackson Turbiditimeter. It consists of a metal container in the form of a cylindrical tube is in turn, supported on metallic stand, having a standard candle fixed and also a graduated glass tube.

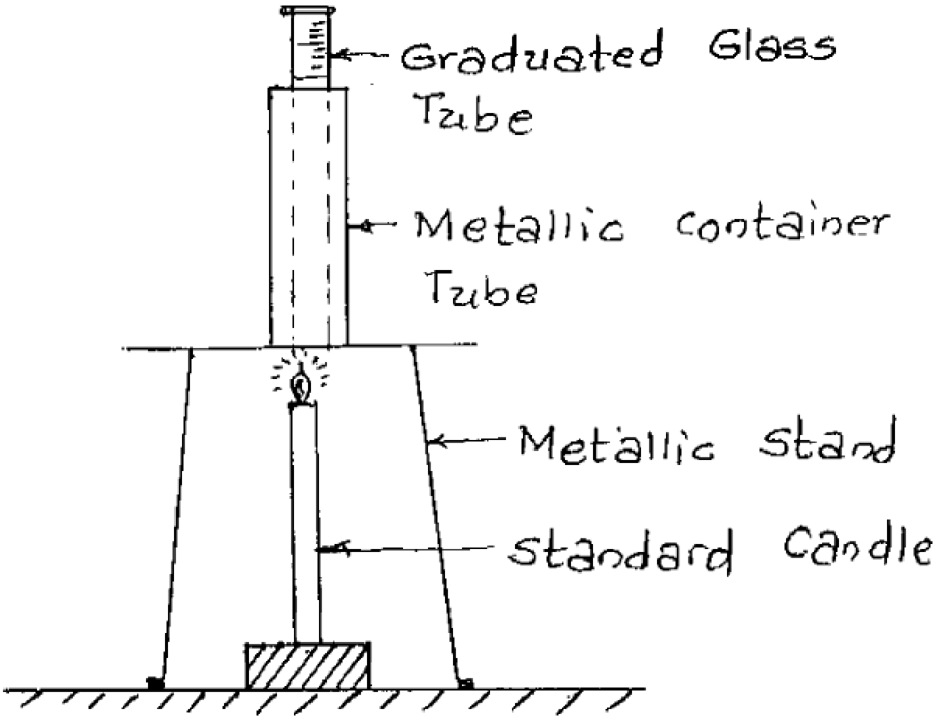


Fig.3.2,: Jackson Turbidimeter

a) Arrange the assembly of the apparatus.

b) Light the candle below the metallic stand.

c) Pour the small quantity of sample of water in the graduated glass tube.

d) Observe the image of flame from the top.

e) If the image of the flame is distinctly seen when observed from the top, go on adding more water in the graduated glass tube.

f) The addition of water is stopped as soon as the image of candle flame ceases to be seen.

g) Observe the reading on the graduated glasses tube to this depth of water.

h) The reading will directly indicate the turbidity of water in ppm.

iii) Baylis Turbidimeter –Procedure:

a) Fill the glass tube with the given sample of water of which the turbidity is to be measured.

b) Fill the glass tube with standard water solution of known turbidity.

c) The electric bulb is lighted and the blue colour in both kept in the instrument is observed from the top.

d) Standard solution tube is replaced by another standard tube of different turbidity, if the colours of the both tubes differ.

e) This process of replacement of standard solution tube is continued till a matching is obtained in the colour of both the tubes.

f) The turbidity of standard solution will then corresponds to the turbidity of the sample of water.

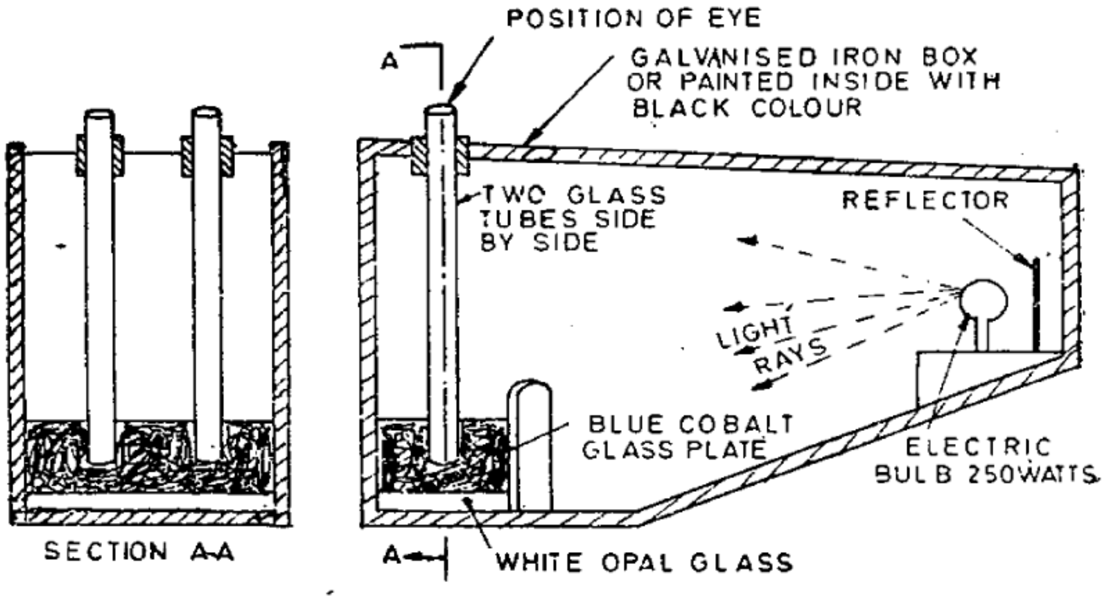


Fig. 3.3 : Baylis Turbidimeter

iv) Digital Turbidimeter (Nephelometric Turbidimeter)

a) Switch on Nephelometric turbidimeter and wait for few minutes till it warms up.

b) Set the instrument at 100 on the scale with a 40 NTU standard suspension. In this case, every division on the scale will be equal to 0.4 NTU Turbidity.

c) Shake thoroughly the sample and keep it for some time to eliminate the air bubbles.

d) Take sample in Nephelometer sample tube and put the sample in sample chamber and find out the value on the scale.

e) Dilute the sample with turbidity free water and again read the turbidity.

2. COLOUR

- It is due to the dissolved organic matter from decaying vegetation or some inorganic materials such as coloured soil etc.
- Excess growth of algae
- Detected by naked eye or nessler tube
- Measured in ppm or mg/l
- Standard unit of colour which is produced by one million of platinum cobalt dissolved in one litre of distilled water.
- Permissible Limit for domestic supply is 20 ppm
- Public supply – less than or equal to 20 ppm
- For small colour intensity Tinometer is generally used.

3. TASTE & ODOURS

- Most organic and some inorganic chemicals, originating from municipal or industrial wastes, contribute taste and odour to the water.
- Due to dissolved gases such as H_2S, CH_4, CO_2, O_2 combined with organic matter & mineral substances like NaCl, iron compounds, phenol, oily matter carbonates and sulphates of other elements.
- Taste and odour can be expressed in terms of odour intensity or threshold values.
- A new method to estimate taste of water sample has been developed based on flavour known as 'Flavour Profile Analysis'(FPA).
- The character and intensity of taste and odour discloses the nature of pollution or the presence of microorganisms.

<u>Threshold Odour</u>

- It represents the dilution ratio at which the odour is hardly detectable (generally 1:4)
- For example:-

- If 40 ml of sample is diluted and made 200 ml , then the threshold odour no is 200/4=5
- For public use it will be 1 and at any time it should not exceed 3.

4. TEMPERATURE

- The increase in temperature decreases palatability, because at elevated temperatures carbon dioxide and some other volatile gases are expelled.
- The ideal temperature of water for drinking purposes is 5 to 12°C - above 25°C, water is not recommended for drinking.

5. SPECIFIC CONDUCTIVITY OF WATER

- To measure the total amount of dissolved salts present in the water
- Dissolved salt content = Specific conductivity of water in micro ohms per cm @25$°C$ × 0.65
- This co-efficient value depends upon the type of salt present in water.

II. CHEMICAL PROPERTIES

1. Total and suspended solids
2. pH value
3. Hardness
4. Chloride content
5. Nitrogen content
6. Iron content
7. Manganese content
8. Metal content
9. Dissolved gases

1. TOTAL SOLIDS & SUSPENDED SOLIDS

- ✓ Total solids = Suspended Solids + Dissolved Solids
- ✓ Total Solids=(T) Evaporating the water samples
- ✓ Suspended Solids=(S) By filtering the water sample and weigh the residue left on the filter paper.
- ✓ Dissolved Solids = T-S (Specific conductivity)

2. pH

- ➢ pH value denotes the acidic or alkaline condition of water.
- ➢ It is expressed on a scale ranging from 0 to 14, which is the common logarithm of the reciprocal of the hydrogen ion concentration.
- ➢ The recommended pH range for treated drinking waters is *6.5 to 8.5*.
- ➢ pH indicates power of hydrogen + ions

$$\log_{10}\left(\frac{1}{H^{+}}\right) = \log_{10}\left(\frac{1}{10^{-7}}\right) = \log_{10} 10^{7} = 7$$

$$in\ pure\ water\ \ H^{+} \rightarrow \sqrt{10^{-14}} = 10^{-7}$$

- ✓ If an acid is added to pure water the no. of hydrogen ions will be increased and due to the increase of acid the pH value will be less than 7 and it turns to acidity.
- ✓ Alkalinity is caused by the presence of bicarbonates of Calcium and Magnesium or hydroxides of Sodium or Potassium, Calcium & Magnesium.
- ✓ We can measure pH value by potentiometer**.**

3. HARDNESS

- ✓ If water consumes excessive soap to produce lather, it is said to be hard.
- ✓ Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions.
- ✓ The major anions associated with these cations are sulphates, carbonates, bicarbonates, chlorides and nitrates.

- ✓ The total hardness of water is defined as the sum of calcium and magnesium concentrations, both expressed as calcium carbonate, in mg/L.
- Hardness are of two types, temporary or carbonate hardness and permanent or non-carbonate hardness.
- Temporary hardness is one in which bicarbonate and carbonate ion can be precipitated by prolonged boiling.
- Non-carbonate ions cannot be precipitated or removed by boiling, hence the term permanent hardness. IS value for drinking water is 300 mg/L as $CaCO_3$.

4. CHLORIDES

- ✓ Chloride ion may be present in combination with one or more of the cations of calcium, magnesium, iron and sodium.
- ✓ Chlorides of these minerals are present in water because of their high solubility in water.
- ✓ Each human being consumes about six to eight grams of sodium chloride per day, a part of which is discharged through urine and night soil.
- ✓ Thus, excessive presence of chloride in water indicates sewage pollution.
- ✓ IS value for drinking water is 250 to 1000 mg/L. The concentration above 250mg/L produces salty taste in drinking water.
- ✓ It can be measured by titrating the sample with standard silver nitrate solution using potassium chromate as indicator.

5. NITROGEN CONTENT

- The presence of nitrogen in water is an indication of the presence of the organic matter.
- It may occur in one or more of the following forms

1. Free Ammonia
2. Albuminoid
3. Nitrites
4. Nitrates

Free Ammonia

- ✓ It indicates the very first stage of the decomposition of organic matter.
- ✓ For potable water its value should not exceed 0.15 mg/l
- ✓ It can be measured by simply boiling the water and measuring the liberated ammonia gas by distillation process.

Albuminoid

- ✓ It indicates the quantity of nitrogen present in water before the decomposition of organic matter has digested.
- ✓ It indicates the pollution of water
- ✓ For potable water it should not exceed 0.3 mg/l
- ✓ It can be measured by adding strong alkaline solution of potassium permanganate to already boiled sample.

Nitrites

- ✓ It indicates the presents of partly decomposed organic matter.
- ✓ The partly oxidised organic matter in the form of nitrites is highly dangerous
- ✓ The permissible amount of nitrites present in the water should be nil.

Nitrates

- ✓ It indicates the presence of fully oxidised organic matter present in the water.
- ✓ The presence of too much of nitrates affects the health of infants causing a disease called “mathemoglobinemia”(Blue baby syndrome)
- ✓ The permissible amount of nitrate is limited to 45 mg/l

- ❑ The amount of nitrites and nitrates can be measured by colour matching method.
- ❑ For nitrites the colour developed by adding sulphuric acid and napthamine .
- ❑ For nitrates the colour developed by phenol –di-sulphonic acid and potassium hydroxide.
- ❑ The colour developed in water is finally compared with the standard colours of known concentrations.

6. IRON

- ✓ Iron is found on earth mainly as insoluble ferric oxide.
- ✓ When it comes in contact with water, it dissolves to form ferrous bicarbonate under favourable conditions.
- ✓ This ferrous bicarbonate is oxidised into ferric hydroxide, which is a precipitate.
- ✓ Under anaerobic conditions, ferric ion is reduced to soluble ferrous ion.
- ✓ Iron can impart bad taste to the water, causes discolouration in clothes and incrustations in water mains.
- ✓ IS value for drinking water is 0.3 to 1.0 mg/L.

7. METAL CONTENTS

- ✓ Manganese should be less than 0.3 mg/l
- ✓ Lead and Barium should be very low in concentration
- ✓ Arsenic & Selenium should be nil.
- ✓ Fluoride:
    - 0.8 to 1 ppm cause dental problems.
    - If it is greater than 1.5 ppm cause spotting and discolouration of teeth and this disease is called FLUROSIS

8. DISSOLVED GASES

- The various gases which may get dissolved in water due to its contact with the atmosphere (or) the ground surface e.g. Nitrogen, Hydrogen Sulphide , carbon di oxide and oxygen.
- It indicates the contamination of the water.
- Nitrogen- as not important
- Methane- Explosive tendency
- Hydrogen Sulphide- Bad odour and taste
- Carbon di oxide – Biologically active and it causes corrosion.

9. BOD- Biochemical Oxygen Demand

- ✓ The amount of oxygen required in the process until oxidation get completed is known as BOD.
- ✓ If the sufficient oxygen is present in water the useful aerobic bacteria in water production will flourish and cause the biological decomposition of wastes and organic matter thereby reducing the carbonaceous materials from the water.
- ✓ We can find the BOD value by dilution method.

III) BACTERIAL & MICROSCOPIAL PROPERTIES

- Bacteria are the minute single cell organisms posessing no defined nucleous and having no green material to help them manufacture their own food.
- Length will be 1 to 4µ
- It presents in raw or contaminated water.

<u>Non –Pathogenic Bacteria:-</u>

- These bacteria are harmless and certain conditions beneficial to the human beings animals and crops.
- Such bacteria or micro organisms are called Non-pathogens.

<u>Pathogenic bacteria:-</u>

- Some bacteria are causing serious water borne diseases like cholera,typhoid etc.
- Most of the bacteria present in water require oxygen for their survival .

Depending upon the oxygen necessities they may be classified as follows

1. Aerobic Bacteria –Those which require oxygen for their survival
2. Anerobic bacteria –Those which flourish and thieve in the absence of free oxygen
3. Facultative bacteria –Those which can survive with or without free oxygen.

WATER QUALITY PARAMETERS AND DRINKING WATER STANDARDS

SL. NO.	PARAMETERS	UNITS	DRINKING WATER IS: 10500 - 1991	
			DESIRABLE	**MAXIMUM**
1.	Colour	Hazen units	**5**	**25**
2.	Odour	-	**Unobjectionable**	**-**
3.	Taste	-	**Agreeable**	**-**
4.	Turbidity	NTU	**5**	**10**
5.	pH value	-	**6.5 to 8.5**	**No relaxation**
6.	Total hardness (as $CaCO_3$)	mg/l	**300**	**600**
7.	Iron	mg/l	**0.3**	**1.0**
8.	Chlorides	mg/l	**250**	**1000**
9.	Residual, free Chlorine	mg/l	**0.2**	**-**
10.	Dissolved Solids	mg/l	**500**	**2000**
11.	Calcium	mg/l	**75**	**200**
12.	Copper	mg/l	**0.05**	**1.5**
13.	Manganese	mg/l	**0.1**	**0.3**
14.	Sulphate	mg/l	**200**	**400**
15.	Nitrate	mg/l	**50**	**No relaxation**
16.	Fluoride	mg/l	**1.0**	**1.5**
17.	Phenolic compounds	mg/l	**0.001**	**0.002**
18.	Mercury	mg/l	**0.001**	**No relaxation**

SL. NO.	PARAMETERS	UNITS	DRINKING WATER IS: 10500 - 1991	
			DESIRABLE	MAXIMUM
19.	Cadmium	mg/l	0.01	No relaxation
20.	Selenium	mg/l	0.01	No relaxation
21.	Arsenic	mg/l	0.05	No relaxation
22.	Cyanide	mg/l	0.05	No relaxation
23.	Lead	mg/l	0.05	No relaxation
24.	Zinc	mg/l	5	15
25.	Anionic detergents	mg/l	0.2	1.0
26.	Chromium	mg/l	0.05	No relaxation
27.	Polynuclear aromatic Hydrocarbons	mg/l	-	-
28.	Mineral oil	mg/l	0.01	0.03
29.	Pesticides	mg/l	Absent	0.001
30.	Radioactive materials (a) Alpha emitters (b) Beta emitters	Bq/l Pci/l	- -	0.1 0.037
31.	Alkalinity	mg/l	200	600
32.	Aluminium	mg/l	0.03	0.2
33.	Boron	mg/l	1	5

UNIT – 2. CONVEYANCE SYSTEM

Water supply -intake structures -Functions and drawings -Pipes and conduits for water-Pipe materials -Hydraulics of flow in pipes -Transmission main design -Laying, jointing and testing of pipes -Drawings appurtenances -Types and capacity of pumps -Selection of pumps and pipe materials.

CONVEYANCE OF WATER

- Drawing off water from the source of water called intakes.
- Leading the water from intakes to the purification plants and then leading the treated water to the consumer through distribution pipes.

INTAKE STRUCTURE FOR WATER SUPPLY

- Intake structures are the construction, used for storing the water, from surface sources (river, reservoir and lakes) and conveying it further to treatment plant.
- An intake may be nearer to water sources such as river, lake, etc.
- An intake is a structure which is constructed across the water source so as to permit the safe withdrawal of water from the water source. The structure may be stone, brick, RCC, or Concrete block masonry

Factors governing location of an intake

1. The location of intake structure should be nearer to the treatment plant, in order to reduce the cost of conveyance water.
2. The location of the intake should be selected in a place, where there is the less impurities presence.
3. The intake should be selected at a place from where the water can be taken during driest season of the year also.
4. The intake location should have the possibility for future expansion and addition without much increase in cost.
5. The intake should not be located at the downstream of the disposal point of sewage.
6. It should be located in such a way that, it should not be affected by heavy flood and the flood should not enter through the intake.
7. The intake should not be located near the navigation channels such as Harbour etc.
8. It should not be interference with river traffic if any.

DESIGN CONSIDERATIONS

Sl.No	Criteria	Design considerations
1	Factor of safety	Against all external forces (Forces by floating materials, pressure, heavy currents etc)
2	Self-weight	To withstand water pressure
3	Safety	If located near the navigation channels
4	Sub structure	Foundation design against water pressure
5	Size	Considerable (Suitable with future expansions)

Type of intake structures

- ✖ Simple submerged Intake
- ✖ Intake Tower or River Intake Structures
  - + Wet Intake Towers
  - + Dry Intake Towers
- ✖ Reservoir Intake
  - + Variable depth lake water intake
  - + Multi-level intake
- ✖ Canal Intake Structures.

1. SIMPLE SUBMERGED INTAKE

- ☒ A submerged intake structures consists of simple concrete block or a rock filled timber crib supporting the starting end of the withdrawal pipe.
- ☒ The withdrawal pipes are generally taken up to the sump well at shore from where the water is lifted by pumps.
- ☒ The intake opening is generally covered by screen so as to prevent the entry of debris, ice etc., into the withdrawal pipe.
- ☒ In case of lakes where silt tends to settle down, the intake opening is generally kept about 2 to 2.5 m above the bottom of the lake and thus to avoid the entry of silt and sediment.
- ☒ Such intake structures should be placed in streams or intakes at a place where they may not get buried under sediment and where there are deep water.

- ☒ These are widely used intakes for small water supply projects drawing water from streams and lakes having relatively little change in water surface elevation throughout the year.

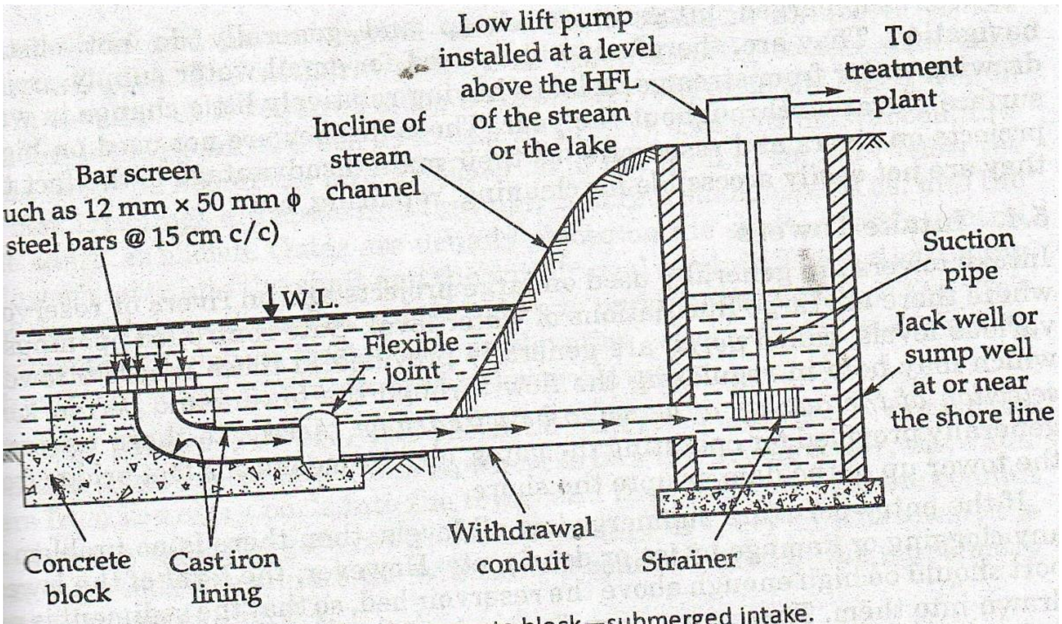


Fig. 5.1. Simple concrete block—submerged intake.

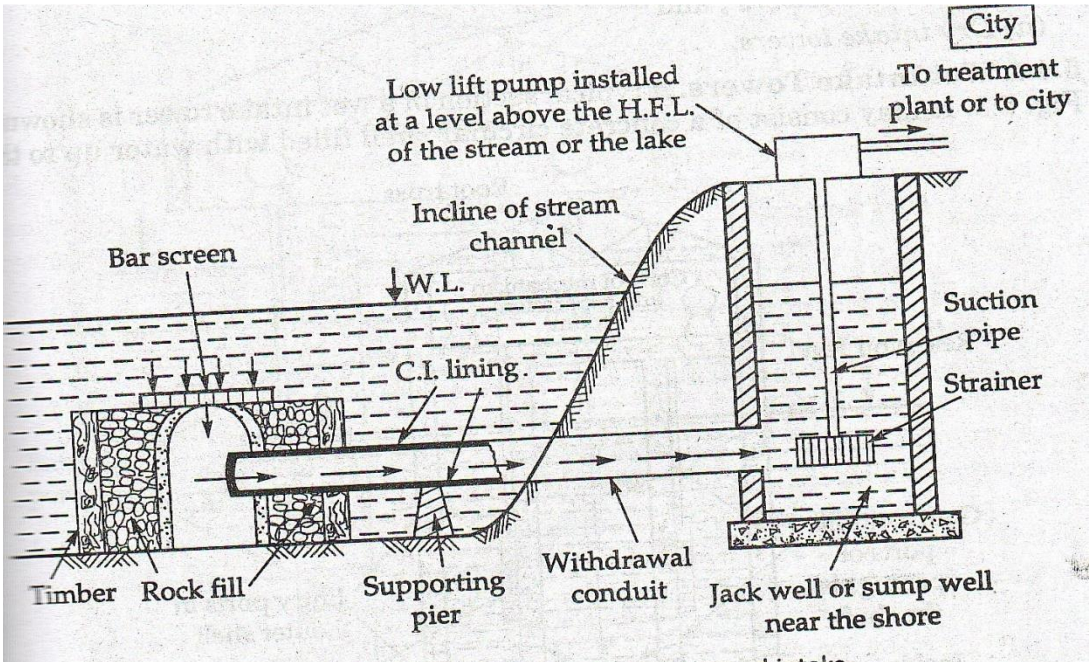


Fig. 5.2. Rock filled timber crib—submerged intake.

2. INTAKE TOWERS OR RIVER INTAKE STRUCTURES

- ✖ Intake towers are generally used on large projects and on rivers or reservoirs where there is large fluctuation of water level.

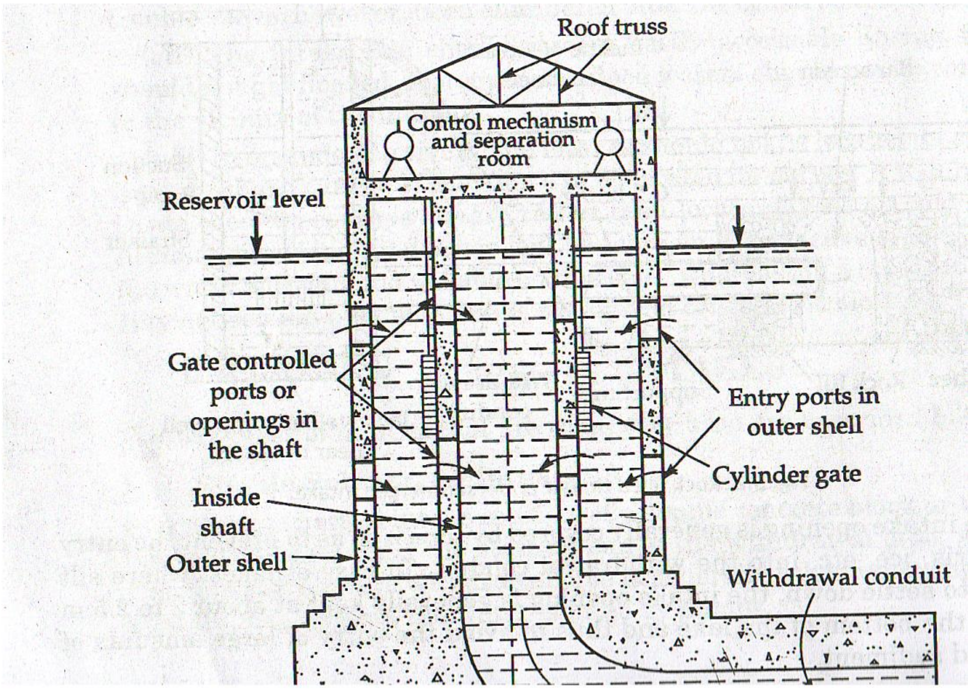
- ✖ Gate controlled openings at various levels called ports are generally provided in these concrete towers which may help in regulating the flow through the towers and permit some selection of the quality of water to be withdrawn.
- ✖ Accesses to these towers are generally provided for operating the gates, etc., by means of a foot bridge from the tower up to the dam or up to the shore.

Types of Intake Towers (river)

- Wet intake Towers
- Dry Intake Towers

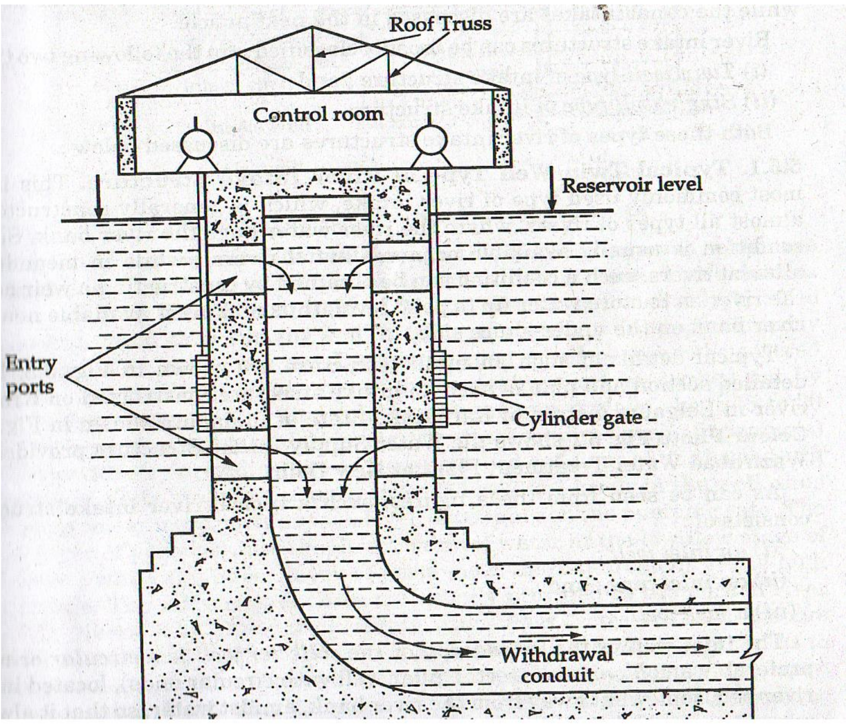
Wet Intake Tower

- ✖ The wet intake is that type of intake tower in which the water level is practically the same as the level of source of supply.
- ✖ It is sometimes known as JACK Well and it is most commonly used.
- ✖ It consists of a concrete circular shell filled with water up to the reservoir level and has a vertical inside shaft which is connected to the withdrawal pipe.



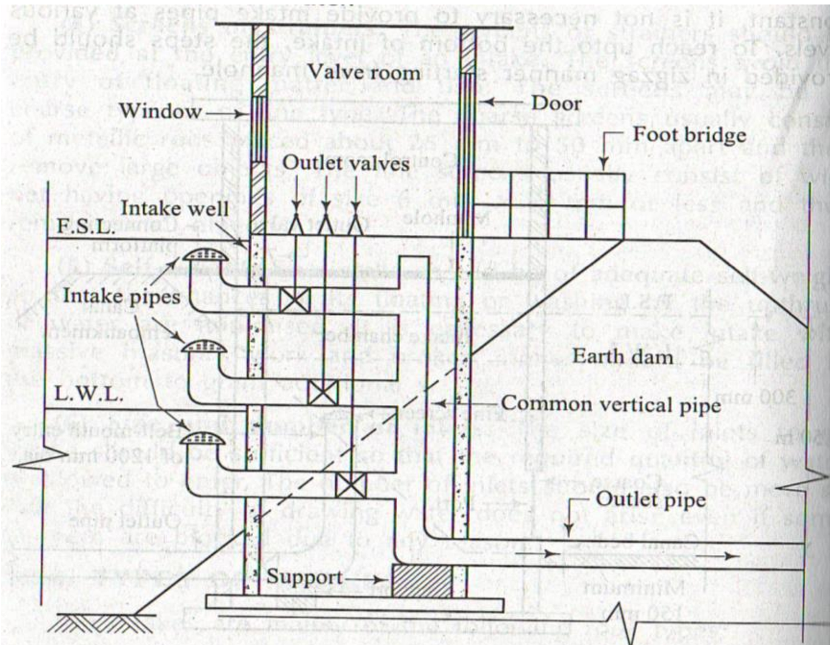
Dry Intake Tower

- ✖ The essential difference between a dry intake and wet intake is that in a wet intake the water enters from the entry ports in to the intake and then it enters in to the conduit pipe through separate gate controlled openings whereas in a dry intake water is directly drawn in to the withdrawal pipe through the gate entry openings.
- ✖ A dry intake will therefore have no water inside the intake if its gates are closed whereas the wet intake will be full of water even if its gates are closed.



3. RESERVOIR INTAKES

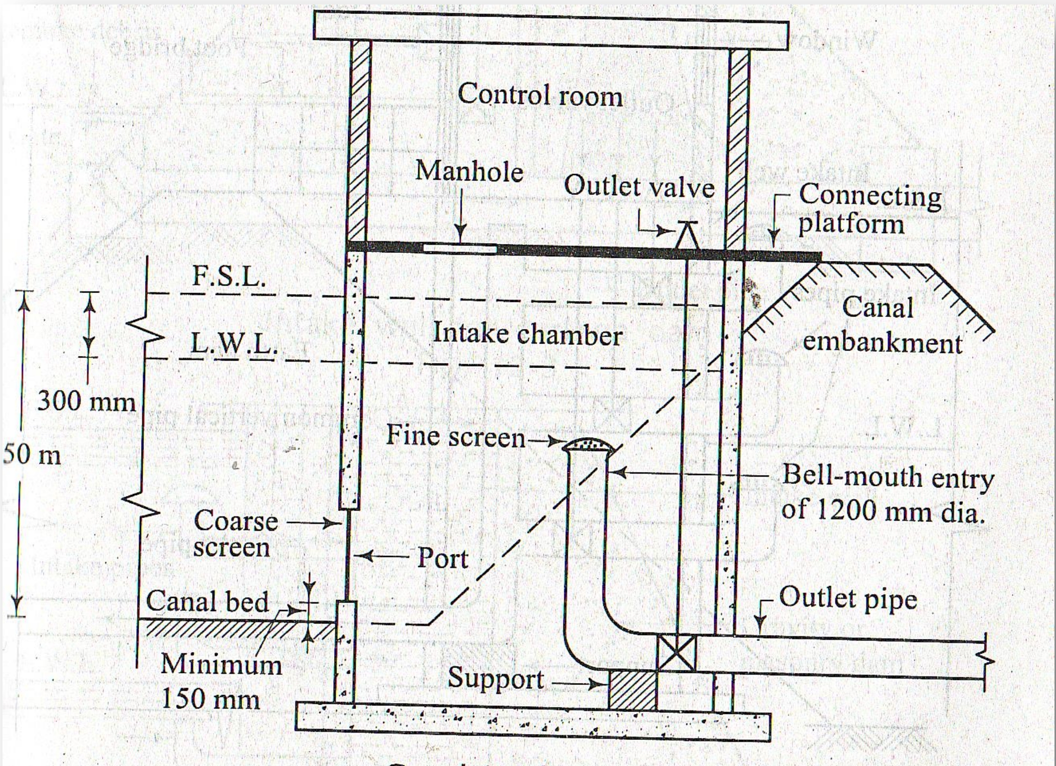
- When the flow in the river is not get guaranteed throught the year a dam is constructed across it to store water in the reservoir so formed.
- The reservoir intakes are practically similar to the river intake except that these are located near the upstream face of the Dam where maximum depth of water is available.
- The access to intake is provided through a foot bridge.
- The water level will be the same as the reservoir level.



Reservoir intake
FIG. 12-2

4. CANAL INTAKE

- In canal intake structure, the intake well is generally located in the bank of the canal and water enters the chamber through the inlet pipe.
- The inlet pipe is covered with a fine screen.
- The top of the screen is generally provided at minimum water level in the canal and bottom is about 0.15 m above the canal bed to avoid entry of bed load.
- The inlet end is of bell mouth shape with perforation of fine screen on its surface.
- The flow velocity through the out let is generally 1.5 m/sec, and this helps in determining the area and diameter at the withdrawal pipe.
- The area of the coarse screen is designed by limiting the flow velocity to as low as 0.15m/sec.
- The flow velocity through the bell mouth is limited to about 0.3 m/sec.



Canal intake

DESIGN OF INTAKES

- Pipe is a circular closed conduit through which the water may flow either under gravity or under pressure. They may be gravity conduit or may be pressure conduits.
- Gravity conduit- Open channel, Flume & Aqueducts
- Pressure conduit- Pipe
- Discharge through pipe Q= A × V
  - Where V is velocity in the pipe, A is cross sectional area of the pipe.
- Diameter of the pipe is worked with the help of modified Darcy-Weisbach formula

$$h_f = \frac{fLQ^2}{12.1d^2}$$

Where, h_f = head loss due to friction

f = co-efficient of friction

L = length of pipe

Q = Discharge through pipe

d = diameter of pipe.

OPEN CHANNEL

- These are rarely used to transport the water from the source to treatment plant.
- These can be effortlessly and cheaply constructed by cutting in elevated grounds and banking in low grounds.
- As water flows only due to gravitational force a uniform slope should be given.

FLUMES

- The flumes are open channels, but the ground is supported by trestles etc.
- The use of flumes is to transport the water across valleys and minor low lying areas or over drains and other obstructions.

AQUEDUCTS

- Aqueducts are channels either above ground, below ground or on the ground that transport water from a lake or stream into a water treatment unit which may be miles away.
- The average velocity will be in the range between 1.0 to 1.5 m/sec.

Stresses in the Pipe

1. Stresses due to change of direction
2. Stresses due to internal water pressure
3. Stresses due to soil above the pipes
4. Stresses due to water hammer
5. Stresses due to yielding of soil below pipes and
6. Temperature stresses.

The final selection of material for the pipe is done by considering various factors such as availability of funds, type of water to be conveyed, carrying capacity of pipes, maintenance, cost and durability.

Various materials used for pipes

1. Asbestos cement pipes
2. Cast-iron Pipes
3. Cement concrete pipes
4. Copper pipes
5. Galvanised pipes
6. Lead pipes
7. Plastic pipes
8. Steel pipes
9. Steel pipes
10. Wood pipes

1. Asbestos cement pipe

- ✖ Made from mixture of Asbestos fibre and cement.
- ✖ Convey water under low pressure.

ADVANTAGES:-

- + Inside surface- Very smooth
- + Joining- Very good, flexible, easily
- + Light in weight, easy to handle & transport
- + Very suitable for distribution pipes of small size

DISADVANTAGES:-

- + Brittle; cannot withstand impact forces
- + Not durable
- + Cannot be laid in exposed places
- + Can be used only for very low pressure.

2. Cast iron pipes

- ✖ Mainly used for conveyance of water.
- ✖ Joined by bell and spigot (or) Expansion joint.
- ✖ The spigot is of smaller diameter and is inserted to the larger diameter bell end.
- ✖ Expansion Joint: Severe change of temperatures
- ✖ A rubber gasket is inserted between the spigot and the bell end.
- ✖ Flanged joint: Water at high pressure. At a wide flange will be provided which are bolted together.
- ✖ They are manufactured by pig-iron and given some suitable treatments

ADVANTAGES

- + The cost is moderate
- + Easy to join
- + Not subjected to corrosion

- Strong & Durable

DISADVANTAGES

- The breakage of these pipes is large.
- Carrying capacity decreases with the increases in life
- Not used for pressure greater than 0.7 N/mm^2
- Heavier & Uneconomical- Size beyond 1200 mm dia.

3. Cement concrete pipes

- Plain (or) Reinforced (or) Pre stressed pipes
- Plain – 15 m , RCC – 75 m and High head – pre stressed.
- Reinforcement in the form of links or hooks and longitudinal bars
- Mould - Hume pipe (or) Spun concrete pipes

ADVANTAGES

- Inside Surface – Very smooth
- Maintenance cost is low
- Pipes can be cast at site and can be transported.
- Does not require expansion joint
- No danger of rusting & incrustation

4. Copper pipes

- Widely used for service connections

ADVANATGAES:-

- Cheap, light in weight and easy to handle and transport.
- Easy to join

DISADVANTAGES

- Liable for incrustation & easily affected by acidic or alkaline water.
- The useful life of pipe is pipe is short about 7 to 10 years.

5. Lead pipes

- Not adopted for conveyance of water due to lead poisoning
- It can be easily bent.
- Apparatus required for alumn & chlorine discharge- can not water.
- It can be bent due to hot water.

6. Plastic pipes

- LDPE- Low Density Poly Ethylene Pipes- Flexible
- Strong in resisting acids
- PVC- Poly Vinyle Chloride Pipes three times as rigid as poly ethylene pipe.

ADVANTAGES

- Freedom from damage due to thawing & freezing
- Pipes are very cheap
- Durable & Hydraulic resistant
- Free from corrosion
- Good electric insulator
- Light in weight easy to bend

DISADVANTAGES

- Co-efficient of expansion for plastic is high
- Difficult to obtain the plastic pipes of uniform compositions
- Less restraint to heat
- Some type- impart to the taste of water.

7. Steel pipes

- ✖ Mild steel is used for steel pipes
- ✖ Joints – Riveted or Welded
- ✖ Generally used for more than 1200 mm dia
- ✖ Inside generally galvanized.

ADVANTAGES

- Available in long length- No of joints less
- Cheap & Best in cost
- Durable & Strong
- Flexible to some extent & laid easily on curves
- Light in weight & easy to transport.

DISADVANTAGES

- Maintenance cost is high
- Rust attack due to alkali water
- Require more time for repairing
- Deform shapes under combined action of internal and external load.

8. Wood pipes

- ✖ Usually prepared of staves or planks wood held together by steel bands.
- ✖ Light in weight cannot bear higher pressure
- ✖ Rarely adopted for conveyance of water.

9. Wrought Iron pipe

- ✖ Light in weight can be easily cut threaded and worked.
- ✖ Costly and Less durable. Not generally used in water conveyance system.

JOINTS IN PIPE

Pipe joints are the assemblies used to connect one pipe with other without any leakage or other losses.

CLASSIFICATION

1. **Based on the Rigidity & Flexibility**

   - ✖ Rigid Joint
   - ✖ Semi Rigid Joint
   - ✖ Flexible Joint

2. **Based on Functions & location**

   - ✖ Spigot and Socket Joint
   - ✖ Expansion Joint
   - ✖ Flanged Joint
   - ✖ Screwed Joint

Rigid joints

- ✓ Rigid Joints are those which admit no movement at all and comprise flanged, welded and turned and bored joint.
- ✓ Flanged joints require perfect alignment and close fittings and are frequently used where a longitudinal thrust must be taken such as at the valves and meters.
- ✓ The gasket used between the flanges of pipes shall be compressed fibre board or natural or synthetic rubber.
- ✓ Welded joints produce a continuous line of pipe with the advantage that interior and exterior coatings can be made properly and are not subsequently disrupted by the movement of joints.

Semi rigid joints

- ✓ A semi rigid joint allows partial movement due to vibration etc.
- ✓ The socketed end of the pipe should be kept against the flow of water and the spigot end of the other pipe is inserted in to this socket .
- ✓ A rope is then placed at the outer end of the socket and is made by tight fit by applying wet clay leaving two holes for the escape of the entrapped air inside.

Flexible joints

- ✓ Flexible joints are used where rigidity is undesirable such as filling of granular and when two sections cannot be welded.
- ✓ They comprise mainly mechanical and rubber ring joints which permit some degree of deflection at each joint and are therefore able to withstand vibration and movements.

- ✓ In the rubber jointing special type of rubber gasket are used to connect cast iron pipe which are cast with a special type of spigot.
- ✓ Rubber joint is to be preferred to lead joining

Spigot & socket joint

- ✓ This is mostly suitable for cast iron pipes
- ✓ This type of joint is connected by inserting the spigot end of one pipe in to the socket or bell end of the other.
- ✓ The connecting procedure includes; wrapping of jute around the spigot before inserting it in to the socket.
- ✓ Then in the remaining space or gap between spigot and socket is filled by molten lead.
- ✓ Cooling time will be given for the solidification of molten lead.
- ✓ The flexibility of this joint is less and need skilled labour.

Expansion joint

- ✓ The main advantage of the expansion joints is its flexibility.
- ✓ In some cases the pipes are laid over the ground and exposed to the atmosphere.
- ✓ Due to thermal stresses the pipe will tend to expand and contract which ultimately results in the formation of cracks in the external surface of the pipe and leak in the joints.
- ✓ In this type of joint the socket end is connected rigidly to an annular ring which can freely over the spigot joint.
- ✓ The provision of gasket will aid the pipe movement at the time of expansion due to thermal stress.

Flanged joint

- ✓ This type of joint mostly used for temporary pipe network.
- ✓ The pipe has flanges at both the ends .This ends are connected by bolts and nut or welding.
- ✓ During the connection process a rubber gasket is placed between the two ends which will prevent leakage.
- ✓ This joint is commonly used in plumbing station boiler house etc.
- ✓ But if this joint is used in steel pipe it will be better to connect by nuts and bolt rather by other connection.

Screwed joint

- ✓ The screwed joints are usually adopted when the pipe diameter is less
- ✓ In this joint the ends of the pipes are threaded outside, while socket or coupling has threads on both the ends of the pipe to join them.
- ✓ For making water tight zinc paint or hemp yarn should be placed in the threads of the pipe, before screwing socket over it.

LOSSES IN PIPE FLOW

1. Major Loss – Due to friction – Darcy's formula $h_f = \frac{fLv^2}{2gd}$

2. Minor Losses –Due to pipe arrangements and flow direction

$$h_m = k\frac{v^2}{2g}$$

k value will be

Sl.No	**Description**	**K value**
1	Sudden Contraction	0.3 - 0.5
2	Entrance	0.5
3	Elbow 1. 90 degree 2. 145 degree 3. 220 degree	0.50 to 1.00 0.40 to 0.75 0.25 to 0.50
4	Tee 1. 90 degree 2. Straight runner 3. Coupling	1.5 0.3 0.3
5	Gate valve (open)	0.3 to 0.4
6	Reducer and Increaser	0.5
7	Globe	10.00
8	Angle	5.00
9	Swing check	2.5
10	Venturimeter	0.3
11	Orificemeter	1.00

PIPE CORROSION

- Loss of pipe materials due to the action of water
- Metallic structure of the pipe is attacked and dissolved by water.
- Action of water flowing through the pipe
- Action of water logged in the soil above the pipe

Factors

1. Acidity, Alkalinity
2. Biological action
3. Chlorination
4. Electrical current
5. Oxygen
6. Mineral and organic constituents

Effects of pipe corrosion

1. Tuberculation- Formation of small projection inside the surface of the pipeline- pipe carrying capacity is reduced.
2. Disintegration of pipeline – Demand heavy repairs
3. Effects on colour, taste & odour to the water
4. Affecting seriously the pipe connections
5. Water dangerous for drinking purposes.

Theories of pipe corrosion

1. Action of water motion
2. Bimetallic action
3. Biological action
4. Chemical reaction
5. Electrolysis

Prevention of pipe corrosion

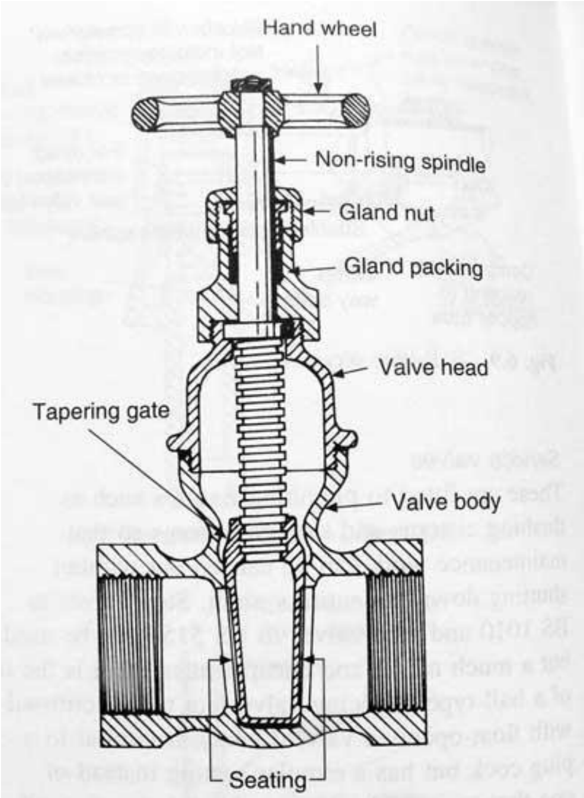
1. Cathodic protection
2. Proper pipe materials
3. Protective lining
4. Treatment of water

PIPE APPURTENANCES

1. Sluice valve or Gate valve
2. Air valves
3. Reflux valves
4. Relief valves
5. Altitude valves
6. Scour valves
7. Fire Hydrants
8. Bib cocks
9. Stop cocks
10. Water meters

1. Sluice valve or Gate valve

- It is used to control the flow of water and helpful in dividing the water mains into the suitable sections.
- They are generally placed at a distance of about 150mm-200mm and at all the junction.
- They are made of cast with brass mounting.
- They are solid wedge type (or) double disk.

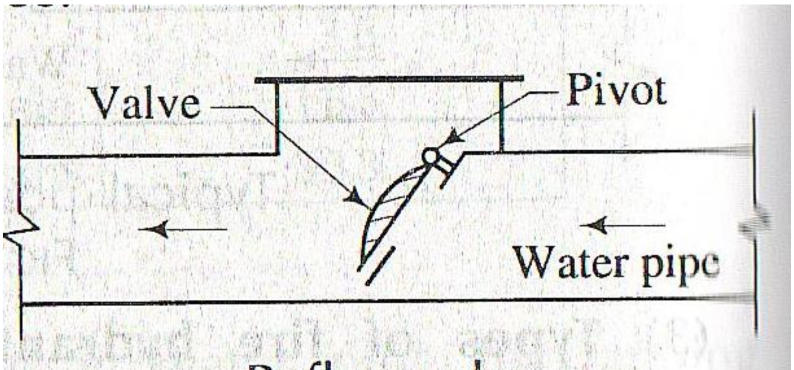


2. Air valves

- They are normally called air relief valves.
- To provide on exit of air, these valve is provided.
- Located very close or above the hydraulic gradients.
- It consists of a cast iron chamber, float, lever and poppet.

3. Reflux valves

- These are also known as automatic cut off valves (or) safety valves.
- They are located at every point along the water pipe where pressure is likely to be maximum .
- Where pressure of water exceeds a predetermined limit, the valve operate automatically and it will save a particular section of water pipe before bursting the pipe.



Reflux valve

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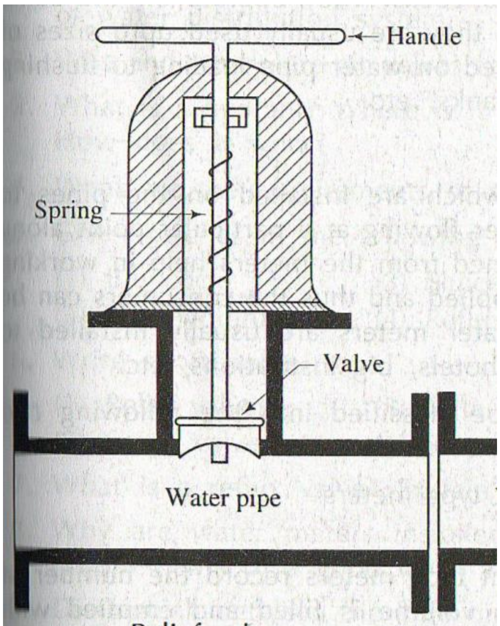
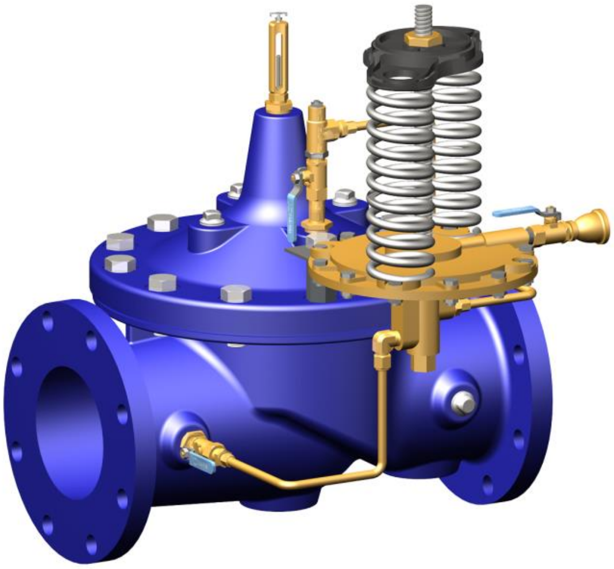


Relief valve

5. Altitude valves

- They are mainly used on those lines which supply water to elevated tanks or stand pipes.
- They close automatically when the tank is full and open when the pressure on the pump side is less than that on the tank side of the valve.



6. Scour valve

- Scour valves (or) blow off (or) washout valves are ordinary sluice that located either at the dead end or at lowest points in the main.
- They are provided to blow off or remove sand and silt deposited in the pipeline.
- They are operated manually.

7. Fire hydrants

- A hydrant is an outlet provided in water pipe for tapping water mainly in case of a fire.
- Fire hydrant is used for fire fighting purposes.
- They are placed at all junctions and so located that if a circle of about 60 to 90 m drawn from any hydrant.

<u>Type of Hydrants:-</u>

1. Flush Hydrant

2. Post Hydrant

Requirements of a fire hydrant

1. It should be cheap
2. Easily detectable in case of fire
3. It can be easily connected with the hose motor pump
4. It should function properly and should not go out of order during operation.
5. It should permit undisturbed flow of water when being fully opened.

8. Bib cock

- These are water taps which are attached at the end of water pipes and from which the consumer obtain water.
- It is operated from a handle.
- They may also push type and they operate automatically.
- They should be water tight; the leaky bib cocks are the source of waste water.

9. Stop cocks

- These are small size sluice valves and they are installed in service pipes, serving the bib cocks.
- They operate on the same principles of sluice.
- They are placed on water pipes leading to flushing tanks, wash basins, water tanks etc.

10. Water meter

These are devices which are installed on the pipes to measure the quantity of water flowing at a particular point along the pipe.

They usually installed at to supply water to industries, hotel, big institutions etc.

Types

1. Positive displacement type meter
2. Velocity meter

- They should accurately measure discharge(2% tolerance)
- They should easy to repair and maintenance
- Should not too costly
- They should be non corrosive.

WATER DISTRIBUTION SYSTEM

Lay out of Water Distribution System

1. Dead end system (or) Tree System
2. Grid- iron system (or) Reticulation System
3. Circular System (or) Ring System
4. Radial System.

1. Dead end or tree system

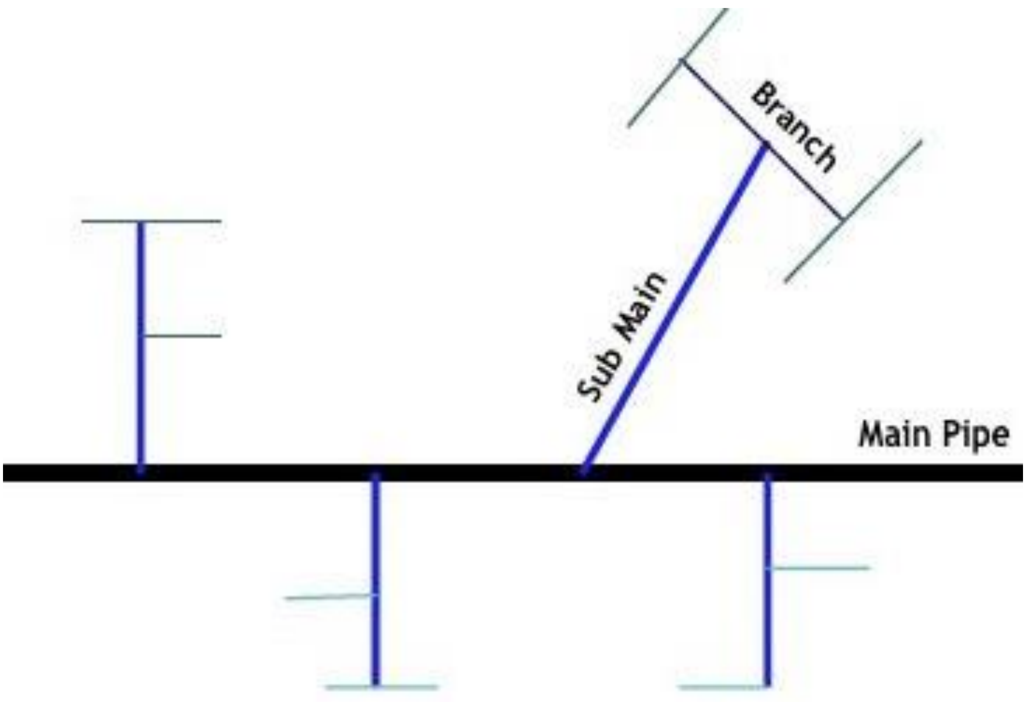
- One main pipe line runs through the center of the populated area and sub-mains takeoff from this to both sides.
- The sub-mains divide into several branch lines from which service connections are provided.

Advantages

i. The design calculation is simple and easy.
ii. A smaller number of cut-off valves are required and the operation and maintenance cost is low.
iii. Pipe-laying is simple.

Disadvantages

i. The system is less successful in maintaining satisfactory pressure in the remote areas and is therefore not favored in modern waterworks practice.
ii. One main pipeline provides the entire city, which is quite risky. Any defect, damage or breakage at one point of this line will disrupt the supply of water beyond that point, cutting off service to the whole area. This could be angerous, especially if there is a fire.
iii. The head loss is relatively high, requiring larger pipe diameter, and/or larger capacities for pumping units.
iv. Dead ends at line terminals might affect the quality of water by allowing sedimentation and encouraging bacterial growth due to stagnation. Water hammer could also cause burst of lines. A large number of scour valves are required at the dead ends, which need to be opened periodically for the removal of stale water and sediment.
v. The discharge available for firefighting in the streets will be limited due to high head loss in areas with weak pressure.



2. Gridiron system

- In Gridiron system the main supply line runs through the center of the area and submains takeoff from this in perpendicular directions. The branch lines interconnect the sub-mains.
- This system is ideal for cities laid out in a rectangular plan resembling a grid iron.
- The distinguishing feature of this system is that all of the pipes are interconnected and there are no dead ends.
- Water can reach a given point of withdrawal from several directions, which permits more flexible operation, particularly when repairs are required.

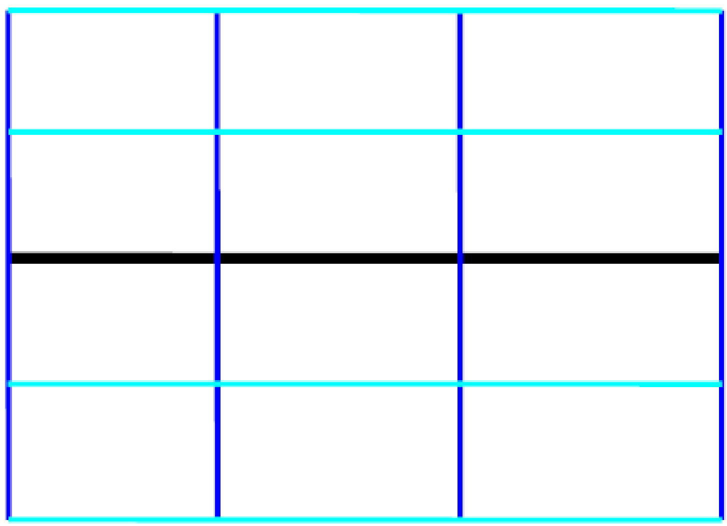


Figure 2: Gridiron distribution system

Advantages

i. The free circulation of water, without any stagnation or sediment deposit, minimizes the chances of pollution due to stagnation.
ii. Water is available at every point, with minimum loss of head, because of the interconnections.
iii. Enough water is available at streets fire hydrants, as the hydrant will draw water from the various branches lines
iv. During repairs, only a small area of distribution is affected.

Disadvantages

i. A large number of cut-off valves are required
ii. The system requires longer pipe lengths with larger diameters.
iii. The analysis of discharge, pressure and velocities in the pipes is difficult and cumbersome.
iv. The cost of pipe-laying is higher

3. Circular or ring system

- In circular or ring system, the supply main forms a ring around the distribution area.
- The branches are connected cross-wise to the mains and also to each other.
- This system is most reliable for a town with well planned streets and roads.
- The advantages and disadvantages of this system are the same as those of the grid iron system. However, in case of fire, a larger quantity of water is available, and the length of the distribution main is much larger.

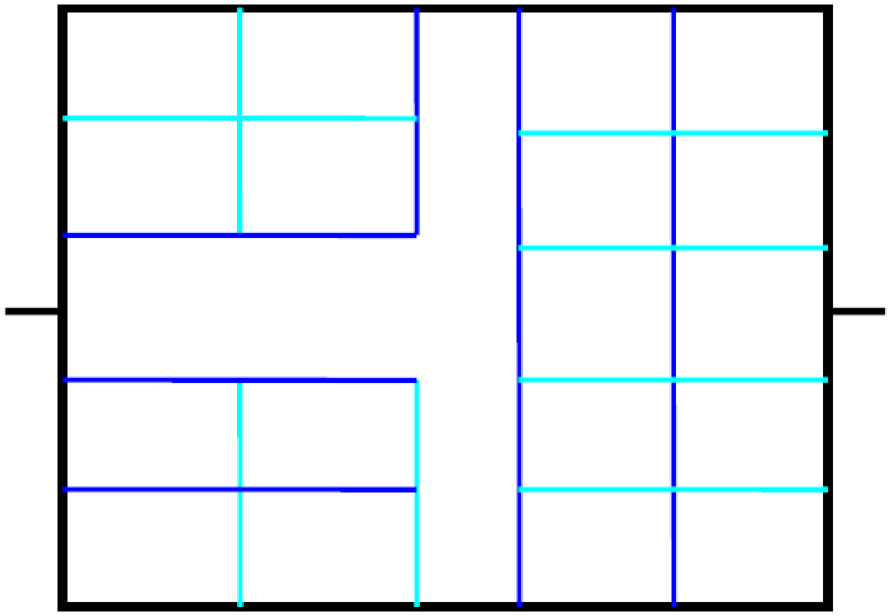
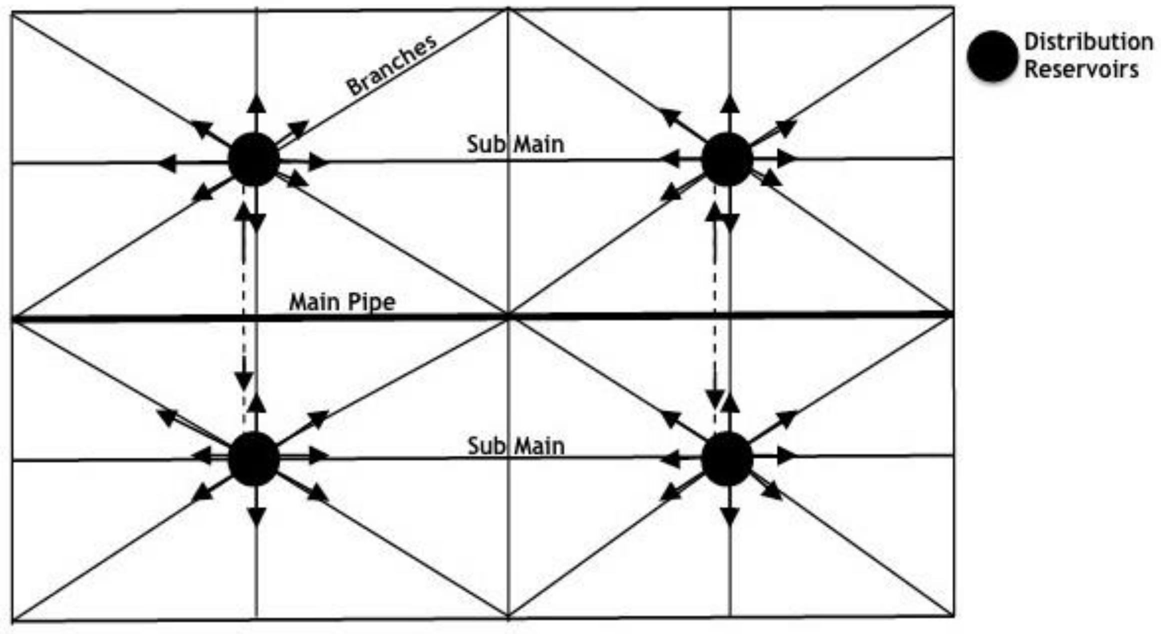


Figure 3: Circular or ring distribution system

4. Radial system

- In a radial system, the whole area is divided into a number of distribution districts.
- Each district has a centrally located distribution reservoir (elevated) from where distribution pipes run radially towards the periphery of the distribution district.
- This system provides swift service, without much loss of head.
- The design calculations are much simpler.



LAYING JOINTING & TESTING OF PIPELINES

Transport

- Pipes should be loaded at the works for transportation either by rail or by road.
- No movements can be take place on vehicle during the transit

Off- Loading

- It should be carried out by means of chain block with shear log or crane
- Slings should be placed around the circumferential of the pipe and should not be threaded through the pipe bore.
- Hooks located at the ends of the pipes should not be used.

Stacking

- Pipes can be directly placed on the ground free from rock and other projections.
- Stacking in tyres is permissible provided timber bearer is placed between succeeding tyres.

Stringing

- It consists of placing of pipes on the ground in line ready for laying.

Trench Excavation

- Trench should be sufficient width to provide a free working space.
- Free working place – not less than 150 mm on either side.

Inspection and Repairs

1. **Inspection of pipes before laying**

   - Visually inspected for evidence of damage
   - Examination of joint surfaces which may damage during transit.

2. **Repairing Damaged Pipes**

   - Minor damages may be repairable at site.

Laying

- Lowered in to the trench with tackle suitable for the weight of pipe
- While lifting the position of the sling should be checked when the pipe is just clear off to ensure proper balance.
- Laying of pipe should be preferably proceed upgrade of a slope
- Expansion joints shall be provided for buried line at maximum interval of 100m but for exposed pipes shall not exceed 45 m.
- When laying is not in progress the open end of the pipe line should be fitted with temporary end closers.
- The pipe buoyant in the event of the trench become flooded and any movements of the pipes should be prevented either by partial refilling of the trench or by temporary strutting.

Jointing

Basic requirements of joining of the pipelines are

- Cleanliness of all the parts particularly joint surfaces
- Correct location of components
- Centralization of spigot within the socket
- Provision of the correct gap between the end of the spigot and the back of the socket to ensure flexibility at each joints
- Any lubrication used shall be approved as composition and method of application
- The section of the pipeline laid and jointed immediately to protect it from weather effects
- A minimum cover of 100 mm is considered adequate
- A polythene sheet also is used to cover the joints to prevent evaporation of water.
- A small change in the direction may be setting out adjacent pipe at a slight angle to one another.

Testing

All pipe lines should be tested before come in service.

- **Hydrostatic Test**

- Filling the pipe line with water and raising pressure to selected limit.
- Draw graph between the quantity of water added and the time.

Site Test Pressure

- Absorption of water by the pipe material under selected pressure
- The important factors of considerations are
- The density of the pipe material.
- Amount of surplus water present in the pipe at the commencement of test.
- The amount and quality of cement matrix in case of concrete pipe
- Thickness of the pipe unit under test
- The pressure applied
- The duration of the test.

The field test pressure to be imposed should not be less than the greatest of the following

- 1.5 times the maximum sustain operating pressure
- 1.5 times the maximum pipe line static pressure
- Sum of maximum sustained pressure and maximum surge pressure
- Sum of maximum pipeline static pressure and maximum surcharge pressure.
- The pressure should be applied and maintain for at least four hours, if there is no leakage then the pipe line is ok

Allowable leakage

$$qL = \frac{ND}{P}$$

where

$qL =$ allowable leakage in $cm^3/hour$

$N =$ No. of joints in the length of pipe line

$D =$ Diametre in cm

$P =$ Average test pressure during leakage test in Kg/cm^2

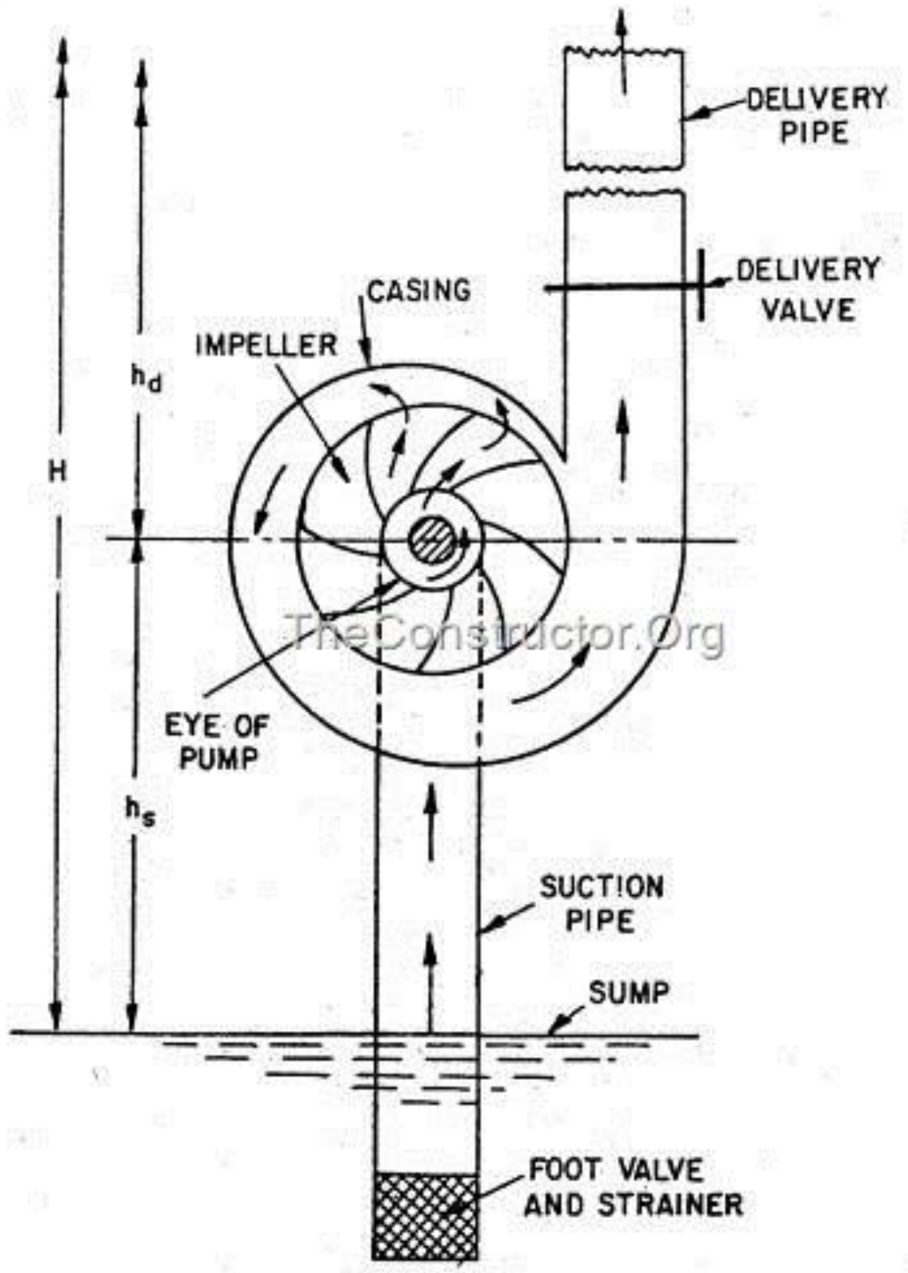
Leak detection

- Visual inspection of each joints if not covered by back fill
- Use of a bar probe to detect signs of water in the vicinity of joints if backfilled
- Aural inspection using a stethoscope or listening stick in contact with pipeline
- Use of an electronic listening device which detect and amplifies the sound of escaping water
- Injection of dye into the test water
- Introduction of Nitrous oxide solution into the test water using IR- gas concentration; escaped through the leaks.

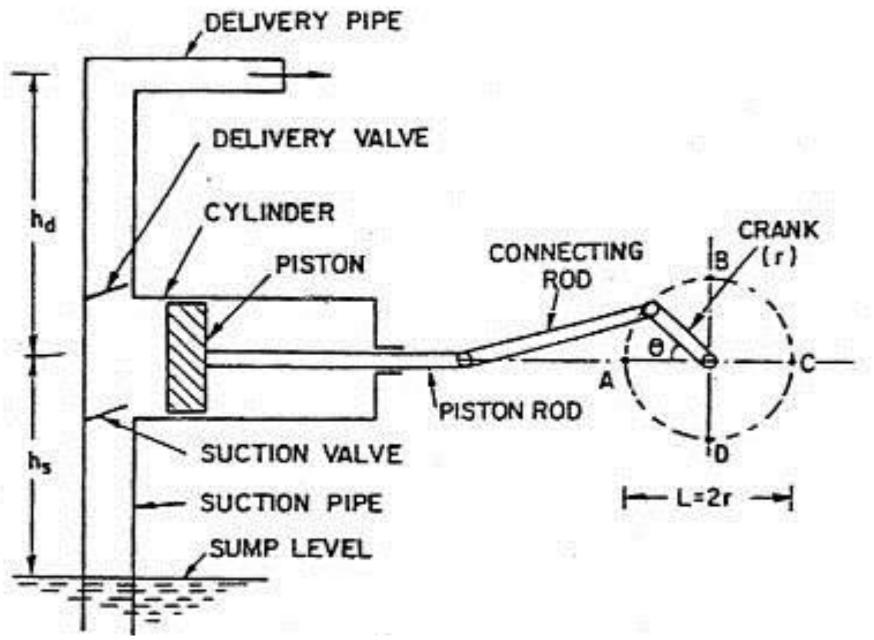
<u>Pumps for water supply</u>

- Centrifugal pump
- Reciprocating pump
- Submergible pump
- Air lift pumps
- Rotary pumps

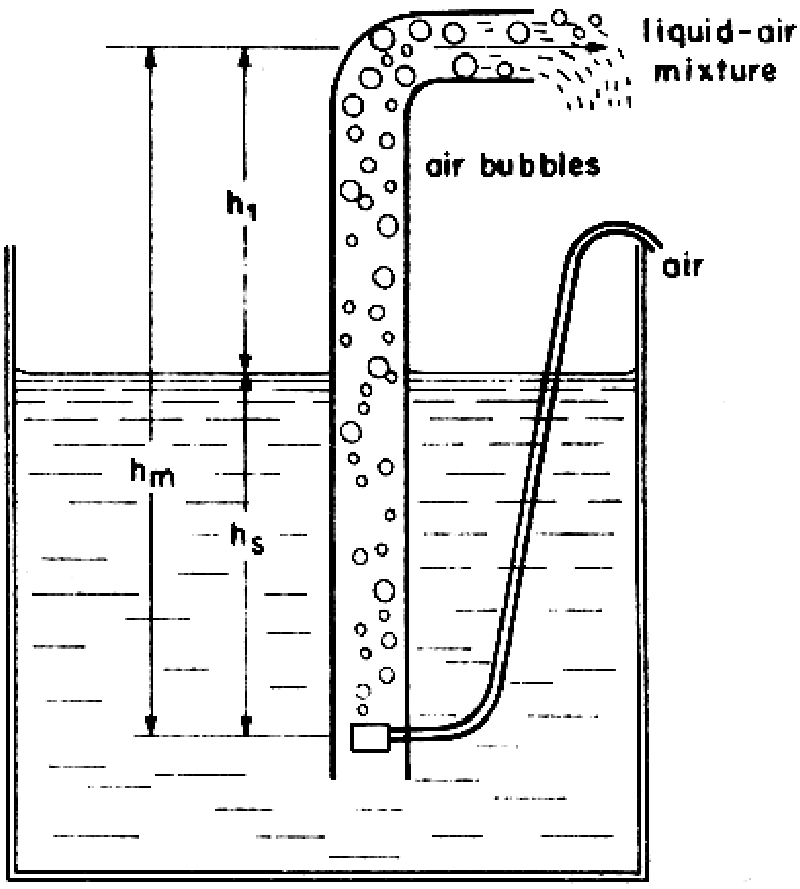
CENTRIFUGAL PUMP



RECIPROCATING PUMP



AIR LIFT PUMPS



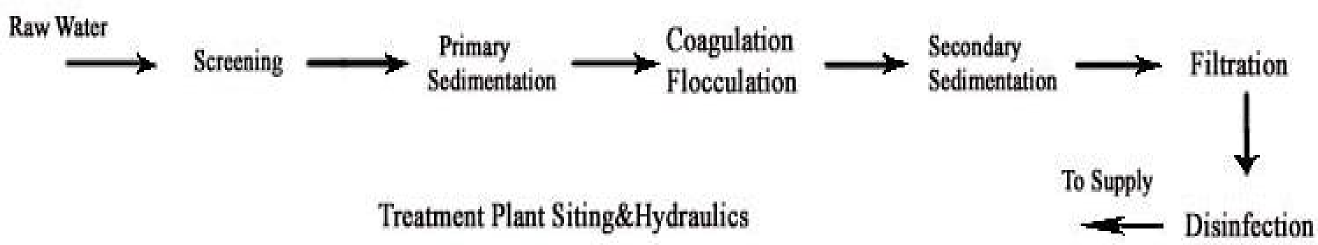
UNIT – 3. WATER TREATMENT

Objectives -Unit operations and processes -Principles, functions design and drawing of chemical feeding, Flash mixers, flocculates, sedimentation tanks and sand filters -Disinfection-Residue Management -Construction and Operation & Maintenance aspects of Water Treatment Plants.

UNIT OPERATIONS

- Unit operations are the methods which changes the physical, chemical and biological character of water (or) waste water.

Depending upon the magnitude of treatment required, proper unit operations are selected and arranged in the proper sequential order for the purpose of modifying the quality of raw water to meet the desired standards



Functions of Water Treatment Units

Unit treatment	Function (removal)
Aeration, chemicals use	Colour, Odour, Taste
Screening	Floating matter
Chemical methods	Iron, Manganese, etc.
Softening	Hardness
Plain Sedimentation	Suspended matter
Sedimentation with Coagulation	Suspended matter, a part of colloidal matter and bacteria
Filtration	Remaining colloidal dissolved matter, bacteria
Disinfection	Pathogenic bacteria, Organic matter and Reducing substances

METHOD OF PURIFICATION OF WATER

1. Screening
2. Plain sedimentation
3. Sedimentation aided with coagulation
4. Filtration
5. Disinfection
6. Aeration
7. Softening
8. Miscellaneous treatments such as fluoridation re carbonation, liming, desalination, etc

SCREENING

- The process of removal of most of the big and visible objects, such as trees, branches, sticks, vegetations, fish, animal life etc present in water of surface source is called Screening.

SCREENS

Screens are generally provided in front of the pumps or the intake works, so as to exclude the large sized particles, such as debris, animals, trees, branches, bushes, ice, etc.

Types of Screen

1. Coarse Screen (Bar Screen)
2. Fine Screens
3. Medium Screen

- Coarse screens or bar screens are generally provided in front of the fine screen.
- It consists of parallel iron rods placed either vertically or at a slight slope at about 2.5 to 5 cm apart.
- The coarse screen removes the bigger floating bodies and the organic solids.

Types of Bar Screen

1. Fixed bar type screen
2. Movable bar type screen or Travelling Bar type Screen

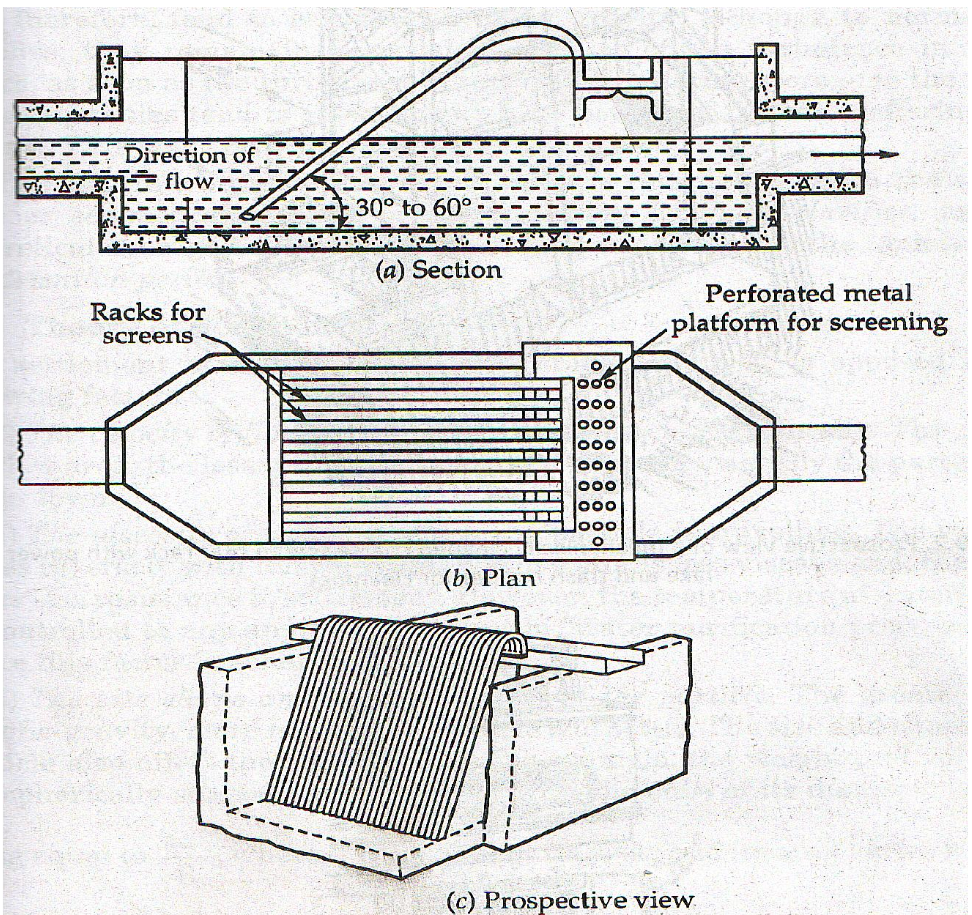


Fig. 9.1. Fixed bar type hand cleaned screen.

FINE SCREEN

- The fine screens are usually made up of woven wire mesh with opening not more than 6mm square.
- The fine screens remove the fine suspended solids.
- The fine screens normally get clogged and are cleaned frequently.
- The fine screens are avoided these days and the finer particles are separated in sedimentation rather than in screening.

PLAIN SEDIMENTATION

- It is the process of removal of suspended particles having more specific gravity than water.
- Principles of Sedimentation
- Most of the suspended impurities in water do have a specific gravity greater than that of water (ie 1.0) In still water these impurities will therefore tend to settle down under gravity, although in normal raw water supplies, they remains in suspension, because of turbulance in water.
- Hence as soon as the turbulance is retarded by offering storage to the water these impuriities tend to settle down at bottom of the tank offering such storage.
- The basin in which the flow of water is retarded is called settling tank or Sedimentation tank or clarifier and the theoretical average time for which the water is detained in the tank is called the detention period.
- Solid liquid separation process in which a suspension is separated into two phases.

1. Clarified supernatant leaving the top of the sedimentation tank (overflow).
2. Concentrated sludge leaving the bottom of the sedimentation tank (underflow).

Purpose of Settling

1. To remove coarse dispersed phase.
2. To remove coagulated and flocculated impurities.
3. To remove precipitated impurities after chemical treatment.
4. To settle the sludge (biomass) after activated sludge process / tricking filters.

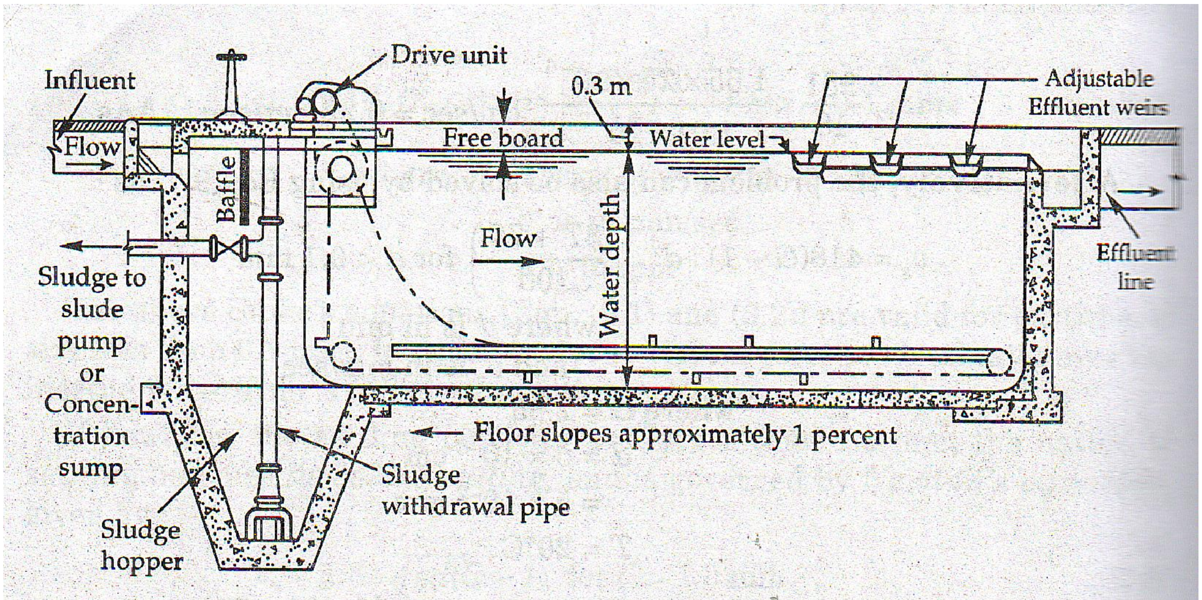


Fig. 9.5. Rectangular sedimentation tank (ideal horizontal flow tank).

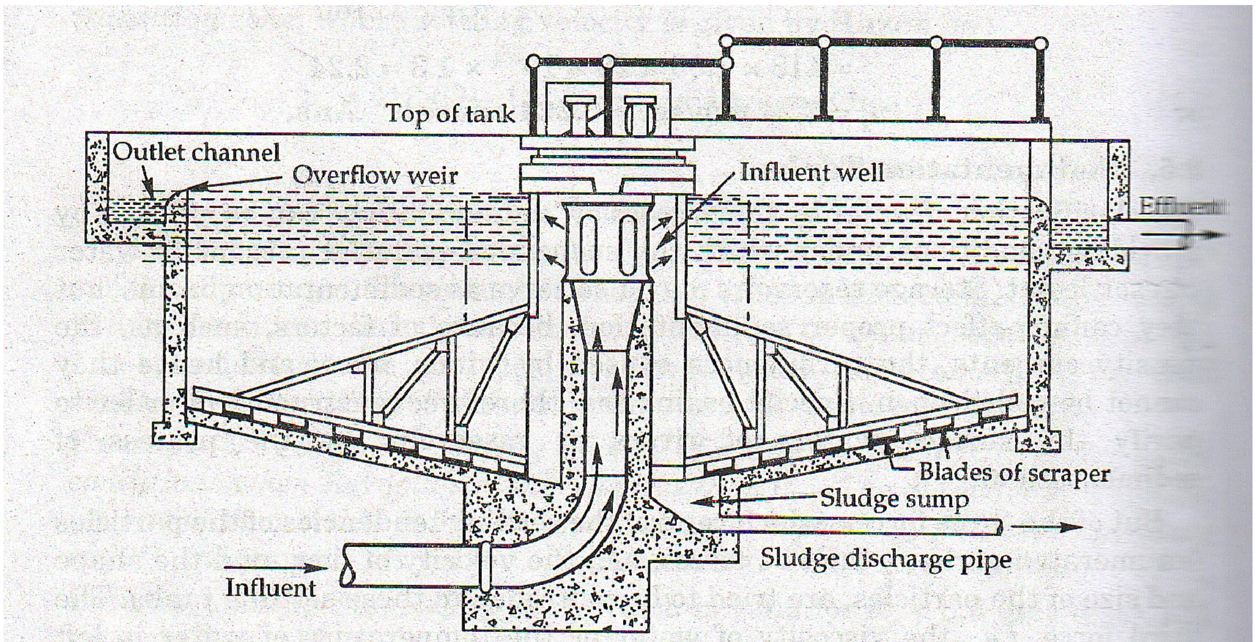
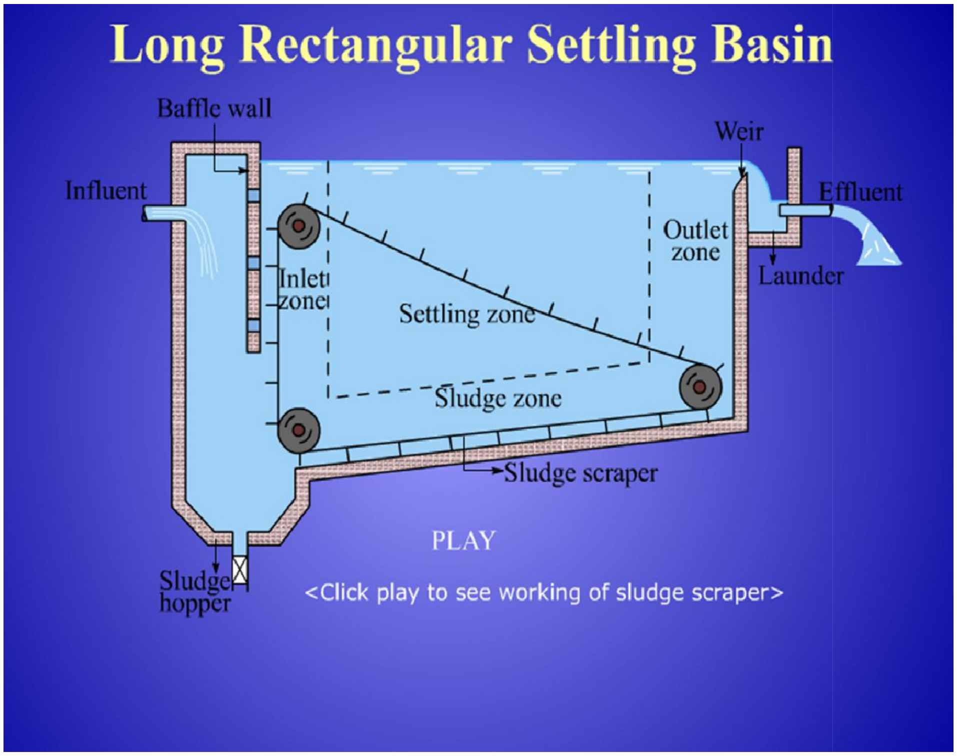


Fig. 9.6. Circular sedimentation tank (Central feed) with radial flow.

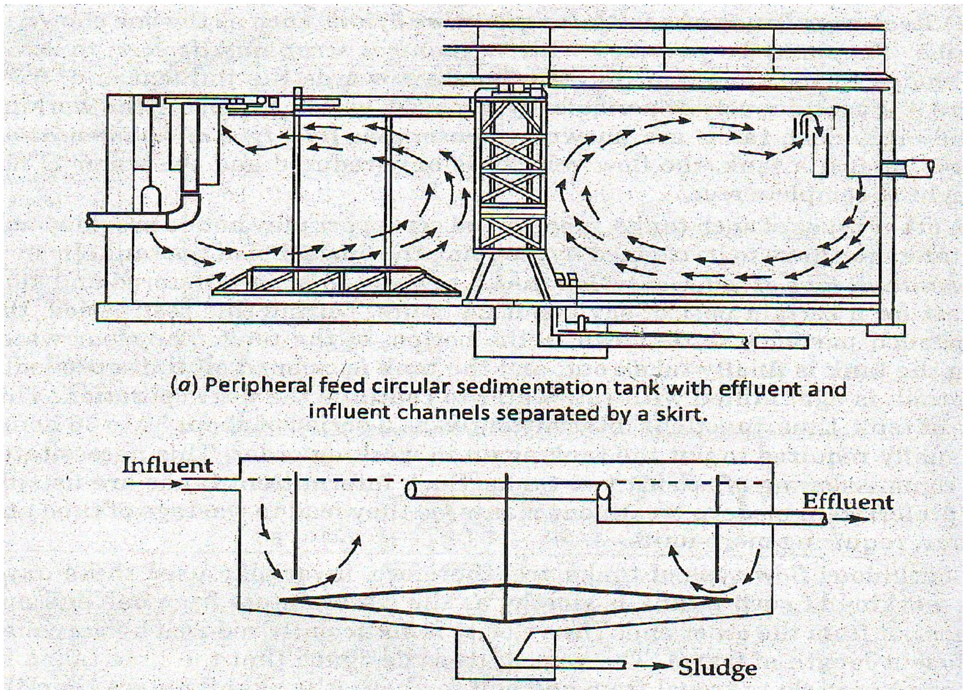
Long Rectangular Settling Basin

- Long rectangular basins are hydraulically more stable, and flow control for large volumes is easier with this configuration.
- A typical long rectangular tank have length ranging from 2 to 4 times their width. The bottom is slightly sloped to facilitate sludge scraping. A slow moving mechanical sludge scraper continuously pulls the settled material into a sludge hopper from where it is pumped out periodically.
- A long rectangular settling tank can be divided into four different functional zones:

Inlet zone: Region in which the flow is uniformly distributed over the cross section such that the flow through settling zone follows horizontal path. ***Settling zone:*** Settling occurs under quiescent conditions. ***Outlet zone:*** Clarified effluent is collected and discharge through outlet weir. ***Sludge zone:*** For collection of sludge below settling zone.



- Circular settling basins have the same functional zones as the long rectangular basin, but the flow regime is different.
- When the flow enters at the center and is baffled to flow radially towards the perimeter, the horizontal velocity of the water is continuously decreasing as the distance from the center increases.
- Thus, the particle path in a circular basin is a parabola as opposed to the straight line path in the long rectangular tank.
- Sludge removal mechanisms in circular tanks are simpler and require less maintenance.



(*a*) Peripheral feed circular sedimentation tank with effluent and influent channels separated by a skirt.

(*b*) Peripheral feed circular sedimentation tank with effluent weirs near the centre of the basin.

Fig. 9.7. Circular Peripheral feed sedimentation tank.

OUTLET ARRANGEMENT

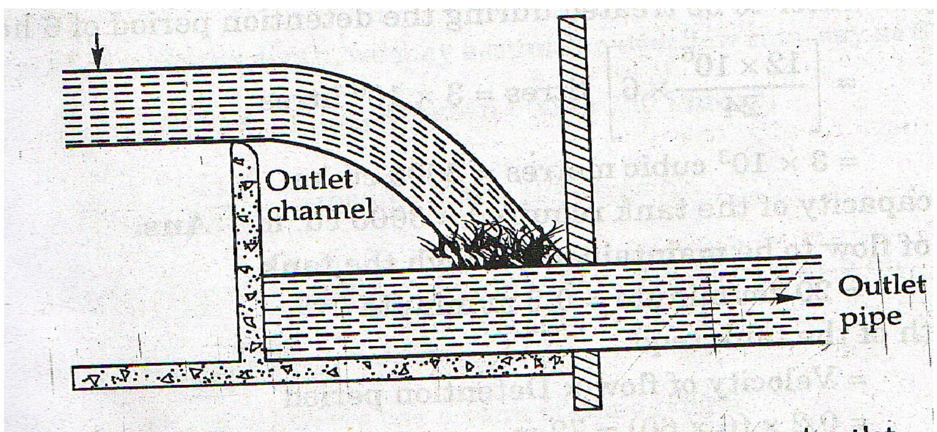


Fig. 9.13. Section of a 'submerged type' or a 'weir type' outlet.

Design Details

- **Detention period:** for plain sedimentation: 3 to 4 h, and for coagulated sedimentation: 2 to 2.5 h.
- **Velocity of flow:** Not greater than 30 cm/min (horizontal flow).
- **Tank dimensions:** L:B = 3 to 5:1. Generally L= 30 m (common) maximum 100 m. Breadth= 6 m to 10 m. Circular: Diameter not greater than 60 m. generally 20 to 40 m.
- **Depth:** 2.5 to 5.0 m (3 m).

- **Surface Overflow Rate:** For plain sedimentation 12000 to 18000 L/d/m2 tank area; for thoroughly flocculated water 24000 to 30000 L/d/m2 tank area.
- **Slopes:** Rectangular 1% towards inlet and circular 8%.

SETTLING VELOCITY (Streamline settling)

As per STOKES law the settling velocity of a spherical particles is expressed as

$$V_s = \frac{g}{18}(G-1)\frac{d^2}{\upsilon}\left(for\ d\ <\ 0.1\ mm\right)$$

Where

V_s = Settling velocity in m/sec

d = diameter of the particle in m

G = Specific gravity of the particle

$$= \frac{\rho_s}{\rho_w} = \frac{Density\ of\ particle}{Density\ of\ water}$$

υ = Kinematic viscosity of water in m^2/sec

Alternatively

$$V_s = 418\ (G\text{-}1)\ d^2\left(\frac{3T+70}{100}\right)(G-1)\left(for\ d\ <\ 0.1\ mm\right)$$

Where

V_s = Settling velocity in m/sec

d = diameter of the particle in m

G = Specific gravity of the particle

$$= \frac{\rho_s}{\rho_w} = \frac{Density\ of\ particle}{Density\ of\ water}$$

υ = Kinematic viscosity of water in m^2/sec

T = Temperature of water in ^0C

$$TURBULANT\ Settling - Newton's\ Equation$$

$$V_s = 1.8\sqrt{gd(G-1)} \quad (for\ d > 1.0\ mm)$$

Where

V_s = Settling velocity in m/sec

d = diameter of the particle in m

G = Specific gravity of the particle

$$= \frac{\rho_s}{\rho_w} = \frac{Density\ of\ particle}{Density\ of\ water}$$

υ = Kinematic viscosity of water in $m^2/\sec$

T = Temperature of water in ${}^0C$

$$Transition\ Velocity\ (Hazen's\ Equation)$$

$$V_s = 418\ (G\text{-}1)\ d\left(\frac{3T+70}{100}\right)(G-1)\ (for\ d\ lies\ between\ 0.1\ mm\ and\ 1mm)$$

Where

V_s = Settling velocity in m/sec

d = diameter of the particle in m

G = Specific gravity of the particle

$$= \frac{\rho_s}{\rho_w} = \frac{Density\ of\ particle}{Density\ of\ water}$$

υ = Kinematic viscosity of water in $m^2/\sec$

T = Temperature of water in ${}^0C$

Coagulation and Flocculation

- ☒ Colloidal particles are difficult to separate from water because they do not settle by gravity and are so small that they pass through the pores of filtration media.
- ☒ To be removed, the individual colloids must aggregate and grow in size.
- ☒ The aggregation of colloidal particles can be considered as involving two separate and distinct steps:

- ☒ Particle transport to effect inter particle collision.
- ☒ Particle destabilization to permit attachment when contact occurs.

☒ Transport step is known as ***flocculation*** whereas ***coagulation*** is the overall process involving destabilization and transport

Flocculation

- Flocculation is stimulation by mechanical means to destabilised particles into compact, fast settleable particles (or flocs).
- Flocculation or gentle agitation results from velocity differences or gradients in the coagulated water, which causes the fine moving, destabilized particles to come into contact and become large, readily settleable flocs.
- It is a common practice to provide an initial rapid (or) flash mix for the dispersal of the coagulant or other chemicals into the water.
- Slow mixing is then done, during which the growth of the floc takes place.

Flash Mixing

- ***Rapid or Flash mixing*** is the process by which a coagulant is rapidly and uniformly dispersed through the mass of water.
- This process usually occurs in a small basin immediately preceding or at the head of the coagulation basin.
- Generally, the detention period is 30 to 60 seconds and the head loss is 20 to 60 cms of water.
- Here colloids are destabilised and the nucleus for the floc is formed.

Slow mixing brings the contacts between the finely divided destabilised matter formed during rapid mixing.

Perikinetic and Orthokinetic Flocculation

- The flocculation process can be broadly classified into two types, perikinetic and orthokinetic.
- **Perikinetic flocculation** refers to flocculation (contact or collisions of colloidal particles) due to Brownian motion of colloidal particles. The random motion of colloidal particles results from their rapid and random bombardment by the molecules of the fluid.

- Orthokinetic flocculation refers to contacts or collisions of colloidal particles resulting from bulk fluid motion, such as stirring. In systems of stirring, the velocity of the fluid varies both spatially (from point to point) and temporally (from time to time). The spatial changes in velocity are identified by a velocity gradient, G. G is estimated as G=(P/hV)1/2, where P=Power, V=channel volume, and h= Absolute viscosity.

CONSTITUENTS OF A COAGULATION TANK

1. **Feeding device**
2. **Mixing Device or Mixing Basin**
3. **Flocculation Tank or Flocculators**
4. **Settling or Sedimentation Tank**

Feeding device

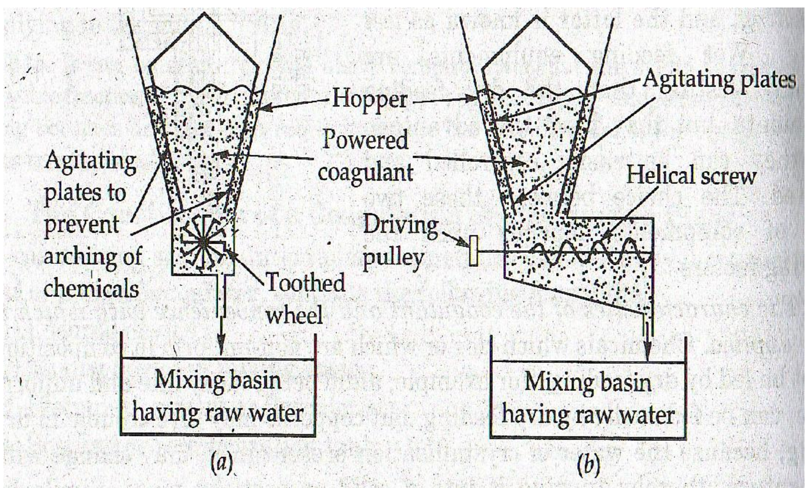


Fig. 9.20. Dry feeders.

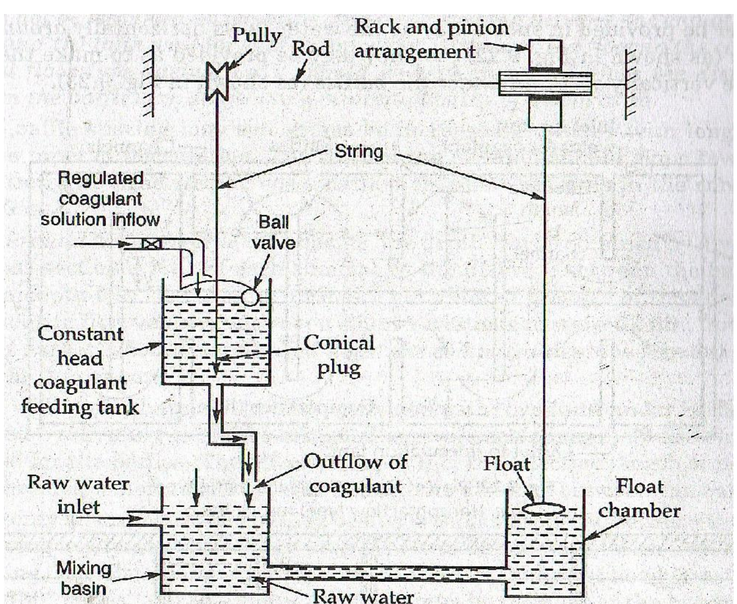


Fig. 9.21. Wet feeding by Conical plug and float arrangement.

Mixing Basin equipped with mechanical devices

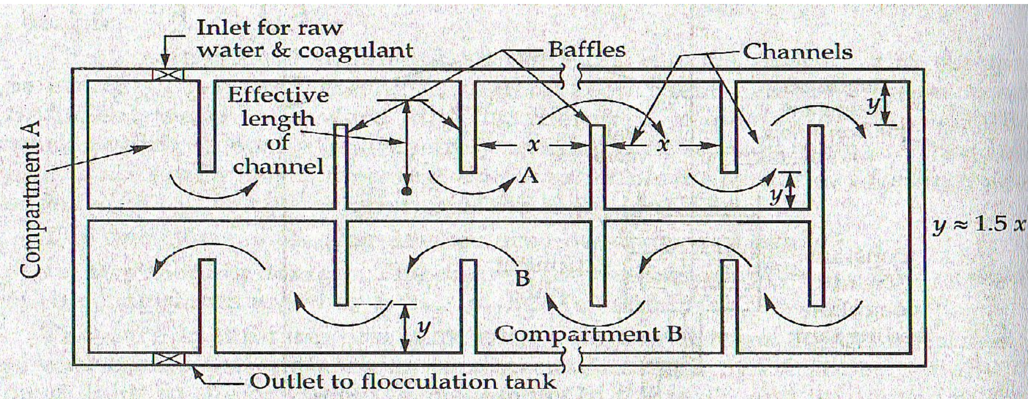


Fig. 9.22. Plan of "Around the end baffle type"
(*i.e.* Horizontal flow type) mixing basin.

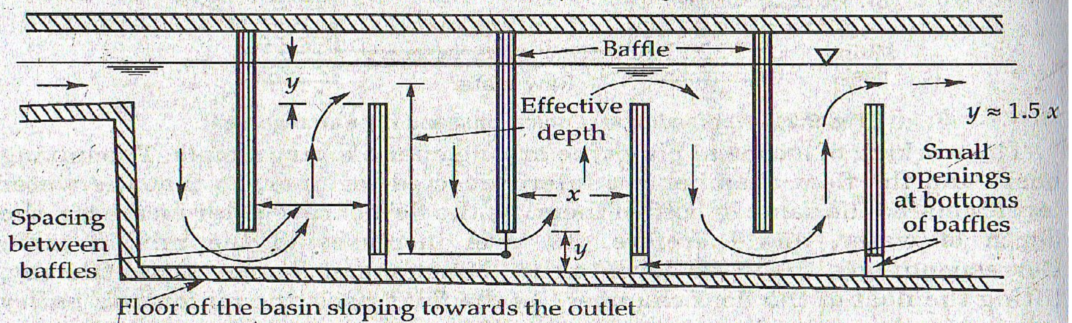


Fig. 9.23. Sectional elevation of "Over and under the baffle type"
(vertical flow type) mixing basin.

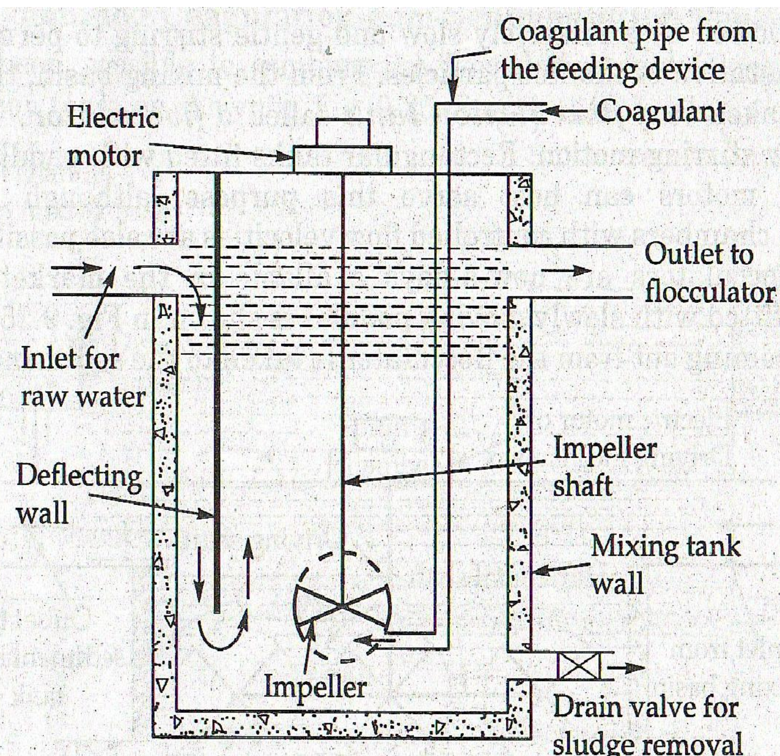


Fig. 9.24. Mixing basin with a flash mixer.

Flocculation Tank or Flocculators

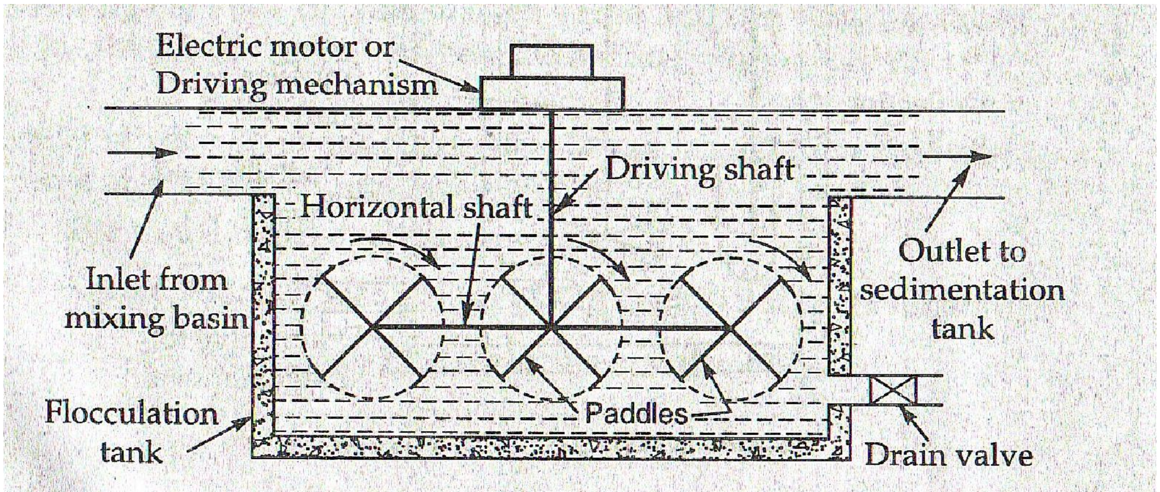


Fig. 9.25. (*a*) A typical Flocculator fitted with paddles.

Combined Coagulation cum Sedimentation Tank

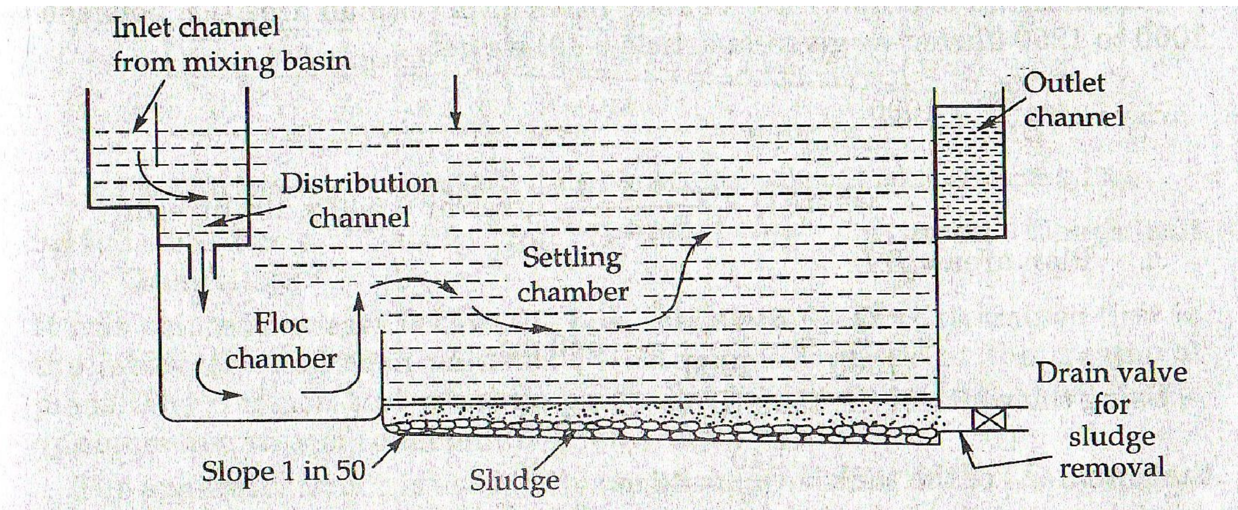


Fig. 9.26. Coagulation-Sedimentation tank.

COAGULANTS

- The various chemical used for secondary sedimentation in the water treatment units are called coagulants.
- These coagulants are most effective when the water is slightly alkaline.

1. **Use of ALUMN as Coagulant**

ALUMN is the name given for Aluminium sulphate with (Al2SO4)3.18H2O

$$Al_2(SO_4)_3.18H_2O + 3Ca(HCO_3)_2 \rightarrow 3CaSO_4 + 2Al(OH)_3 \downarrow + 6CO_2 \uparrow$$

2. **Use of COPPERAS as Coagulants**

Copperas is the name given to ferrous Sulphate with its chemical formula FeSO4.7H2O

$$i)\ FeSO_4.7H_2O + Ca(OH)_2 \rightarrow CaSO_4 + Fe(OH)_2 + 7H_2O$$

$$ii)\ Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3 \downarrow$$

3. **Use of Chlorinated COPPERAS as Coagulants**

When chlorine is added to solution of copperas the two react chemically so as to form ferric sulphate and ferric chloride.

$$i)\ 6FeSO_4.7H_2O + 3Cl_2 \rightarrow 2Fe_2(SO_4)_3 + 2FeCl_3 + 42H_2O$$

$$ii)\ Fe_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 3CaSO_4 + 2Fe(OH)_3 \downarrow$$

Comparison of Alumn &Iron Salts

1. Iron Salts produce heavy floc and can therefore remove much more suspended matters than Alumn
2. Iron Salts being good oxidizing agents can remove hydrogen sulphide and its corresponding taste and odour from water.
3. Iron salts can be used over a wider range of pH value.
4. Iron salts cause staining and promote the growth of iron bacteria in the distribution system.
5. Iron salts imparts more corrosiveness to water than that which is imparted by Alumn.
6. Iron salts are used as coagulants in treating sewage and Alumn is used as coagulants in treating drinking water.

Jar Test

- The jar test is a common laboratory procedure used to determine the optimum operating conditions for water or wastewater treatment.
- This method allows adjustments in pH, variations in coagulant or polymer dose, alternating mixing speeds, or testing of different coagulant or polymer types, on a

small scale in order to predict the functioning of a large scale treatment operation.

- The jar testing apparatus consists of six paddles which stir the contents of six 1 liter containers.
- One container acts as a control while the operating conditions can be varied among the remaining five containers.
- A rpm gage at the top-center of the device allows for the uniform control of the mixing speed in all of the containers.

Design – Problem

- ❖ Design a coagulation-cum-sedimentation tank with continuous flow for a population of 60,000 persons with a daily percapita water allowance of 120 litres. Make suitable arrangements wherever needed.

1.*Design of Settling Tank*

Average daily consumption

$$= \textit{Population X Per capita demand}$$

$$= 60000\, X\, 120$$

$$= 7.2\, X\, 10^6\, \textit{litres}$$

Assuming that the Max. daily demand as 1.8 times the average daily demand

The maximum daily demand $= 1.8\ \text{X}\ (7.2\ \text{X}\ 10^{6})$litres

$= 12.96\ \text{X}\ 10^{6}$ litres

Quantity of water to be treated during an assumed detention period of 4 hours

The capacity of tank required $= \dfrac{12.96\ \text{X}\ 10^{6}}{24}\text{X4}$

$$= 2.16\,\text{X}\,10^6\ \textit{litres}$$

$$= 2.16\,\text{X}\,10^3\ \text{m}^3$$

Assuming the flow rate as 1000 litres/hr/m^2 of plan area

(ie. between 1000 to 1250 litres/hr/m^2)

$$\frac{\text{Q}}{\text{B.L}} = 1000$$

$$\textit{where}\ \text{Q} = \frac{2.16\text{X}\,10^6}{4} = 540\,X10^3\,\textit{litre / hour}$$

$$B.L =$$

Plan area is 540 m^2

Assu min *g* the width as (B) 12 m

The length will be =

Hence use a tank of 45 m X 12 m X 4 m .

Provide extra depth of 0.5 m for sludge removal at the starting end and ($\frac{45}{50} = 1.4$m) at the downstreem side.

Use a free board of 0.5 m above the water level

2.*Design* of Floc Chamber

In addition to 45 m length of the settling tank the floc chambers at the entry has to be provided. Assume that the effective dept in the floc chamber as half of the depth in the tank near the floc chamber. ie 2.25 m.

Assume the period of flocculation or detention period as 20 min. (ie. between 15 to 40 mins)

Now the capacity of each chamber

$$= \frac{12.96 \text{ X } 10^3}{24} X \frac{20}{60}$$

$$= 180 \text{ cu. m}$$

$$\text{The plan area required} = \frac{\text{Capacity}}{Depth}$$

$$= \frac{180}{2.25} = 80 m^2$$

Using the same width (ie 12 m) then the length as 6.7m

The details and dimensions are shown in Fig. 9.27.

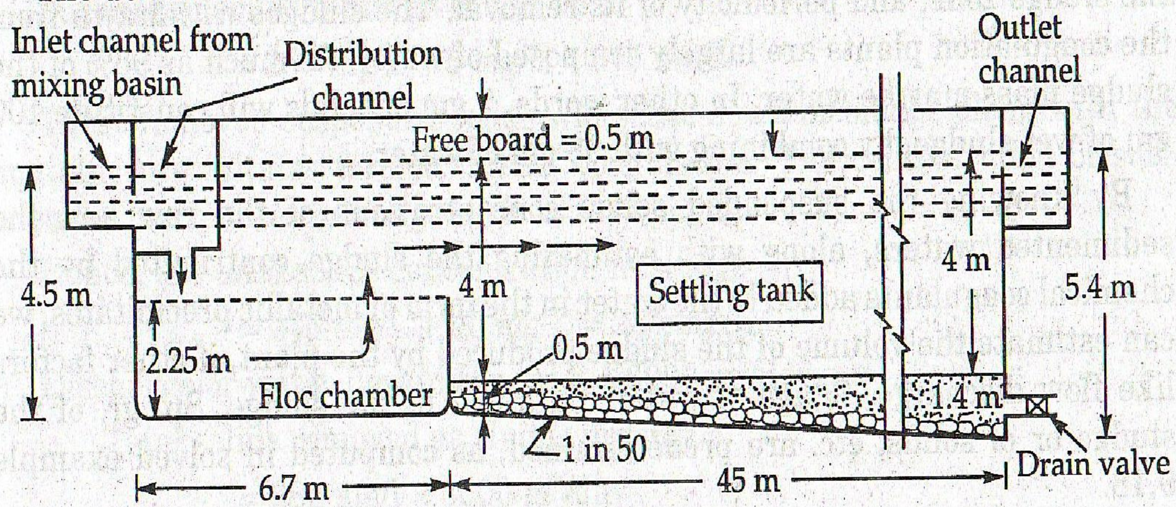


Fig. 9.27. Dimensions of the Coagulation-cum-Sedimentation tank in example 9.17.

Filtration Mechanisms

There are four basic filtration mechanisms:

1. ***SEDIMENTATION* :** The mechanism of sedimentation is due to force of gravity and the associate settling velocity of the particle, which causes it to cross the streamlines and reach the collector.
2. ***INTERCEPTION* :** Interception of particles is common for large particles. If a large enough particle follows the streamline, that lies very close to the media surface it will hit the media grain and be captured.
3. ***BROWNIAN DIFFUSION* :** Diffusion towards media granules occurs for very small particles, such as viruses. Particles move randomly about within the fluid, due to thermal gradients. This mechanism is only important for particles with diameters < 1 micron.
4. ***INERTIA* :** Attachment by inertia occurs when larger particles move fast enough to travel off their streamlines and bump into media grains.

THEORY OF FILTERATION

1. **Mechanical Straining**
2. **Flocculation & Sedimentation**
3. **Biological metabolism**
4. **Electrolytic Change**

FILTER MATERIALS

- ***Sand:*** Sand, either fine or coarse, is generally used as filter media.
- The size of the sand is measured and expressed by the term called effective size. *The <u>effective size</u>*, i.e. D10 may be defined as the size of the sieve in mm through which ten percent of the sample of sand by weight will pass.
- The uniformity in size or degree of variations in sizes of particles is measured and expressed by the term called *<u>uniformity coefficient</u>*. The uniformity coefficient, i.e. (D60/D10) may be defined as the ratio of the sieve size in mm

through which 60 percent of the sample of sand will pass, to the effective size of the sand.

❖ ***Gravel:*** The layers of sand may be supported on gravel, which permits the filtered water to move freely to the under drains, and allows the wash water to move uniformly upwards.

❖ ***Other materials:*** Instead of using sand, sometimes, anthrafilt is used as filter media. Anthrafilt is made from anthracite, which is a type of coal-stone that burns without smoke or flames. It is cheaper and has been able to give a high rate of filtration.

TYPES OF FILTER

1. Slow sand filter
2. Rapid Sand Filter
3. Gravity Filter

Slow sand filter

- They consist of fine sand, supported by gravel. They capture particles near the surface of the bed and are usually cleaned by scraping away the top layer of sand that contains the particles.
- **Various parts**

1. **Enclosure tank:**

It consists of an open water tight rectangular tank, made of masonry or concrete. The bed slope is kept at about 1 in 100 towards the central drain. The depth of the tank varies from 2.5 to 3.5m.

2. **Filter media**

The filtering media consists of sand layers about 90 to 110 cm depth and placed over a gravel support. The effective size D10 of the sand varies from 0.2 to 0.4 and the uniformity co-efficient D60/D10 varies from 1.8 to 2.5 or 3.0. The top 15 cm layer of this sand is generally kept of finer than that of rest

3. **Base Material**

The base material is gravel, and it supports the sand. It consists of 30 to 75 cm thick gravel of different size placed in three to four layers each of 15-20 cm depth.

4. **Under Drainage System**

The gravel support is laid on the top of an under drainage system. The under drainage system consists of a central drain and lateral drains placed 3 to 5 m apart on the bottom and sloping towards the main covered central drain.

The lateral collects the filtered water and discharges it into the main drain which leads the water to the filtered water well.

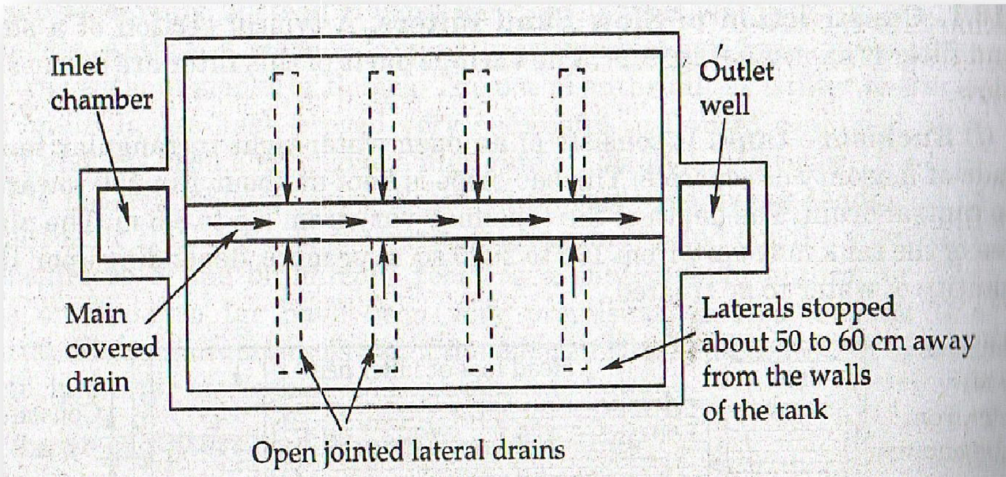


Fig. 9.30. Plan of under drainage system for slow sand filter.

Inlet and Outlet arrangement

An inlet chamber is constructed for admitting the effluent from the plain sedimentation tank without disturbing the sand layers of the filter and to distribute it uniformly over the filter bed. A filtered water well is to collect the filtered water coming out from the main under drain, for this an adjustable telescopic tube is required.

Other Appurtenances

1. Vertical air pipe
2. A gauge
3. Filtering head

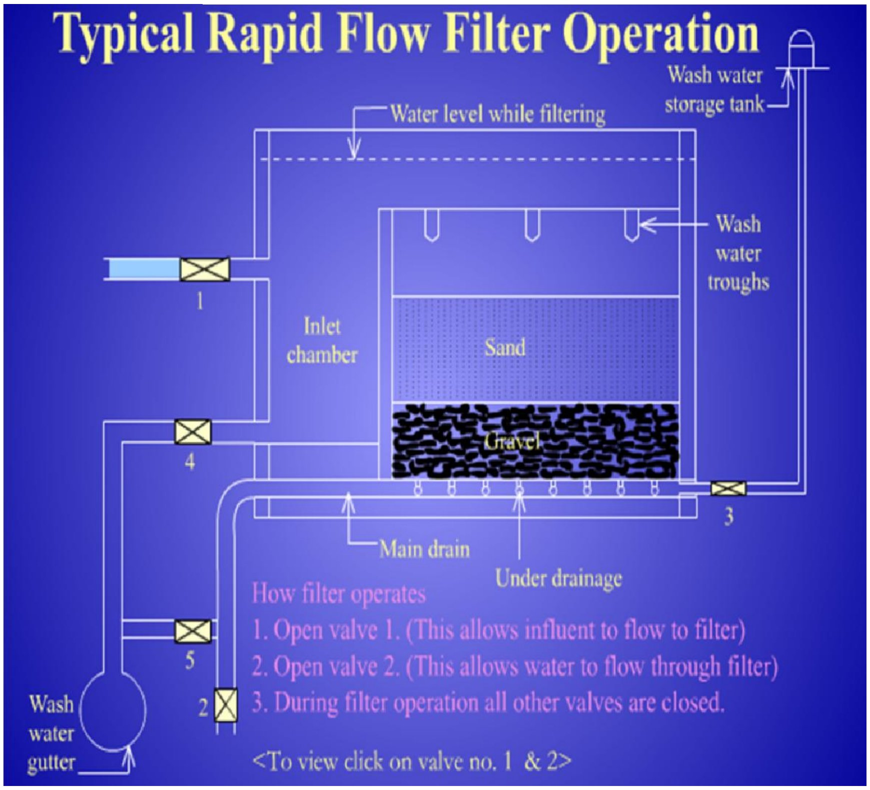
Operation of Slow Sand Filter

The treated water from the sedimentation tank is allowed to enter the inlet chamber of the filter unit and get distributed uniformly over the filter bed. The water percolates through the filter media and gets purified during the process of filtration.It gets collected in the laterals through the open joints which discharges into the main drain.

Cleaning of Slow Sand Filter

It is done by scrapping and removing the 1.5 to 3 cm of top sand layer. The top surface is raked roughened cleaned and washed good water. The amount of wash water required is 0.2 to 0.6 percent of the total water. A lot of manual labour is needed for cleaning and also small quantity of wash water is required.

RAPID SAND FILTER



Types

1.Rapid Gravity Filters

2.Pressure Filters

RAPID GRAVITY FILTER

These filters may yield as high as 30 times the yield given by slow sand filter. Water from coagulation sedimentation tank is used in these filter and filtered water is treated with disinfectant so as to obtain whole sum water.

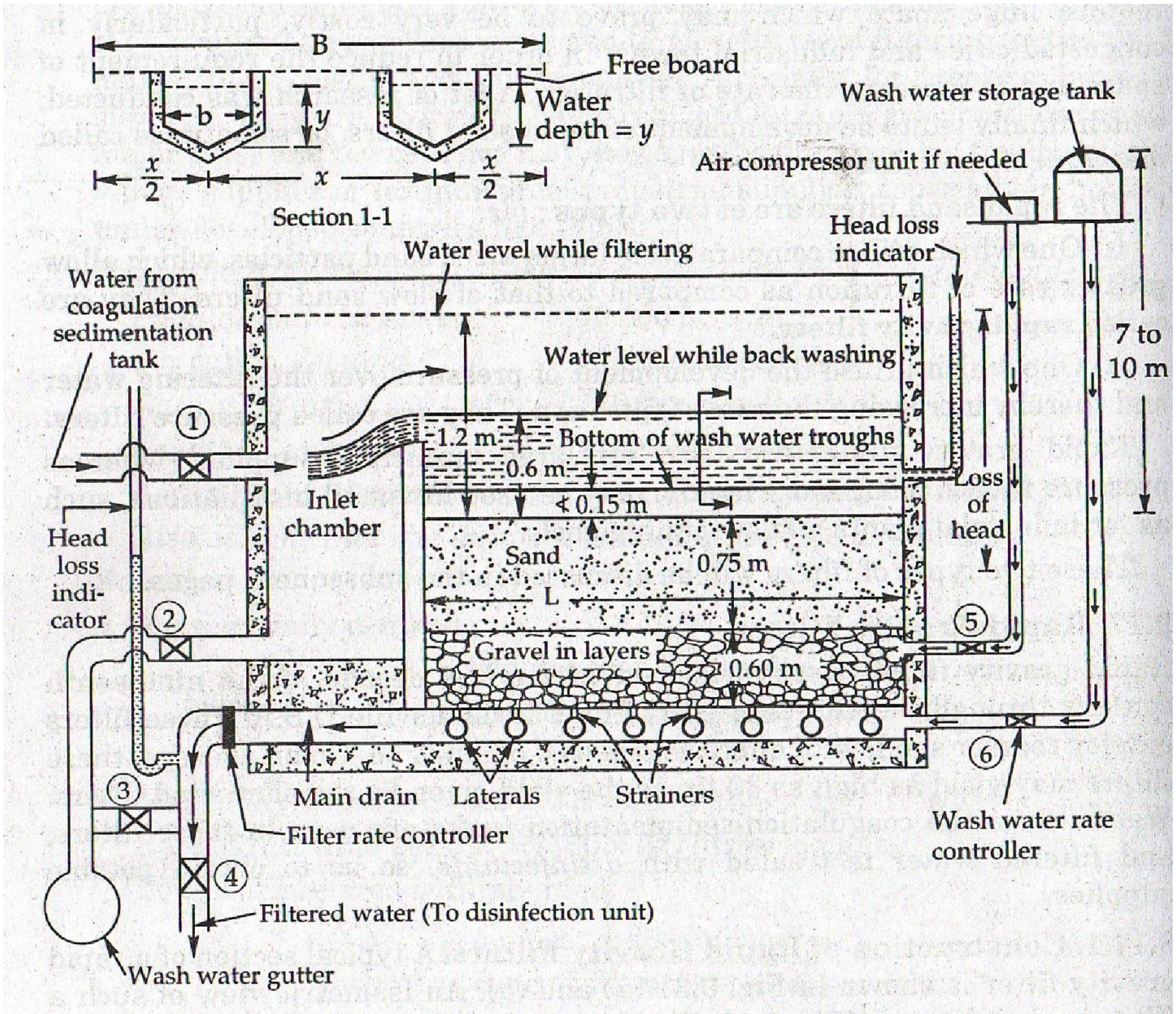


Fig. 9.31(a). Typical section of a Rapid Gravity filter.

CONSTRUCTION OF RAPID SAND FILTER

1. Enclosure Tank

It consists of an open water tight rectangular tank, made of masonry or concrete. The bed slope is kept at about 1 in 100 towards the central drain. The depth of the tank varies from 2.5 to 3.5m.

2. Filter media

The filtering media consists of sand layers about 60 to 90 cm depth and placed over a gravel support. The effective size D10 of the sand varies from 0.3 to 0.55 and the uniformity co-efficient D60/D10 varies from 1.3 to 1.7.

3. Base Material

The base material is gravel, and it supports the sand. It consists of 90 to 60 cm thick gravel of different size placed in three to four layers each of 10-15 cm depth.

4. Under Drainage System

1. To receive and collect the filtered water.
2. To allow the back washing for clean water

The gravel support is laid on the top of an under drainage system. There are three systems. They are

1. Manifold and lateral System
2. The wheeler bottom
3. The porous plate bottom.

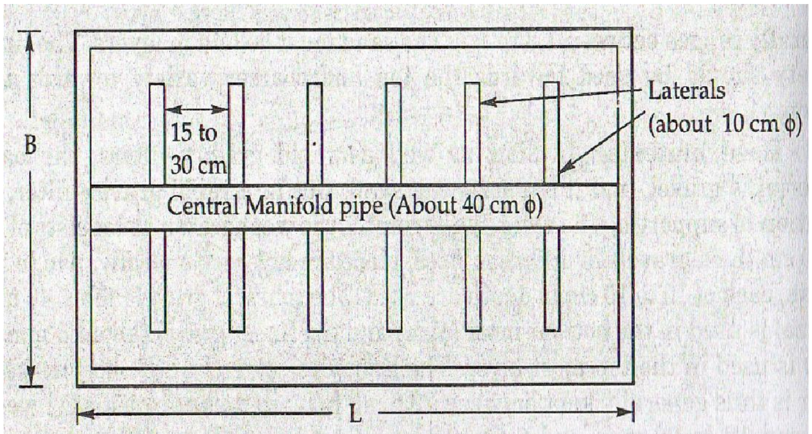


Fig. 9.33. Plan of a 'manifold and lateral' under drainage

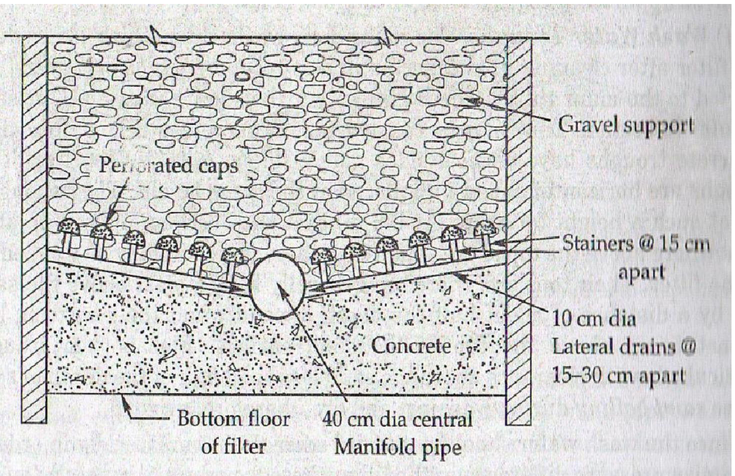


Fig. 9.35. Section of the 'manifold and lateral' system, in which laterals are provided with strainers.

Backwashing of Rapid Sand Filter

- For a filter to operate efficiently, it must be cleaned before the next filter run.
- Treated water from storage is used for the backwash cycle. This treated water is generally taken from elevated storage tanks or pumped in from the clear well.
- The filter backwash rate has to be great enough to expand and agitate the filter media and suspend the floc in the water for removal.
- However, if the filter backwash rate is too high, media will be washed from the filter into the troughs and out of the filter.

When is Backwashing Needed ?

- The filter should be backwashed when the following conditions have been met:
- The head loss is so high that the filter no longer produces water at the desired rate; and/or
- Floc starts to break through the filter and the turbidity in the filter effluent increases; and/or
- A filter run reaches a given hour of operation.

Operational Troubles in Rapid Gravity Filters

1. ***Air Binding :***

- When the filter is newly commissioned, the loss of head of water percolating through the filter is generally very small.
- However, the loss of head goes on increasing as more and more impurities get trapped into it.
- A stage is finally reached when the frictional resistance offered by the filter media exceeds the static head of water above the and bed. Most of this resistance is offered by the top 10 to 15 cm sand layer.
- The bottom sand acts like a vacuum, and water is sucked through the filter media rather than getting filtered through it.
- The negative pressure so developed, tends to release the dissolved air and other gases present in water.

- The formation of bubbles takes place which stick to the sand grains. This phenomenon is known as Air Binding as the air binds the filter and stops its functioning.
- To avoid such troubles, the filters are cleaned as soon as the head loss exceeds the optimum allowable value.

2. *Formation of Mud Balls :*

- The mud from the atmosphere usually accumulates on the sand surface to form a dense mat.
- During inadequate washing this mud may sink down into the sand bed and stick to the sand grains and other arrested impurities, thereby forming mud balls.

3. *Cracking of Filters :*

- The fine sand contained in the top layers of the filter bed shrinks and causes the development of shrinkage cracks in the sand bed.
- With the use of filter, the loss of head and, therefore, pressure on the sand bed goes on increasing, which further goes on widening these cracks.

Remedial Measures to Prevent Cracking of Filters and Formation of Mud Balls

- Breaking the top fine mud layer with rakes and washing off the particles.
- Washing the filter with a solution of caustic soda.
- Removing, cleaning and replacing the damaged filter sand.

SLOW SAND FILTER Vs RAPID SAND FILTER

Sl. No	Criteria	Slow Sand Filter	Rapid Sand Filter
1	Base material	varies from 3 to 65 mm in size and 30 to 75 cm in depth	3 to 40 mm in size and its depth is slightly more, i.e. about 60 to 90 cm

2	Filter sand	the effective size ranges between 0.2 to 0.4 mm and uniformity coefficient between 1.8 to 2.5 or 3.0.	the effective size ranges between 0.35 to 0.55 and uniformity coefficient between 1.2 to 1.8.
3	Rate of filtration	it is small, such as 100 to 200 L/h/sq.m. of filter area	it is large, such as 3000 to 6000 L/h/sq.m. of filter area.
4	Flexibility	SSF are not flexible for meeting variation in demand	RSF are quite flexible for meeting reasonable variations in demand.
5	Post treatment required	Almost pure water is obtained from SSF. However, water may be disinfected slightly to make it completely safe.	Disinfection is a must after RSF.
6	Method of cleaning	Scrapping and removing of the top 1.5 to 3 cm thick layer is done to clean SSF.	To clean RSF, sand is agitated and backwashed with or without compressed air.
7	Loss of head	SSF approx. 10 cm is the initial loss, and 0.8 to 1.2m is the final limit when cleaning is required	RSF 0.3m is the initial loss, and 2.5 to 3.5m is the final limit when cleaning is required.

PRESSURE FILTERS

- Pressure filters are just like gravity filters placed in closed vessels and through which water to be treated is passed under pressure.
- The pressure developed may vary between 30 to 70 m head.

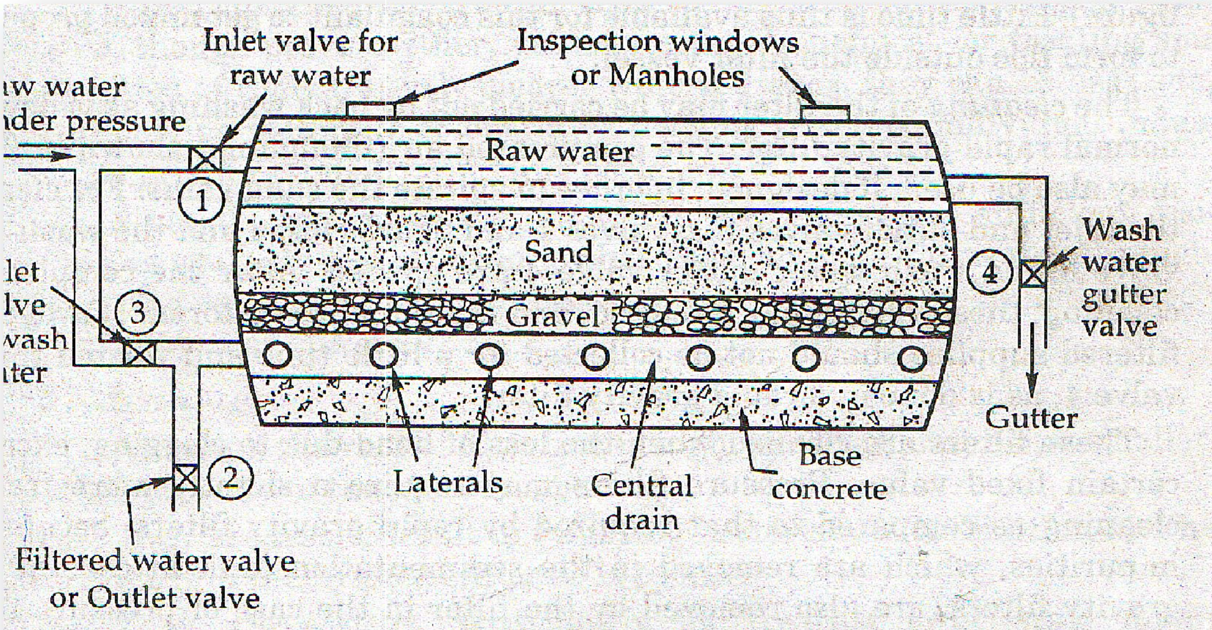


Fig. 9.40. (*a*) Horizontal pressure filter.

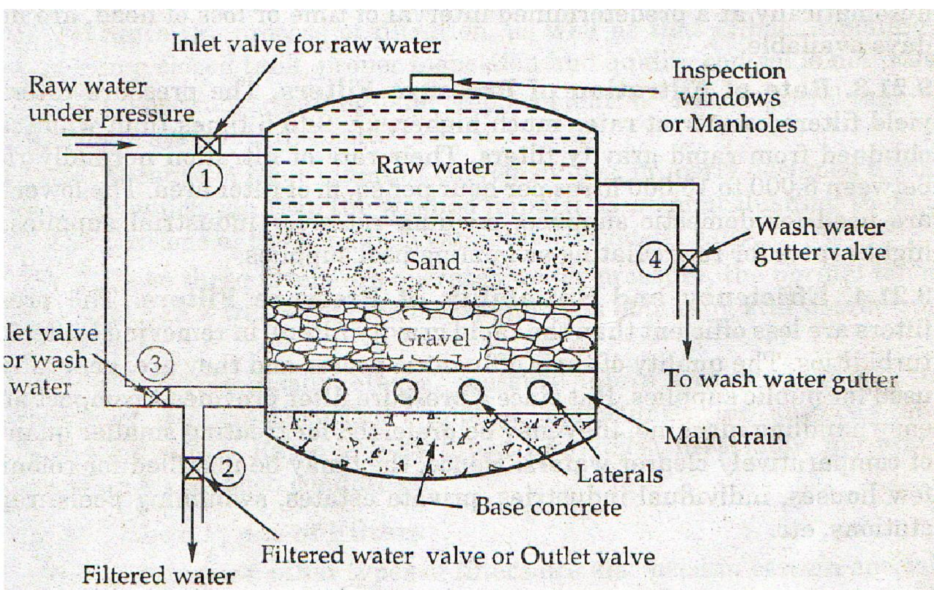


Fig. 9.40. (*b*) Vertical pressure filter.

CONSTRUCTION OF PRESSURE FILTER

1. Horizontal Pressure filter
2. Vertical Pressure filter

Steel cylinders are used as pressure vessels and may be riveted or welded. Their diameters generally vary between 1.5 to 3 m and their length and heights may be varying from 3.5 to 8 m. Inspection windows are provided at the top for inspection purposes.

WORKING AND OPERATION

Same as in the case of rapid gravity filter.

RATE OF FILTERATION

2 to 5 times higher than the rapid gravity filter.

EFFICIENCY

Less efficient that rapid gravity filters.

ADVANTAGES

1. A pressure filter is a compact machine and can be handled easily.
2. Lesser space and lesser filtering material but higher yield.
3. They are more flexible
4. Economical when treating smaller quantity of water.
5. Re pumping is not required.

DISADVANTAGES

1. Overall capacity is small
2. Lesser efficient in removing bacteria and turbidity
3. They are costlier
4. While cleaning proper inspection and quality control is not possible
5. Replacement of sand, gravel and under drainage system is difficult.

DISINFECTION OR STERILISATION

The filtered water may normally contain some harmful disease producing bacteria in it. These bacteria must be killed in order to make the water safe for drinking. The process of killing these bacteria is known as Disinfection or Sterilization.

Minor Methods of Disinfection

1. Boiling of Water
2. Treatment with Excess lime
3. Treatment with Ozone
4. Treatment with iodine and Bromine
5. Treatment with ultra violet rays
6. Treatment with potassium permanganate
7. Treatment with Silver called Electro katadyn process

Boiling:

The bacteria present in water can be destroyed by boiling it for a long time. However it is not practically possible to boil huge amounts of water. Moreover it cannot take care of future possible contaminations.

Treatment with Excess Lime:

Lime is used in water treatment plant for softening. But if excess lime is added to the water, it can in addition, kill the bacteria also. Lime when added raises the pH value o water making it extremely alkaline. This extreme alkalinity has been found detrimental to the survival of bacteria. This method needs the removal of excess lime from the water before it can be supplied to the general public. Treatment like re carbonation for lime removal should be used after disinfection.

3. **Treatment with Ozone:** Ozone readily breaks down into normal oxygen, and releases nascent oxygen. The nascent oxygen is a powerful oxidising agent and removes the organic matter as well as the bacteria from the water.

$$3O_2 \rightarrow 2O_3$$

$$\text{Due to instability}$$

$$O_3 \rightarrow O_2 + O$$

$$O \rightarrow \text{Nascent Oxygen}$$

Advantages of using OZONE:

1. It becomes unstable nothing remains in water by the time it reaches the distributing system
2. Ozone removes the colour, taste and odour from water in addition to removing the bacteria from it.
3. The ozonised water becomes tasty and pleasant unlike the chlorinated water which becomes bitter to tongue.

Treatment with Iodine and bromine

Addition of iodine and bromine to water can help in killing the pathogenic bacteria. The quantity of these disinfectant may be limited to about 8ppm and a contact period of 5 minutes.

- **Treatment with Ultra Violet rays**

UV rays are the invisible light rays having wave length of 1000 to 4000 milli micron. These rays are highly effective in killing all types of bacteria thus yielding a truly sterilised water. It is very costly. This method is also used to treat the swimming pool water.

- **Treatment with potassium permanganate**

Potassium permanganate is used as a popular disinfectant for well water in villages which are generally less contaminated with bacteria. It is also used for removing colour and iron from water. The normal dose varies between 1 to 2 mg/l with the contact period of 4 to 6 hours.

- **Treatment with Silver or Electro – Katadyn Process**

In this method metallic silver ions are introduced into water by passing through a tube containing solid silver electrodes which are connected to a DC supply of 1.5 Volts.

The recommended silver dose may vary between 0.05 to 1.00 mg/l and the contact period of 15 minutes to 3 hours.

CHLORINATION

Chlorine in its various forms invariably and almost universally used for disinfecting public water supplies.It is cheap, reliable,easy to handle, easily measurable, and above all capable of providing residual effects for longer period .

The disadvantage is that when used in greater amount it imparts bitter taste to the water.

Chlorine Chemistry

- The germicidal action of chlorine is explained by the recent theory of *Enzymatic hypothesis*, according to which the chlorine enters the cell walls of bacteria and kill the enzymes which are essential for the metabolic processes of living organisms.
- Chlorine is added to the water supply in two ways. It is most often added as a gas, Cl2(g). However, it also can be added as a salt, such as sodium hypochlorite (NaOCl) or bleach. Chlorine gas dissolves in water Once dissolved, the following reaction occurs forming hypochlorous acid (HOCl)

$$Cl_2 + H_2O \xrightarrow{pH>5} \underset{Hypochlorous\ acid}{HOCl} + HCl$$

Hypochlorous acid is a weak acid that dissociates to form hypochlorite ion (OCl-).

$$HOCl \underset{pH<7}{\overset{pH>8}{\Longleftrightarrow}} H^+ + OCl^-$$

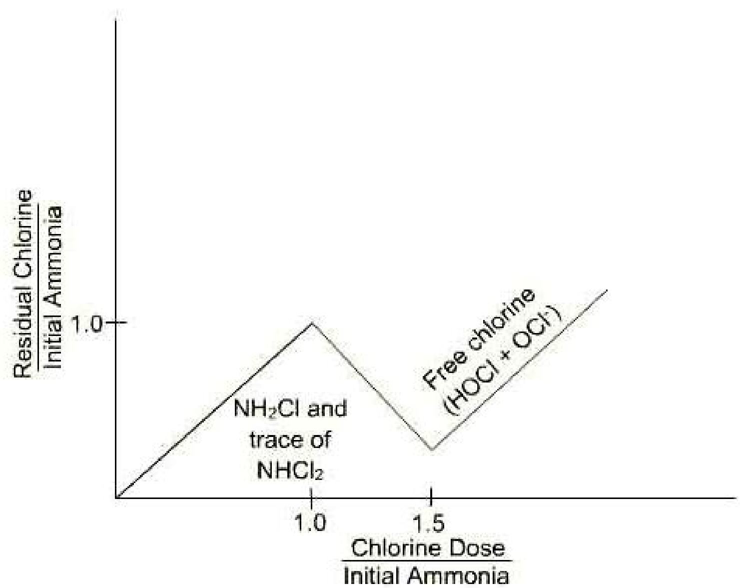
$$Hydogenion\,s \quad Hypochlori\,teions$$

- Hypochlorous acid and hypochlorite ion compose what is called the free chlorine residual.
- These free chlorine compounds can react with many organic and inorganic compounds to form chlorinated compounds.
- If the products of these reactions posses oxidizing potential, they are considered the combined chlorine residual.

- A common compound in drinking water systems that reacts with chlorine to form combined residual is ammonia.
- Reactions between ammonia and chlorine form chloramines, which is mainly monochloramine (NH2Cl), although some dichloramine (NHCl2) and trichloramine (NCl3) also can form. Many drinking water utilities use monochloramine as a disinfectant.
- If excess free chlorine exits once all ammonia nitrogen has been converted to monochloramine, chloramine species are oxidized through what is termed the breakpoint reactions.

Breakpoint Chlorination

When excess free chlorine is added beyond the 1:1 initial molar ratio, monochloramine is removed.The formation of chloramines and the breakpoint reaction create a unique relationship between chlorine dose and the amount and form of chlorine as illustrated below.



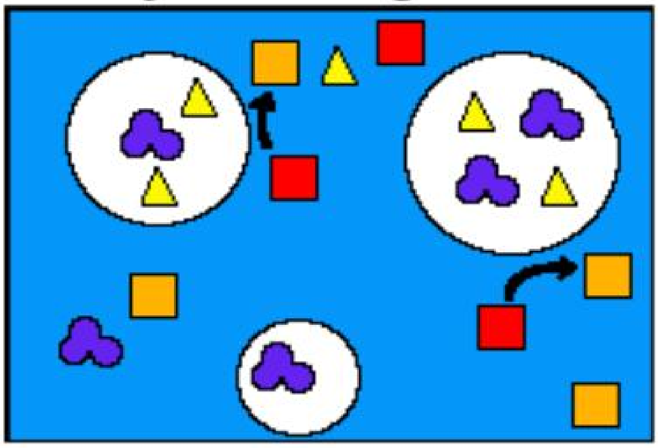
- Various forms of Chlorine

1. In the form of liquid chlorine or as chlorine gas
2. In the form of hypochlorites or bleaching powder
3. In the form of chloramines (mixture of chlorine and ammonia)
4. In the form of chlorine tablet
5. In the form of chlorine di oxide

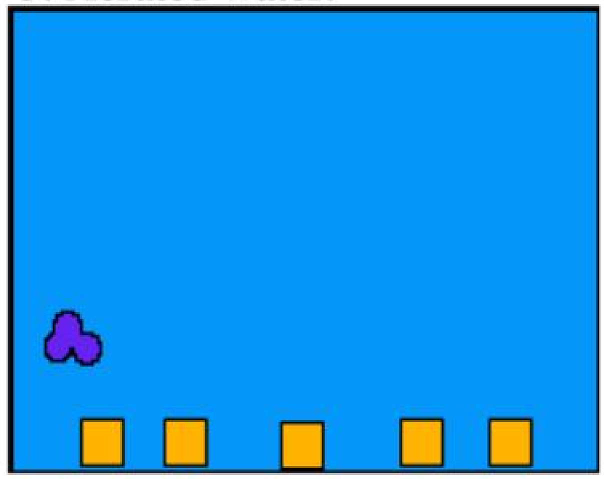
UNIT – 4. ADVANCED WATER TREATMENT

Principles and functions of Aeration -Iron and manganese removal, Defluoridation and demineralization -Water softening -Desalination -Membrane Systems -Recent advances

2. Air passes through the water:



3. Aerated water:



Aeration Process

- Aeration removes or modifies the constituents of water using two methods - scrubbing action and oxidation.
- Scrubbing action is caused by turbulence which results when the water and air mix together.
- The scrubbing action physically removes gases from solution in the water, allowing them to escape into the surrounding air.
- In the picture above, carbon dioxide and hydrogen sulfide are shown being removed by scrubbing action.
- Scrubbing action will remove tastes and odors from water if the problem is caused by relatively volatile gases and organic compounds.
- Oxidation is the other process through which aeration purifies water.
- Oxidation is the addition of oxygen, the removal of hydrogen, or the removal of electrons from an element or compound. When air is mixed with water, some impurities in the water, such as iron and manganese, become oxidized.
- Once oxidized, these chemicals fall out of solution and become suspended in the water.
- The suspended material can then be removed later in the treatment process through filtration.

Efficiency

- The efficiency of the aeration process depends almost entirely on the amount of surface contact between the air and water.
- This contact is controlled primarily by the size of the water droplet or air bubble.
- The goal of an aerator is to increase the surface area of water coming in contact with air so that more air can react with the water.

As air or water is broken up into smaller drops/bubbles or into thin sheets, the same volume of either substance has a larger surface area

Problems with Aeration

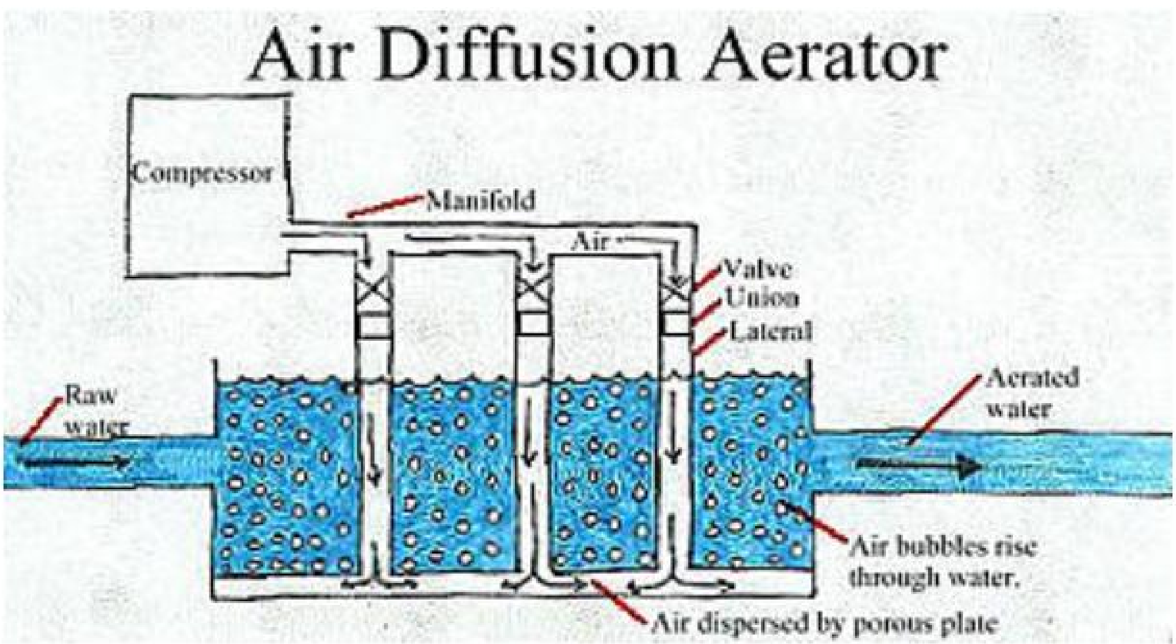
- Aeration typically raises the **dissolved oxyge**n content of the raw water. In most cases, this is beneficial since a greater concentration of dissolved oxygen in the water can remove a flat taste.
- However, too much oxygen in the water can cause a variety of problems resulting from the water becoming supersaturated. Supersaturated water can **cause corrosion** (the gradual decomposition of metal surfaces) and sedimentation problems.
- In addition, air binding occurs when excess oxygen comes out of solution in the filter, resulting in **air bubbles** which harm both the filtration and backwash process.
- Aeration can also cause other problems unrelated to the supersaturated water. Aeration can be a very energy-intensive treatment method which can result in **over use of energy.**
- In addition, aeration of water can promote **algai growth** in the water and can clog filters.

Methods of Aeration

- There are several different methods used to aerate water, but all either involve passing water through air or air through water.
- Water can be exposed to air by spraying or by distributing it in such a way that small particles or thin sheets of water come in contact with the air.
- Water can also by aerated by pumping large volumes of air through the water.
- In general, pumping water through air is much more energy efficient than pumping air through water.

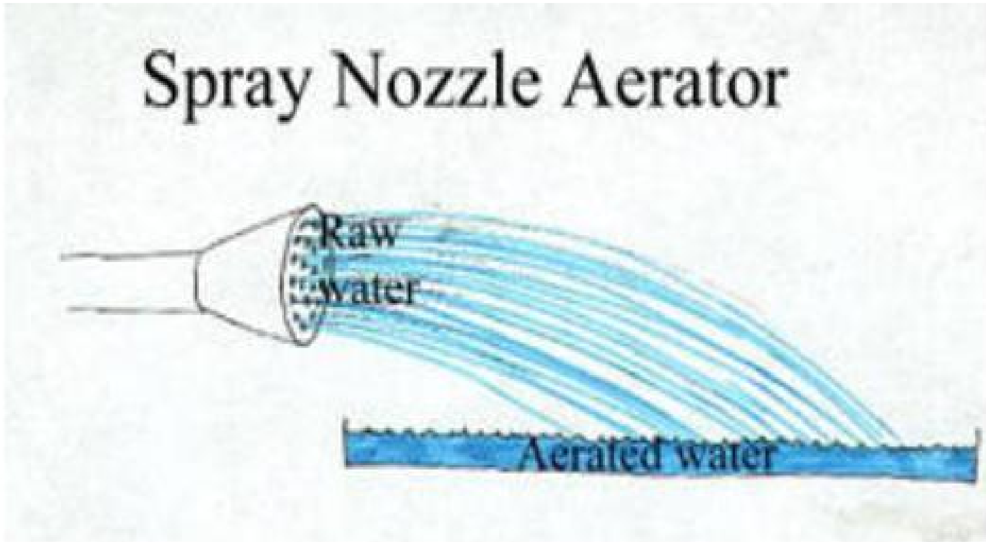
Types of Aerators

Air diffusion Aerator



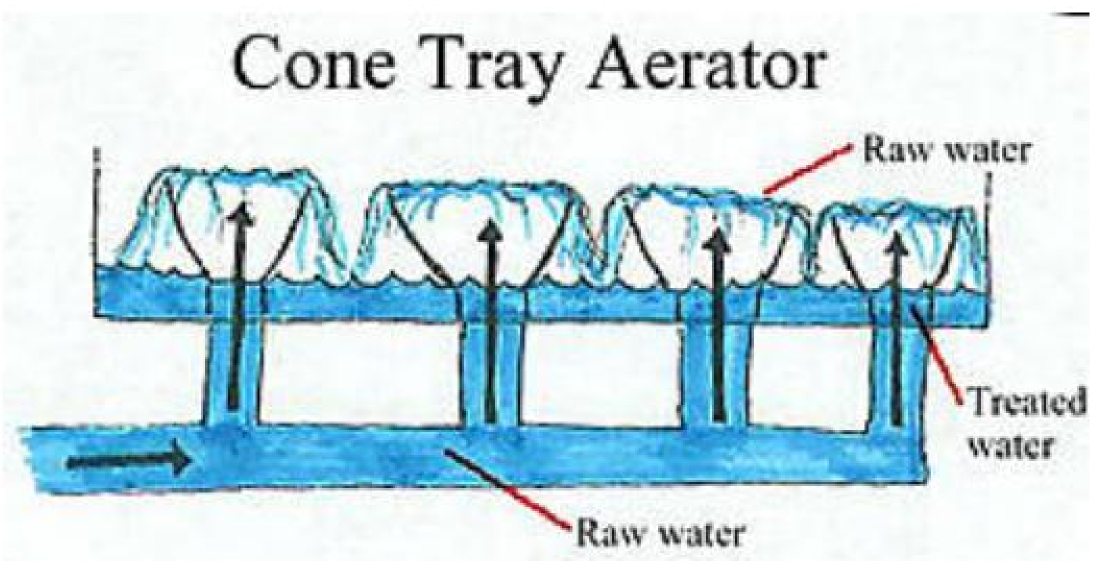
- **Air diffusion** is a type of aerator in which air is blown through a trough of water.
- As water runs through the trough, compressed air is blown upward through porous plates on the bottom.
- This method is not very efficient due to limited air transfer.

Spray nozzle aerators



- Most of the other aeration methods work by passing raw water through air in small streams rather than by passing air through water.
- A few, such as **spray nozzle aerators**, pump water through nozzles breaking the water into a fine spray.

Cone tray aerators

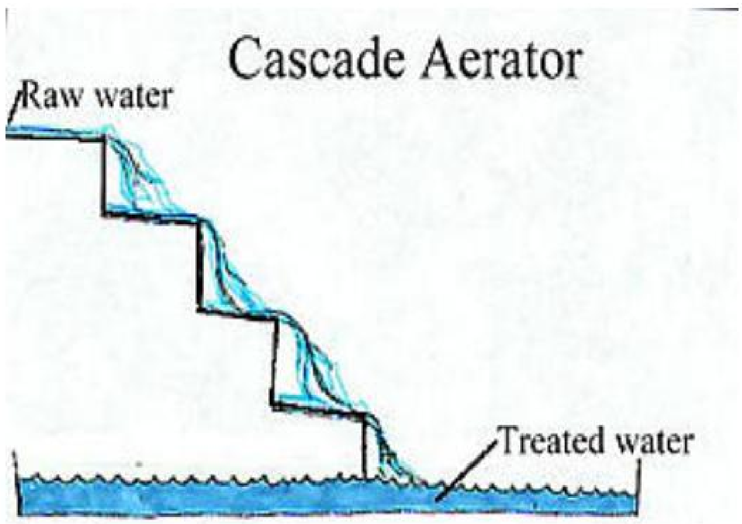


- **Cone tray aerators and cascade aerators** both work by forming little waterfalls.

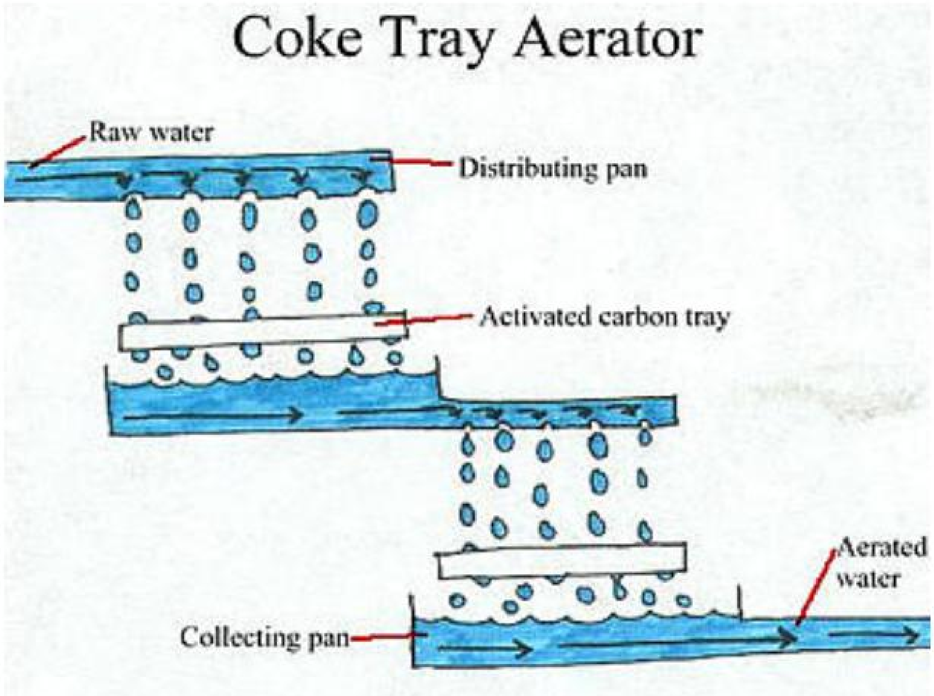
- The cone tray aerator, shown below, consists of several cones in which water flows through the cone and over the rim of the cone. Cone aerators are primarily used to oxidize iron.

Cascade aerators

- **Cascade aerators** allow water to flow in a thin layer down steps. In both the case of the cone tray aerator and the cascade aerator, the waterfalls allow the water to come in contact with air.

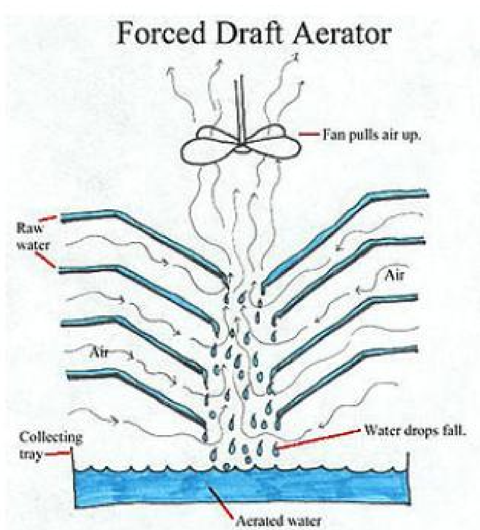


Coke tray aerators



- **Coke tray aerators** also pass water through air in small streams. A coke tray aerator is comprised of a series of activated carbon trays, one above another, with a distributing pan above the top tray and a collecting pan below the bottom tray.
- The distributing pan breaks the water up into small streams or drops. The holes in the trays should be designed to develop some head loss to provide for equal distribution to the lower tray

Forced draft aerator



- The last type of aerator which we will discuss here, the **forced draft aerator**, combines both methods: it blows air through water which has been broken into fine streams. The forced draft aerator consists of a series of trays over which raw water runs.
- As the water comes to the end of each tray, it cascades off and falls down to the collecting tray (also known as a drip pan).
- At the same time, a fan at the top of the aerator pulls air up through the water.
- So, as small streams of water fall from the trays, they comes in intimate contact with the strong updraft of air. This type of aerator is most effective in the reduction of hydrogen sulfide and carbon dioxide.

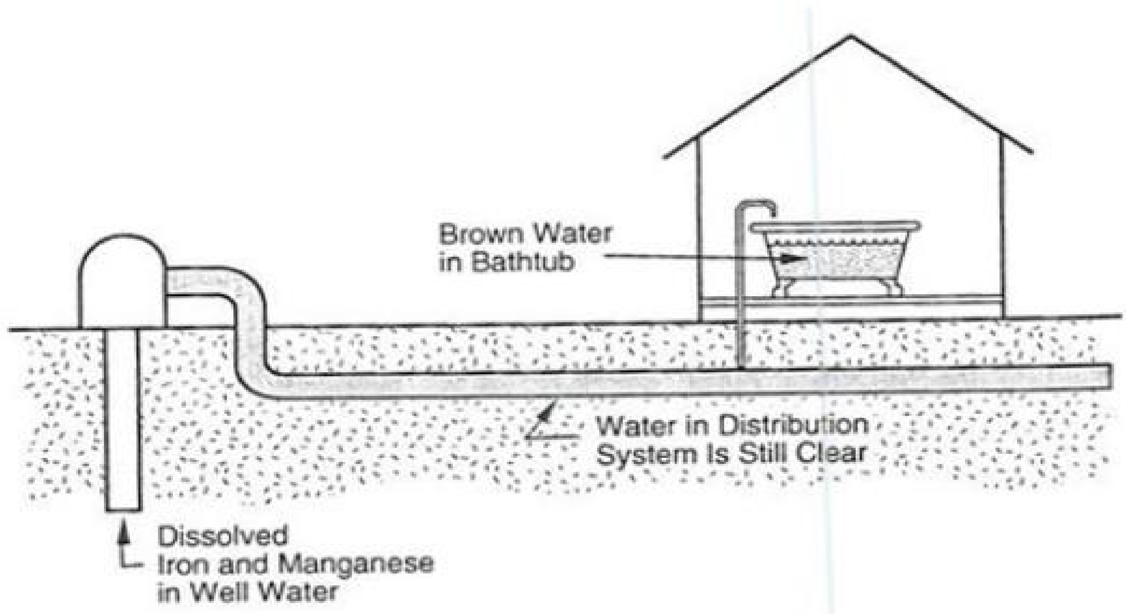
Iron and Manganese Removal

- Iron and manganese are often present in ground waters and surface waters. Iron is more prevalent in ground waters.
- Manganese is present only occasionally, and then usually together with iron.
- Iron and manganese may also be present in surface waters, usually as organic complexes.
- Excessive iron and manganese can result in aesthetic and operational problems.

Aesthetic Problems

- Iron and manganese in raw water are generally in the soluble, reduced, divalent state.
- The water is clear, and the substances are not noticeable except that they can cause a taste or odor effect at high concentrations.
- When they are oxidized, iron and manganese change and discolor the water from turbid yellow to black, depending on their concentration and the presence or absence of other contaminants.

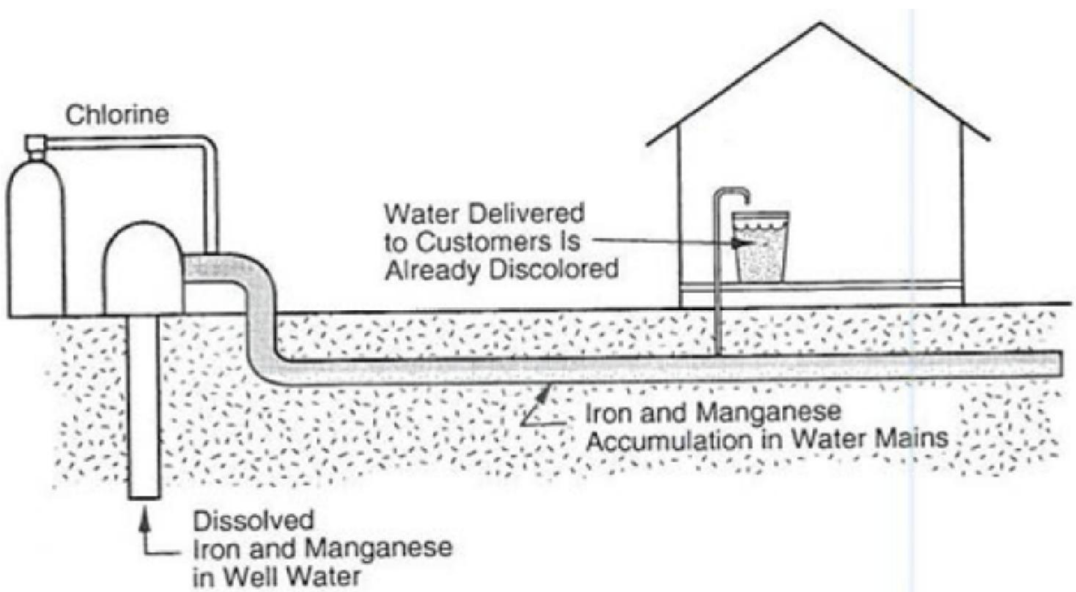
- When a groundwater system pumps water directly from wells to the distribution system and uses no disinfection or other treatment, dissolved iron in the water usually first becomes oxidized when it is exposed to the oxygen in air.
- After a customer fills a glass, bathtub, or washing machine with water, the iron gradually oxidizes and changes color. This not only makes the water unpalatable for consumption, but it also stains porcelain fixtures and discolors laundry.



- The presence of iron or manganese in the distribution system often provide a food source for bacterial growth.
- The bacterial slimes contribute to aesthetically offensive tastes and odors.
- The presence of manganese is a problem for industries that incorporate water into their product because it will react with other chemicals to form undesirable tastes, odors, or colors.
- Manganese also tends to accumulate, corrode, and clog industrial fixtures.
- The maximum desirable level of manganese is 0.05 mg/L, and the point at which it creates an undesirable taste is about 5 mg/L.

Operational Problems

- The presence of iron in a water distribution system may also be caused by corrosion of metal pipes in the system.
- In this case, the problem must be corrected by corrosion control.
- If a disinfectant is added to the water, or if iron and manganese are fully or partially oxidized by any means before entering the distribution system, the oxidized iron and manganese will precipitate in the distribution system.



- Much of the precipitate could settle out in the mains. The worst problems will usually be in dead-end mains, where velocity is the lowest. If the iron and manganese problem in the system is not very serious, sometimes only the customers on dead ends will continually have a problem with rusty water.
- Sudden demands for extra water, such as the opening of a fire hydrant, may disrupt the normal flow in the system. The sediment that has accumulated on the bottom of mains will then be put back into suspension. Parts of the system, or even the whole system, will then have rusty water for a few hours or even a couple of days.

- The presence of iron and manganese in the distribution system, in either the dissolved or oxidized state, can also provide a food source for bacterial growth in the system. The bacterial slimes that form can have the following detrimental effects:
- Reduction in pipeline flow capacity
- Clogging of meters and valves
- Further discoloration of the water as a result of the bacterial growth & Increased chlorine demand

Iron and Manganese Indicators

- In wells the oxygen content is low and the iron and manganese bearing water is colorless and clear, meaning the iron and manganese is dissolved.
- Your water from your tap may look clear but after it is exposed to air the iron and manganese become oxidized and change from being colorless, dissolved form to colored and solid form.
- The color and the flavor of food and water are affected by iron and manganese. These elements can react with the tannins that are found in coffee and tea and can produce a black sludge. In water, when present, manganese is objectionable in smaller amounts than iron.
- Another problem with iron in a water supply is the reddish-brown staining on laundry, glassware dishes and utensils.

Treatment Methods

1. Phosphate compounds
2. Ion exchange water softeners
3. Oxidizing filters
4. Aeration (pressure type) followed by filtration

5. Chemical oxidation followed by filtration

1. Phosphate compounds

- In phosphate treatment, low levels of dissolved iron and manganese at the combined concentrations up to 3 mg/l can be eliminated by using phosphate compound treatment.
- The phosphate chemicals are a group of chemicals that can surround minerals and keep them in the solution.
- When this compound is injected into the water system, it stabilizes and disperses dissolved iron at this level, resulting in the iron and manganese not being able to react with the oxygen and separate the solution.
- Phosphate compounds must be introduced into the water at a point where the iron is still dissolved to help maintain the waters clarity and to prevent the possibility of iron staining.
- This form or treatment is inexpensive and a good way to treat water for low levels of iron and manganese. Since this treatment does not actually remove the iron, the water that was treated will still have a metallic taste. If too much phosphate compounds are used, the water will have a slippery feel.

2. Ion exchange

- In ion exchange water softener, low to mid levels of dissolved iron, at less than 5 mg/l concentrations, may be removed by using ion exchange water softener.
- The same principle that is used to remove hardness minerals, calcium and manganese, the iron in the untreated water is exchanged with sodium on the ion exchange medium.
- The process adds sodium to the resin and the iron is carried away in the wastewater. The softening capacity of the unit is reduced since iron is being removed and the softener will require recharging more often.

- One health concern with using a water softener is they add sodium to the water and can cause a concern for individuals that are on a sodium restricted diet.
- One way to help reduce the risk is to install a separate water faucet that provides non-softened water for drinking and cooking.

3. Oxidizing Filter Treatment

- The oxidizing filter treatment system is used for moderate levels of dissolved iron and manganese at combined concentrations that range up to 15 mg/l.
- The filter material, usually greensand or manufactured zeolite that is coated with manganese oxide, which absorbs the dissolved iron and manganese.
- The synthetic zeolite requires less backwashing of the water and softens the water as it removes the iron and manganese.
- This type of system must be selected and operated based on the amount of dissolved oxygen.
- The amount of dissolved oxygen content can be determined by some water treatment companies, a laboratory or using a field test kit.

4. Aeration followed by Filtration

- In this process, high levels of dissolved iron and manganese at combined concentrations up to 25 mg/l can be oxidized to a solid form by aeration (mixing with air). In domestic water processing, the pressure-type aerator is often used.
- In this system, the air is sucked in and mixed with the passing stream of water. The air saturated water then enters the precipitator or aerator vessel where air then separates from the water.
- From here, the water flows through a filter where various filter media are used to screen out oxidized particles of iron, manganese, some carbonate or sulfate.

- Periodic backwashing of the filter is the most important maintenance step involved with using this process. Manganese oxidation is slower than for iron and requires greater quantities of oxygen.

- Water containing organic complexes of iron and manganese or iron and manganese bacteria, aeration is not recommended because they will clog the aspirator and filter.

5. Chemical Oxidation followed by Filtration

- In water with high levels of dissolved or oxidized iron and manganese greater than 10 mg/l can be treated by chemical oxidation, use of an oxidizing chemical, like chlorine, followed by a sand trap filter to remove the precipitated material.

- Iron and manganese can also be oxidized from the dissolved to solid form by adding potassium permanganate or hydrogen peroxide to the untreated water. This type of treatment is considered valuable when there is a combination of iron and organic matter or iron bacteria present.

- In the process, the oxidizing chemical is put into the water by a small feed pump that operates when the well is in operation.

- This can be done in the well but is usually done just before the water enters the storage tank.

- A 20 minute retention time is required to allow oxidation to take place. The solids that result must be filtered. If large concentrations of iron are present, a flushing sand filter may be needed in the filtering process.

6. Manganese Greensand Filters

- Manganese greensand filters use a special type of medium that removes iron and manganese by a combination of both adsorption and oxidation. In the process, permanganate is added ahead of the greensand filter to allow the grains of the medium to become coated with oxidation products.

- The oxidized greensand then adsorbs the dissolved iron and manganese from the water, after which the substances are oxidized with permanganate and removed by the filtering action of the filter bed. A potassium permanganate backwash is used to regenerate the bed, or permanganate is fed continuously in a small dose.
- Greensand grains are somewhat smaller than silica sand, so the head loss can quickly become excessive under a heavy loading.
- The length of filter runs can be increased by adding a layer of anthracite above the greensand.

Eliminating Plumbing Corrosion

- The cause for reddish-brown particles in water, when drawn from the tap but settle out as the water stands, may be caused by corroded pipes and equipment.
- This indicates that oxidized iron, and in some occurrences it may only be iron corrosion particles.
- To help solve the problem, raise the water's pH and use a sediment filter.

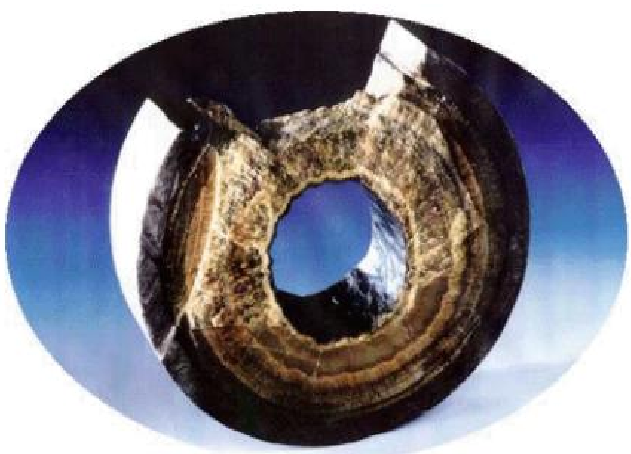
Softening

- Softening is the removal of hardness from water. This is not a required part of the water treatment process since hard water does not have any health consequences.

What is Hard Water?

- Hard water is usually defined as water which contains a high concentration of calcium and magnesium ions. Measurements of hardness are given in terms of the calcium carbonate equivalent, which is an expression of the concentration of hardness ions in water in terms of their equivalent value of calcium carbonate.
- Water is considered to be hard if it has a hardness of 100 mg/L or more as calcium carbonate.

- Hard water makes soap precipitate out of water and form a scum, such as the ring which forms around bathtubs.
- In addition to being unsightly, the reaction of hard water with soap results in excessive use of soaps and detergents.
- Hard water may also cause taste problems in drinking water and may shorten the life of fabrics washed in hard water.
- Excessively hard water will nearly always have to be softened in order to protect the water treatment plant equipment and piping systems.
- At a hardness of greater than 300 mg/L as calcium carbonate, scale will form on pipes as calcium carbonate precipitates out of the water. The scaling can damage equipment and should be avoided.



Calcium carbonate scale on a piece of pipe.

Types of Hardness

- The type of anion found in these salts distinguishes between the two types of hardness - carbonate and non carbonate hardness.

Carbonate hardness compounds	Noncarbonate hardness compounds
Calcium carbonate ($CaCO_3$)	Calcium sulfate ($CaSO_4$)
Magnesium carbonate ($MgCO_3$)	Magnesium sulfate ($MgSO_4$)
Calcium bicarbonate ($Ca(HCO_3)_2$)	Calcium chloride ($CaCl_2$)
Magnesium bicarbonate ($Mg(HCO_3)_2$)	Magnesium chloride ($MgCl_2$
Calcium hydroxide ($Ca(OH)_2$)	
Magnesium hydroxide ($Mg(OH)_2$)	

Temporary & Permanent Hardness

- Carbonate hardness is sometimes called temporary hardness because it can be removed by boiling water. Non carbonate hardness cannot be broken down by boiling the water, so it is also known as permanent hardness.
- In general, it is important to distinguish between the two types of hardness because the removal method differs for the two.
- When measuring hardness, we typically consider total hardness which is the sum of all hardness compounds in water, expressed as a calcium carbonate equivalent.
- Total hardness includes both temporary and permanent hardness caused by calcium and magnesium compounds.

Hardness Problems

- Carbonate hardness is the most common and is responsible for the deposition of calcium carbonate scale in pipes and equipment.
- Calcium bicarbonate → Calcium carbonate + Water + Carbon dioxide

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$$

In contrast, non carbonate hardness is the culprit in forming soap cum.

- Non carbonate hardness reacts with the carbonate alkalinity found in soap and detergents in this reaction:

Calcium sulfate + Sodium carbonate → Calcium carbonate + Sodium sulfate

$$CaSO_4 + NaCO_3 \rightarrow CaCO_3 + Na_2SO_4$$

Softening Processes

- Chemical Precipitation
- Ion Exchange or zeolite softening
- Reverse-osmosis softening
- Electro dialysis
- Distillation
- Freezing

Chemical Precipitation or Lime Softening

- Softening through chemical precipitation is similar to removal of turbidity by coagulation, flocculation, and sedimentation.
- There are many variations, but the typical process involves adding lime to raise the pH of water until it is high enough for reactions to occur which prompt hardness compounds to settle out of the water.
- The equipment used also resembles turbidity removal equipment - lime is added in the flash mixer, the water is flocculated, and then the hardness compounds precipitate out in the sedimentation basin.
- Chemical precipitation using lime will remove carbonate hardness.

- If soda ash is added as well as lime, both carbonate and non carbonate hardness may be removed. In either case, chemical precipitation does not remove all hardness from water.

- The hardness can be reduced as low as 30 to 40 mg/L using chemical precipitation.

Disadvantages

- Chemical precipitation is an effective softening process, but it does have some disadvantages.

- The process requires a lot of operator control to get an efficient result, which may make lime softening too operator-intensive for small treatment plants.

- The high pH used in lime softening can set colors in water and make them difficult to remove.

- Finally, lime softening produces large quantities of sludge which can create disposal problems.

Ion Exchange

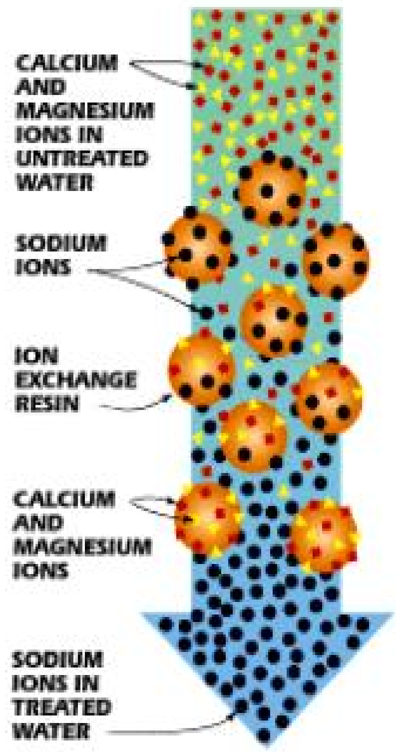
- Ion exchange softening, also known as zeolite softening, passes water through a filter containing resin granules.

- In the filter, known as a softener, calcium and magnesium in the water are exchanged for sodium from the resin granules.

- The resulting water has a hardness of 0 mg/L and must be mixed with hard water to prevent softness problems in the distributed water.

- Ion exchange softening does not require the flash mixer, flocculation basin, and sedimentation basin required for lime-soda ash softening. In addition, the process does not require as much operator time.

- Ion exchange softening is effective at removing both carbonate and non carbonate hardness and is often used for waters high in non carbonate hardness and with a total hardness less than 350 mg/L.



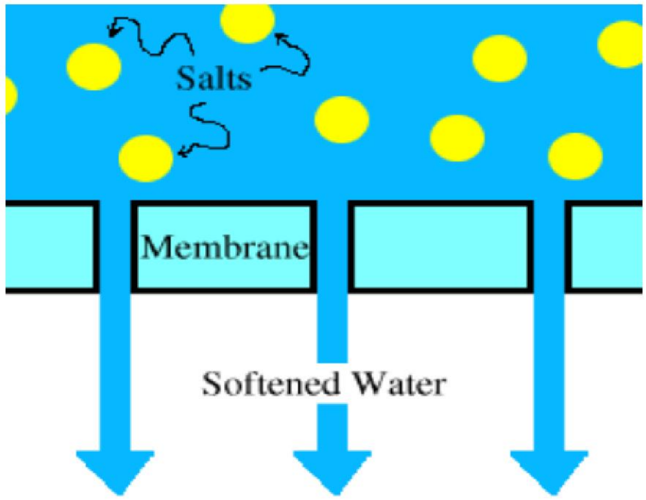
Disadvantages

- However, ion exchange softening has its disadvantages as well.
- The calcium and magnesium in the hard water are replaced by sodium ions, which may cause problems for people with health problems who are not supposed to eat any salt.
- Softeners have to be backwashed in a manner similar to a filter, and the recharge water, known as brine, can cause disposal problems.

Reverse-osmosis softening

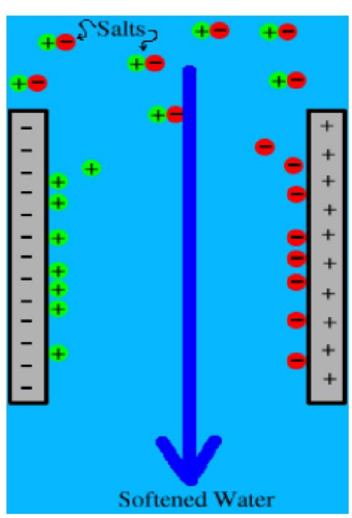
- Reverse-osmosis softening involves water being forced through a semi permeable membrane.

- Calcium, magnesium, and dissolved solids are captured while the softened water is passed through the membrane.



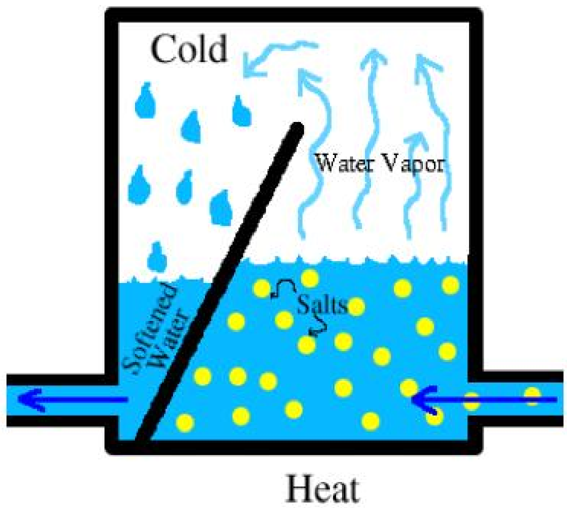
Electro dialysis

- Electro dialysis involves passing water between two plates with opposite electrical charges.
- The metals in the water are attracted to the plate with the negative charge while the non-metals are attracted to the plate with the positive charge.
- Both types of ions can be removed from the plates and discarded.
- Electro dialysis is used on very hard water, with a hardness of more than 500 mg/L as calcium carbonate.



Distillation

- Distillation involves the evaporation of water.
- The evaporated water leaves behind all hardness compounds, softening the water.



Freezing

- Freezing will also remove hardness.

Demineralization

- Demineralization is the removal of minerals and nitrate from the water.
- The three methods for the Demineralization are ion exchange, reverse osmosis and electro dialysis.
- These methods are widely used for water and wastewater treatment.
- Ion exchange is primarily used for the removal of hardness ions like magnesium and calcium and for water demineralization.
- Reverse osmosis and electro dialysis, which are both membrane processes, remove dissolved solids from water using membranes.

Ion Exchange

- The ion exchange units are used to remove any charged substance from the water but are mainly used to remove hardness and nitrate from groundwater.
- The water is pretreated to reduce the suspended solids and total dissolved solids load to ion-exchange unit.
- The methods used for pretreatment include:

1. Cold lime without soda ash
2. Hot lime with or without soda ash
3. Coagulation and filtration
4. Filtration
5. Evaporation or distillation
6. Reverse osmosis
7. Ultrafiltration

Advantages of Ion Exchange

- 1. Ion exchange can be used with fluctuating flow rates.
- 2. Makes effluent contamination impossible
- 3. Resins are available in large varieties from suppliers and each resin is effective in removing specific contaminant

Limitations of Ion Exchange

- 1. Pretreatment is required for most surface waters
- 2. Waste is highly concentrated and requires careful disposal
- 3. Unacceptable high levels of contamination in effluent

- 4. Units are sensitive to the other ions present.

Reverse Osmosis

- In a reverse osmosis system, the water is put under pressure and forced through a membrane that filters out the minerals and nitrate.
- These systems are compact and easy to operate and require minimal labor, which make them suitable for small systems and for systems where there is a high degree of seasonal fluctuation in water demand.
- When the units are operated properly, ninety-six percent removal rates will be attained.
- Reverse osmosis also affectively removes natural organic substances, pesticides, radium and microbiological contaminants. To work effectively, reverse osmosis should be used in series.

Near 0 effluent contaminant concentrations can be achieved by water passing through multiple units.

Advantages of Reverse Osmosis

1. Nearly all contaminant ions and most dissolved non-ions are removed
2. Suitable for small systems with a high degree of seasonal fluctuation in water demand.
3. Insensitive to flow and TDA levels
4. Operates immediately without any minimum break-in period
5. Possible low effluent concentrations
6. Removes bacteria and particles
7. Simplicity and automation operation allows for less operator attention which makes them suitable for small system applications.

Limitation of RO

1. High operating costs and capital
2. Potential problem with managing the wastewater brine solution
3. Pretreatment at high levels
4. Fouling of membranes

Electro dialysis

- Electro dialysis is effective in removing fluoride and nitrate from water.
- This process also uses membranes but direct electrical currents are used to attract ions to one side of the treatment chamber.
- This system includes a source of pressurized water, direct current power supply and a pair of selective membranes.

Advantages of Electro dialysis

1. All the contaminant ions and many of the dissolved non-ions are removed
2. Insensitive to flow and TDS levels
3. Possible low effluent concentrations

Limitations of Electro dialysis

1. Operating costs and capital are high
2. Level of pretreatment required is high
3. Twenty to ninety percent of feed flow is rejected stream
4. Replacement of electrodes

De-Fluoridation

Effects of Excessive Fluoride in Water

- Surface water normally contains only trace amounts of fluoride, groundwater often contains fluoride near the optimal level.
- Some wells have fluoride levels up to four or five times the optimal level.
- When children are exposed to excessive levels of fluoride, a condition known as fluorosis occurs.
- In its mildest form, fluorosis appears as very slight, opaque, whitish areas (called mottling) on the tooth surface. More severe fluorosis causes teeth to darken, turning from shades of gray to black.
- When the fluoride concentration is over 4 mg/L, teeth are likely to be pitted; they then become more susceptible to cavities and wear.

Studies have shown that fluorosis starts to occur when children younger than eight years old regularly drink water containing twice the optimal fluoride level for three months or longer

Ways to Remove Fluoride from Water

- Reverse Osmosis Filtration - This is used to purify several types of bottled water (not all), so some bottled waters are unfluoridated. Reverse osmosis systems are generally unaffordable for personal use.
- Activated Alumina Defluoridation Filter - These filters are used in locales where fluorosis is prevalent. They are relatively expensive and require frequent replacement, but do offer an option for home water filtration.
- Distillation Filtration - There are commercially available distillation filters that can be purchased to remove fluoride from water

Fluoride Treatment Method

The defluoridation methods are divided into three basic types depending upon the mode of action :

1. Based on some kind of chemical reaction with fluoride: Nalgonda technique, Lime...

2. Based on adsorption process: Bone charcoal, processed bone, tricalcium phosphate, activated carbons, activated magnesia, tamarind gel, serpentine, activated alumina, plant materials, burnt clay...

3. Based on ion-exchange process: Anion/Cation exchange resins

Filtration:

a. Reverse Osmosis Filtration

b. Activated Alumina Defluoridation Filter

c . Distillation Filtration

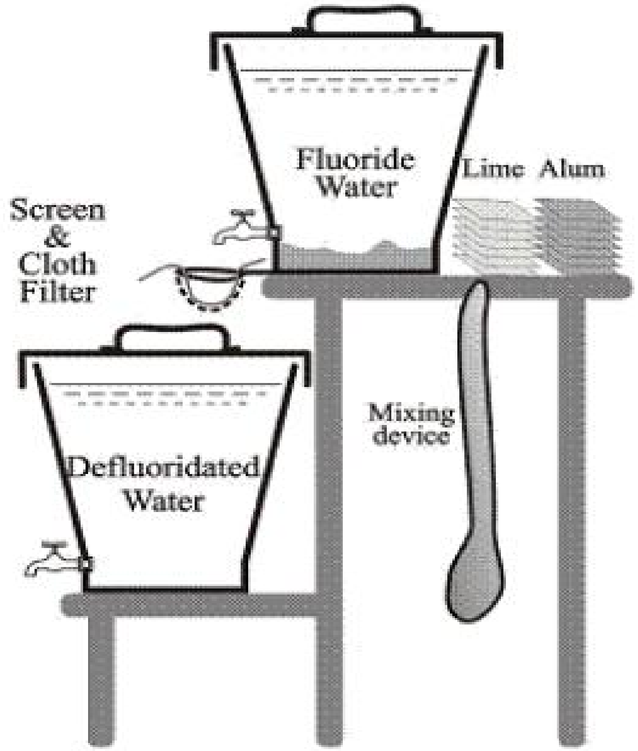
The Nalogonda technique

- The Nalogonda technique (named after the village in India where the method was pioneered) employs flocculation principle

- Nalgonda technique is a combination of several unit operations and the process involves rapid mixing, chemical interaction, flocculation, sedimentation, filtration, disinfection and sludge concentration to recover waters and aluminium salts.

- Alum (hydrated aluminium salts) - a coagulant commonly used for water treatment is used to flocculate fluoride ions in the water.

- Since the process is best carried out under alkaline conditions, lime is added. For the disinfection purpose bleaching powder is added. After thorough stirring, the chemical elements coagulate into flocs and settle down in the bottom.



The Nalgonda process as optimised for use in the Rift Valley.

The reaction occurs through the following equations

- 2 Al2 (SO4)3 . 18H2 O + NaF + 9Na2CO3 → [5Al(OH)3.Al(OH)2F] + 9Na2SO4+NaHCO3 + 8 CO2 + 45 H2O 3 Al2 (SO4)3 . 18H2 O + NaF +17NaHCO3 → [5Al(OH)3.Al(OH)2F] + 9Na2SO4+ 17 CO2 + 18 H2O

Salient features of Nalgonda technique

- No regeneration of media
- No handling of caustic acids and alkalis
- Readily available chemicals used in conventional municipal water treatment are only required
- Adaptable to domestic use
- Flexible up to several thousands m3 / d
- Higly efficient removal of fluorides from 1.5 to 20 mg/L to desirable levels

- Simultaneous removal of color, odor, turbidity, bacteria and organic contaminants
- Normally associated alkalinity ensures fluoride removal efficiency
- Sludge generated is convertible to alum for use elsewhere
- Little wastage of water and least disposal problem
- Needs minimum of mechanical and electrical equipment
- No energy except muscle power for domestic equipment
- Economical - annual cost of defluoridation (1991 basis) of water at 40 lpcd works out to Rs.20/- for domestic treatment and Rs.85/- for community
- treatment using fill and draw system based on 5000 population for water

Precipitation methods

- This method involving the addition in sequence, of an alkali, chlorine and aluminium sulphate or aluminium chloride or both was developed. It is cheap and is used extensively in India.
- Though lime softening accomplishes fluoride removal, its high initial cost, large dosage and alkaline pH of the treated water renders it unsuitable for field application.
- Large dosage and alkaline pH of the treated water renders it unsuitable for field application.

Activated alumina

- Activated alumina is a granular, highly porous material consisting essentially of aluminum trihydrate.
- It is widely used as a commercial desiccant and in many gas drying processes.
- An initial concentration of 5 mg/L was effectively brought down to 1.4 mg/L before regeneration and to 0.5 mg/L on regeneration with 2N HCl.

- The bed was regenerated with a solution of 2% Na OH,5% NaCl,2N HCl,5% NaCl and 2N HCl.

Advantages:

- It requires minimum contact time for maximum defluoridation .
- Percentage of regeneration is considerably high.
- There is very little attritional loss (to a negligible extent) during the regeneration at the initial stage of operation
- It is indigenously available and cheap.
- Defluoridation capacity at neutral pH is appreciable, although it has greater
- defluoridation efficiency at low pH.
- Its defluoridation capacity is independent of temperature.
- The effect of other ions present in drinking water, like chlorides, sulphates and carbonates, over the defluoridation efficiency of activated alumina is minimum, even though the presence of bicarbonate ions show considerable influence in the process of defluoridation.

Contact Precipitation

- It is a technique by which fluoride is removed from the water through the addition of calcium and phosphate compounds and then bringing the water in contact with an already saturated bone charcoal medium.

Degreased and alkali treated bones

- Degreased and alkali treated bones are effective in the removal of fluoride from initial fluoride concentration ranging from 3.5 mg fluoride/L to 10 mg fluoride/L to less than 0.2 mg fluoride/L

- Bone contain calcium phosphate and has a great affinity for fluoride. The bone is degreased, dried and powdered. The powder can be used as a contact bed for removal of fluoride in water. The exhausted bed is regenerated with sodium hydroxide solution.

Synthetic tri calcium phosphate

Florex

- A mixture of tri-calcium phosphate and Hydroxy -apatite, commercially called Florex, showed a fluoride removal capacity of 600 mg of fluoride per liter and is regenerated with 1.5% sodium hydroxide solution.
- Owing to high attritional losses, Florex was not successful and the pilot plants using this material were abandoned

Activated Carbon

- Most of the carbons prepared from different carbonaceous sources showed fluoride removal capacity after alum impregnation.
- High Fluoride removal capacities of various types of activated carbons had been reported.
- Alkali digested alum impregnated paddy husk carbon was an efficient defluoridating agent.

WATER DESALINATION

- **Fresh Water Needs**

- Economic expansion
- Agriculture and food
- Public health
- Quality of life

Can we drink salt water?

The Rime of the Ancient Mariner

Water, water, everywhere

And all the boards did shrink

Water, water, everywhere

Nor any drop to drink

-Samuel Taylor Coleridge

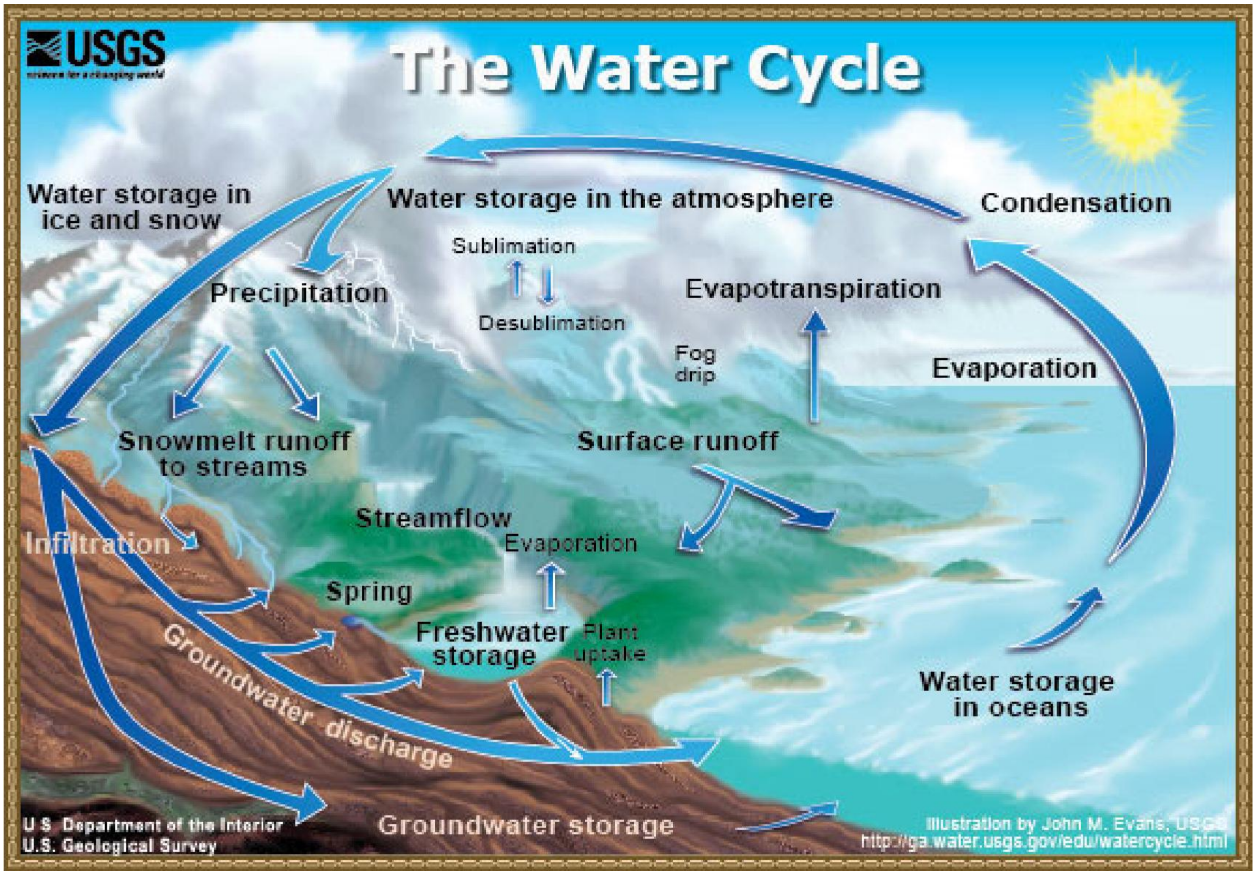
- Small quantities are not harmful, but it is counterproductive (it just makes you more thirsty!)
- Eventually, it can be dangerous, ultimately producing fatal seizures, heart arrhythmias and kidney failure

Why Desalination?

- 75% of the Earth's surface is covered by water
- 97.5% of that water is oceans
- Only 1% is available for drinking
- 80 countries suffered from water scarcity by the mid-1990s
- 1.5 billion people lack ready access to drinking water

Natural Desalination: Water Cycle!- Major Stages

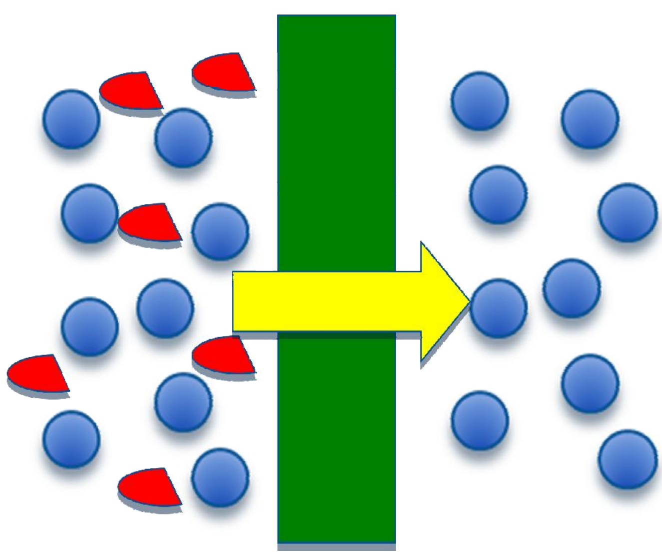
1. Evaporation
2. Condensation
3. Precipitation
4. Collection



Desalination Technologies

1. Membrane Desalination Processes

- Saltwater is forced through membrane sheets at high pressures
- Membrane sheets are designed to catch salt ions
- Process produces clean water and brine



Desalination

- Desalination can be defined as any process that removes salts from water.
- Desalination processes may be used in municipal, industrial, or commercial applications.
- With improvements in technology, desalination processes are becoming cost-competitive with other methods of producing usable water for our growing needs.

Technology

Thermal Technology	Membrane Technology
Multi-Stage Flash Distillation (MSF)	Electrodialysis (ED)
Multi-Effect Distillation (MED)	Electrodialysis reversal (EDR)
Vapor Compression Distillation (VCD)	Reverse Osmosis (RO)

Thermal Technologies

- Thermal technologies, as the name implies, involve the heating of saline water and collecting the condensed vapor (distillate) to produce pure water.
- Thermal technologies have rarely been used for brackish water desalination, because of the high costs involved.
- They have however been used for seawater desalination and can be sub-divided into three groups:
- Multi-Stage Flash Distillation (MSF), Multi-Effect Distillation (MED), and Vapor Compression Distillation (VCD).

Multi-Stage Flash Distillation (MSF)

- This process involves the use of distillation through several (multi-stage) chambers.

- In the MSF process, each successive stage of the plant operates at progressively lower pressures. The feed water is first heated under high pressure, and is led into the first ‘flash chamber’, where the pressure is released, causing the water to boil rapidly resulting in sudden evaporation or ‘flashing’.
- This ‘flashing’ of a portion of the feed continues ineach successive stage, because the pressure at each stage is lower than in the previous stage. The vapor generated by the flashing is converted into fresh water by being condensed on heat exchanger tubing that run through each stage. The tubes are cooled by the incoming cooler feed water.
- Generally, only a small percentage of the feed water is converted into vapor and condensed.

Multi-Effect Distillation (MED)

- Multi-effect distillation occurs in a series of vessels (effects) and uses the principles of evaporation and condensation at reduced ambient pressure.
- In MED, a series of evaporator effects produce water at progressively lower pressures. Water boils at lower temperatures as pressure decreases, so the water vapor of the first vessel or effect serves as the heating medium for the second, and so on.
- The more vessels or effects there are, the higher the performance ratio. Depending upon the arrangement of the heat exchanger tubing, MED units could be classified as horizontal tube, vertical tube or vertically stacked tube bundles

Vapor Compression Distillation

- The vapor compression distillation (VCD) process is used either in combination with other processes such as the MED, or by itself.
- The heat for evaporating the water comes from the compression of vapor, rather than the direct exchange of heat from steam produced in a boiler .

- Vapor compression (VC) units have been built in a variety of configurations.
- Usually, a mechanical compressor isused to generate the heat for evaporation.
- The VC units are generally small in capacity, and are often used at hotels, resorts and in industrial applications.

Membrane Technologies

- Membrane technologies can be subdivided into two broad categories:
- Electrodialyis/Electrodialysis Reversal (ED/EDR), and Reverse Osmosis (RO)

Electrodialysis (ED) and Electrodialysis Reversal (EDR)

- Electrodialysis (ED) is a voltage-driven membrane process. An electrical potential is used to move salts through a membrane, leaving fresh water behind as product water.

Reverse Osmosis (RO) and Nanofiltration (NF)

- Osmosis is a natural phenomenon by which water from a low salt concentration passes into a more concentrated solution through a semi-permeable membrane.
- When pressure is applied to the solution with the higher salt concentration solution, the water will flow in a reverse direction through the semi-permeable membrane, leaving the salt behind. This is known as the Reverse Osmosis process or RO process.

An RO desalination plant essentially consists of four major systems:

a) Pretreatment system

b) High-pressure pumps

c) Membrane systems

d) Post-treatment

V V COLLEGE OF ENGINEERING, TISAIYANVILAI.

DEPARTMENT OF CIVIL ENGINEERING

P.MUTHURAMAN

Email:muthuraman@vvcoe.org **ASSISTANT PROFESSOR**

Date: 10.09.2014

CLASS NOTES ON UNIT V

WATER DISTRIBUTION AND SUPPLY TO BUILDINGS

Requirements of water distribution -Components -Service reservoirs -Functions and drawings -Network design - Economics -Computer applications -Analysis of distribution networks -Appurtenances -operation and maintenance -Leak detection, Methods. Principles of design of water supply in buildings -House service connection -Fixtures and fittings -Systems of plumbing and drawings of types of plumbing.

DISTRIBUTION SYSTEM

After the water properly treated and made safe & wholesome it has to be supplied to the consumers in their individual homes through proper water distribution network.

COMPONENTS

1. Pipe lines of various sizes for carrying water to the street
2. Various valves for controlling the flow rate in the pipes
3. Hydrants for providing connections with the water mains for releasing water during fire
4. Meters for measuring discharges
5. Service connections (services) to the individual homes
6. Pumps for lifting and forcing the water in to the distribution pipes
7. Distribution or service reservoirs for storing the treated water to be feed in the distribution pipes.

UNIT-V

Requirements of Good Distribution System

- It should be capable of supplying water at all the intended places within the city with the reasonably sufficient pressure head.
- It should be capable of supplying requisite amount of water for fire fighting
- It should be cheap with the least capital construction cost
- It should be simple and easy to operate and repair thereby keeping the RMO cost and troubles to the minimum.
- It should be safe against any future pollution of water.
- It should be safe as not cause the failure of the pipe lines by bursting etc.
- It should be fairly water tight as to keep the losses due to leakage to the minimum

Layouts of Distribution Networks

- Dead end system
- Grid iron system
- Ring system
- Radial system

Gravitational Distribution System

- In this system, the water from high levelled source is distributed to the consumer at lower levels by the action of gravity without any pumping.

- For proper functioning of this system the difference of head available between the source and localities must be sufficient enough as to maintain the adequate pressure level.

- The gravitational system is designed so as to leave only minimum permitted available head to the consumer.

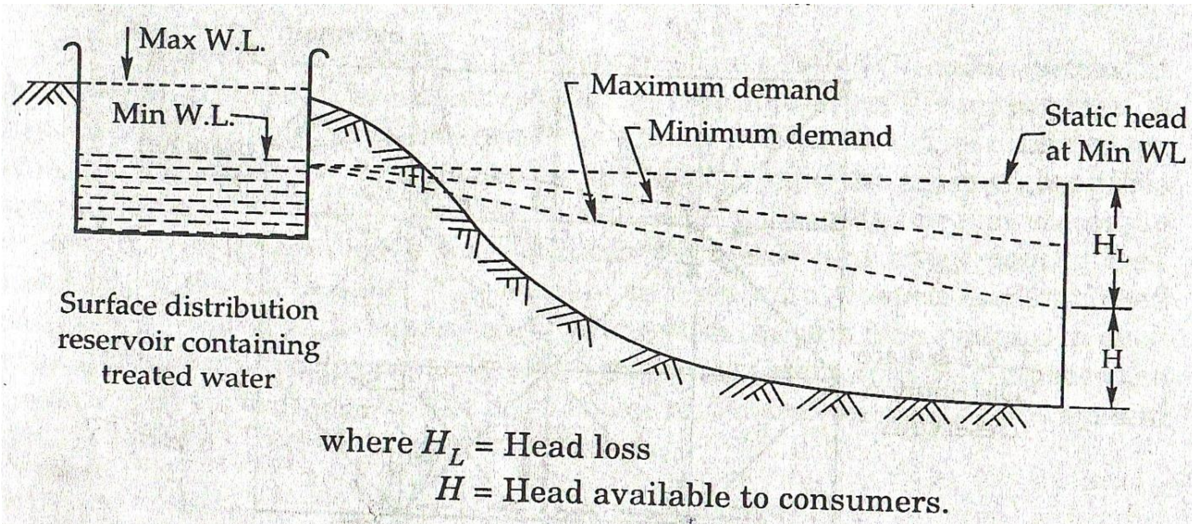


Fig. 10.6. Gravitational distribution system.

PUMPING SYSTEM

- In this system the treated water is directly pumped into the distribution main without storing it anywhere .

- For this reason this system is also sometimes called pumping without storage system.

- High lift pumps are required in this system which have to operate at variable speeds so as to meet variable demand of water.

- If the power supply fails there will be complete stoppage of water supply and if by chance fire breaks out such a time it will bring disaster.

- This method is generally not used.

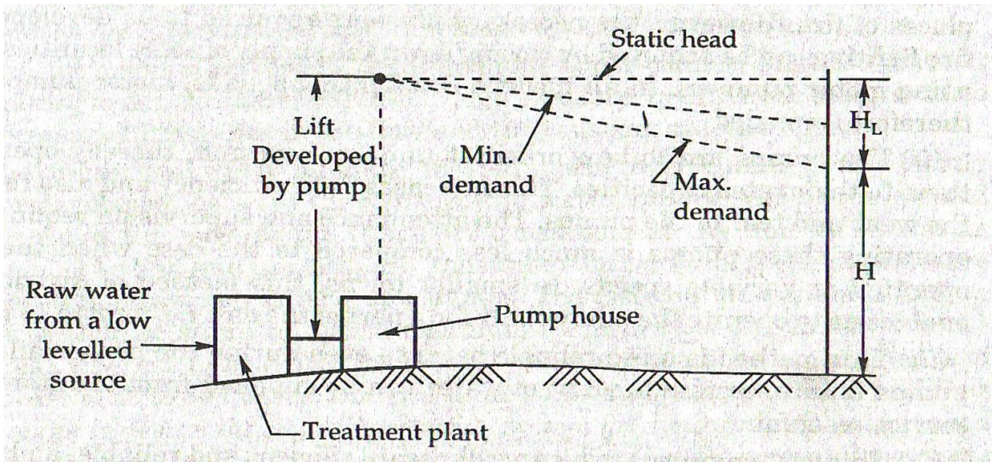
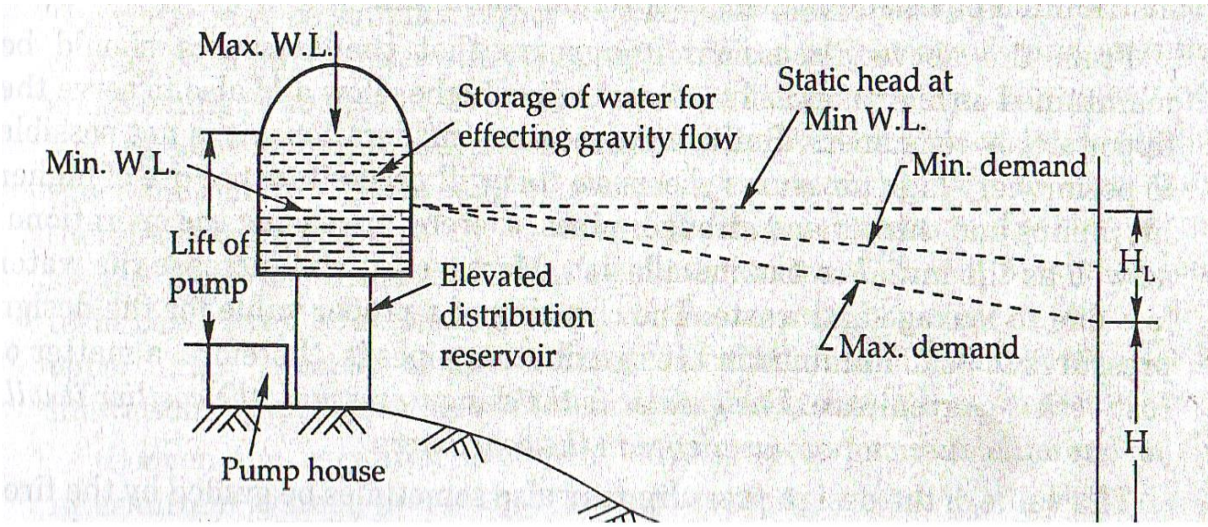


Fig. 10.7. Pumping system for water distribution.

COMBINED GRAVITY AND PUMPING SYSTEM

- In this system the treated water is pumped at a constant rate and stored in a elevated distribution reservoir from where it distributed to the consumer by the action of gravity.
- Sometimes the entire water is first of all pumped in tp the distribution reservoir and many a times it is pumped into the distribution main and reservoir simultaneously.
- This method thus combines the pumping and gravity flow and is sometimes called pumping with storage system.



Advantages

- The balancing reserved water of the distribution system can be supplied to the places of fire.
- The pumps are to be worked at uniform rate and thereby operating them to their rated capacities.
- This method is quite reliable because even during the fire failure or pump failure , certain amount of water can be supplied from the storage or service reservoir.
- This system proves overall cheap efficient and reliable and hence adopted practically everywhere.

Systems of Supply

- Intermittent Supply System
- Continuous Supply System

Distribution Reservoir (or) Service Reservoir

- Distribution reservoirs also called service reservoirs, are the storage reservoir which store the treated water for supplying the water during the emergencies and also to help in absorbing the hourly fluctuations in the normal water demand .

Functions of service reservoirs

- They absorbs the hourly fluctuations in the normal water demand .
- They help in maintaining the constant pressure in the distribution system.
- The pumping of water in shifts is made possible by them without affecting the supply.
- Water stored in the reservoir can be supplied during emergencies
- They lead to overall economy by reducing the size of pumps and pipes and treatment units etc.

TYPES OF SERVICE RESERVOIR

- Based on the elevation with respect to the ground they may be classified in to two types
- Surface Reservoir
- Elevated Reservoir

SURFACE RESERVOIR

- Surface reservoir are circular or rectangular tanks constructed at ground level or below the ground level .

- They are therefore called Ground reservoir.
- They are generally constructed at high points in the city.
- These types of reservoir generally divided in to two compartments so that one may be cleaned and repaired while the other in use.
- Ventilators are provided in the roof slab so as to obtain free circulation of air.
- The floor cement concrete will sloped towards the central washout pipes.

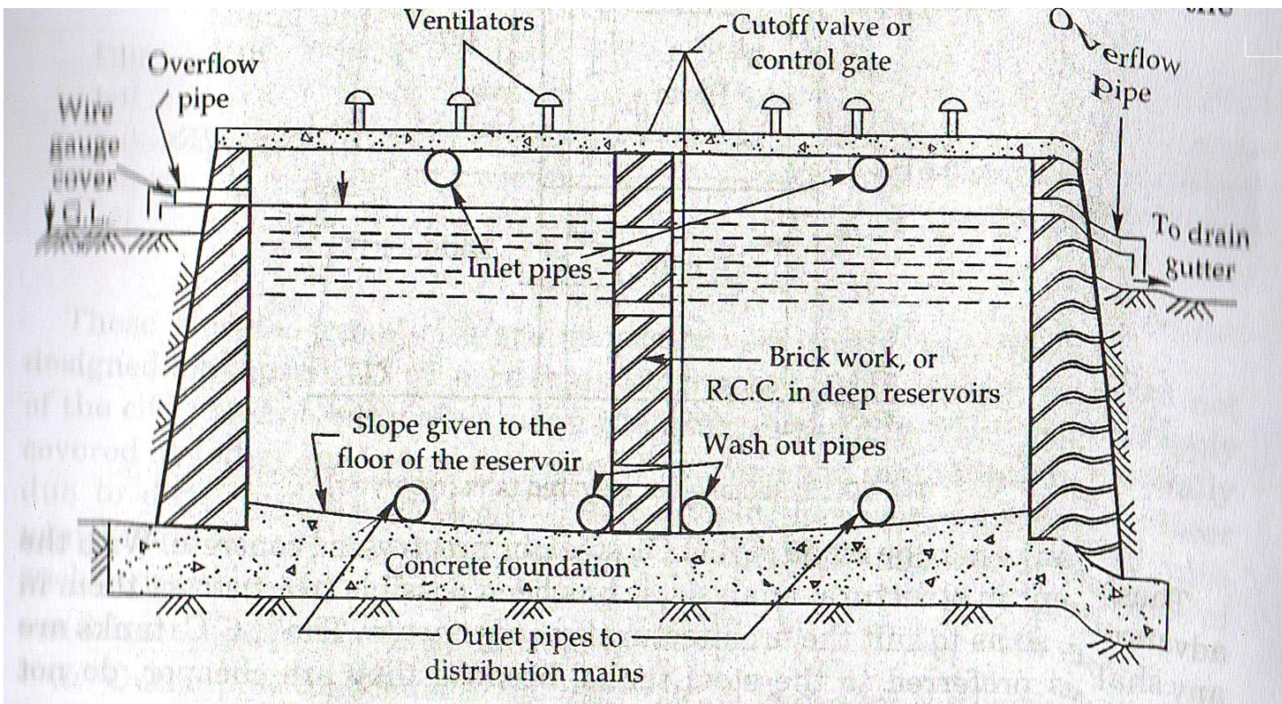


Fig. 10.9. Typical section of a ground reservoir.

ELEVATED RESERVOIR

- Elevated reservoirs are the rectangular, circular, or the elliptical overhead tanks erected at certain suitable elevation above the ground level and supported on towers.

- They are constructed where the pressure requirements necessitate considerable elevation above the ground surface and where the use of stand pipes becomes impracticable.
- They are constructed in areas where the combined gravity and pumping system for water distribution is adopted.
- Water is pumped in to this elevated tanks from the filter units and then supplied to the consumer.

Accessories of Service Reservoir

- Inlet pipe for the entry of water
- Outlet pipe connected to the distribution main
- Overflow pipe discharging into the drain gutter and maintaining the constant head
- A float gauge or an indicator for indicating the depth of water which can read from outside.
- A wash out pipe for removing of water after cleaning the reservoir.
- Automatic device to stop pumping when the tank is full
- Ladders to reach the top of the reservoir and then up to the bottom of the reservoir for inspection.
- Manholes for providing entry into the tank for inspection purposes.
- Ventilators for fresh air circulation

STAND PIPE

- Stand pipes are a kind of elevated tanks without any erected towers for resting the tank body.
- They are thus tall cylindrical shells resting directly on the ground.
- The stand pipes may be 15 to 30 m high and 10 to 15 m in diameter.
- They may be made up of RCC or preferably of steel containing 0.2% copper.
- Because of their large heights , the hoop tension is developed at the portion is very high . RCC is difficult to withstand such a high pressure.

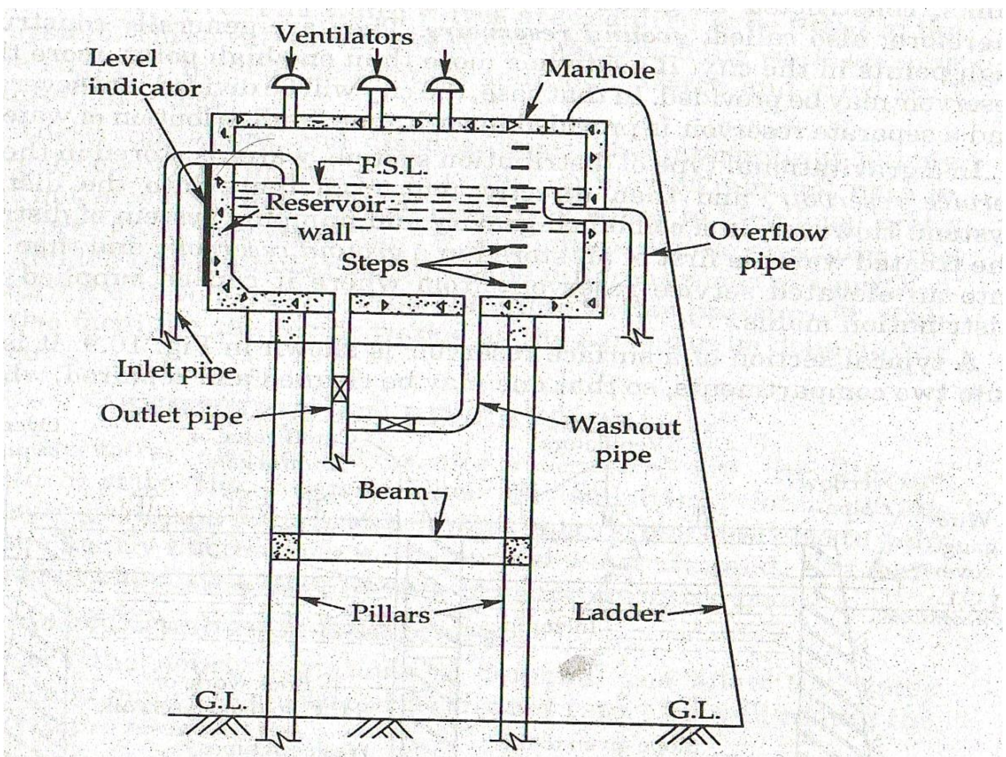
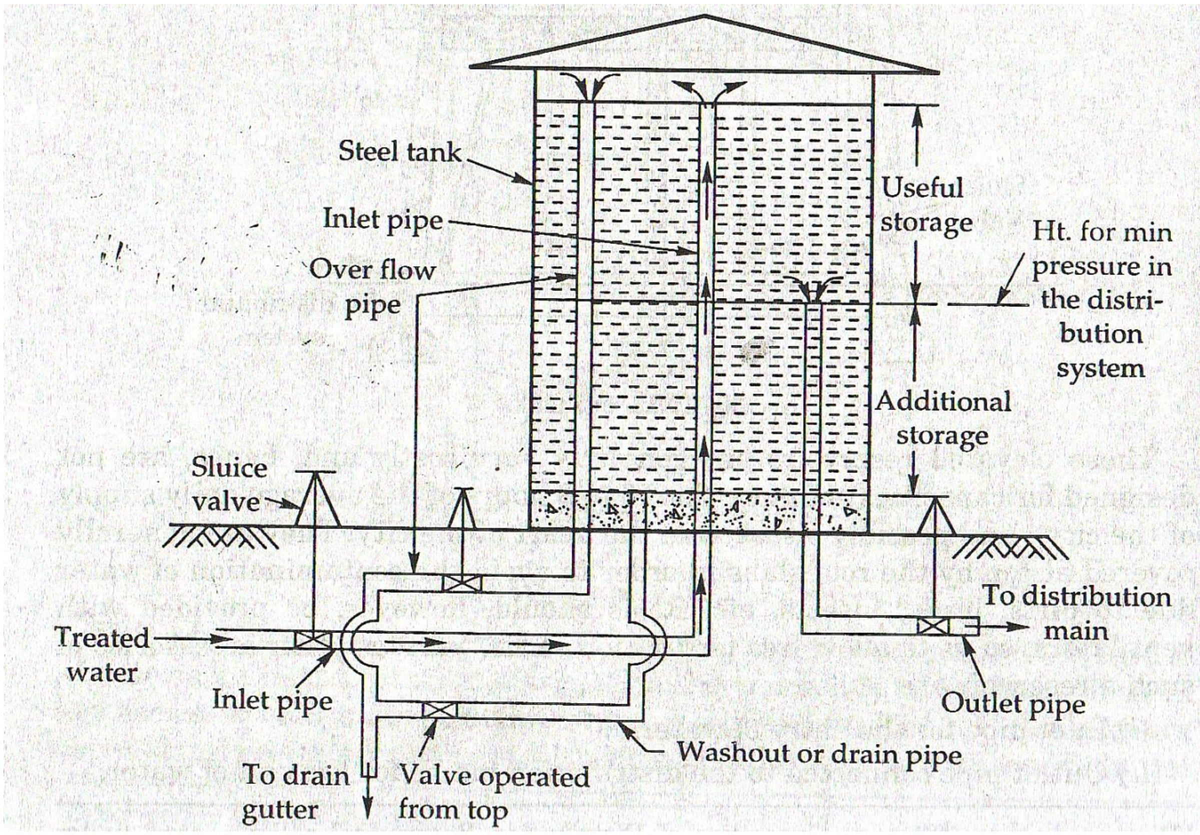


Fig. 10.10. Rectangular elevated tank (reservoir).

STAND PIPE



Storage capacity of Distribution Reservoir

- The total storage capacity of a storage reservoir is the summation of
- Balancing Storage (or equalizing or operating storage)
- Breakdown Storage
- Fire Storage

Balancing Storage (or equalizing or operating storage)

- The main aim of a distribution reservoir is to meet the fluctuation in water demand with a constant rate of supply from the treatment plant.
- The quantity of water required to be stored in the reservoir for equalizing or balancing this variable demand against the constant supply is known as

Balancing Storage or equalizing or operating storage .

LOCATION OF DISTRIBUTION RESERVOIR

- They should be located in the heart of the city so as to command the maximum area all around.
- They should be located at high elevations so that adequate pressure is maintained in the distribution system.
- Based on the pumping station it can be located in two different ways.

    a) they can be placed between the pumping station and distribution area

    b) they can be placed at the farthest end of the distribution area.

LEAK DETECTION

- By Direct observation
- By using Sounding rod
- By plotting Hydraulic gradient
- By using waste detecting meter

DESIGN & ANALYSIS OF WATER DISTRIBUTION NETWORK

- HARDY CROSS METHOD
- EQUIVALENT PIPE METHOD
- OTHER METHOD

WATER SUPPLY PLUMPING SYSTEM

- **Plumbing**
- Plumbing is the general term which indicates the practice materials and fixtures used in the installation or maintenance of all piping , and fixtures etc.
- **Plumbing water supply system.**
- The entire system of piping, fixtures and other appliance etc used in providing water supply and drainage facilities in a building is called plumbing water supply system.

THE HOUSE WATER CONNECTION

- To get water supply connection from municipalities
- It consists of the followings.
- A ferrule
- Goose neck
- Service pipe
- Stop cock
- Water meter

WATER CONNECTIONS

A Ferrule

- A ferrule is a right angled sleeve made of brass or gun metal and is joined to a hole drilled in the water main to which it is screwed down with a plug.

Goose neck

- Goose neck is small sized curved pipe made up of a flexible material and is about 75 cm in length forming a flexible connection between the water main and the service pipe.

Service pipe

- It is a galvanized iron pipe of size less than 50 mm dia . It should be laid in under ground in a trench in which no sewage or drainage pipe is laid. The service pipe which supplies water to the building through the municipal mains is connected to the main through goose neck and ferrule.

Stop cock

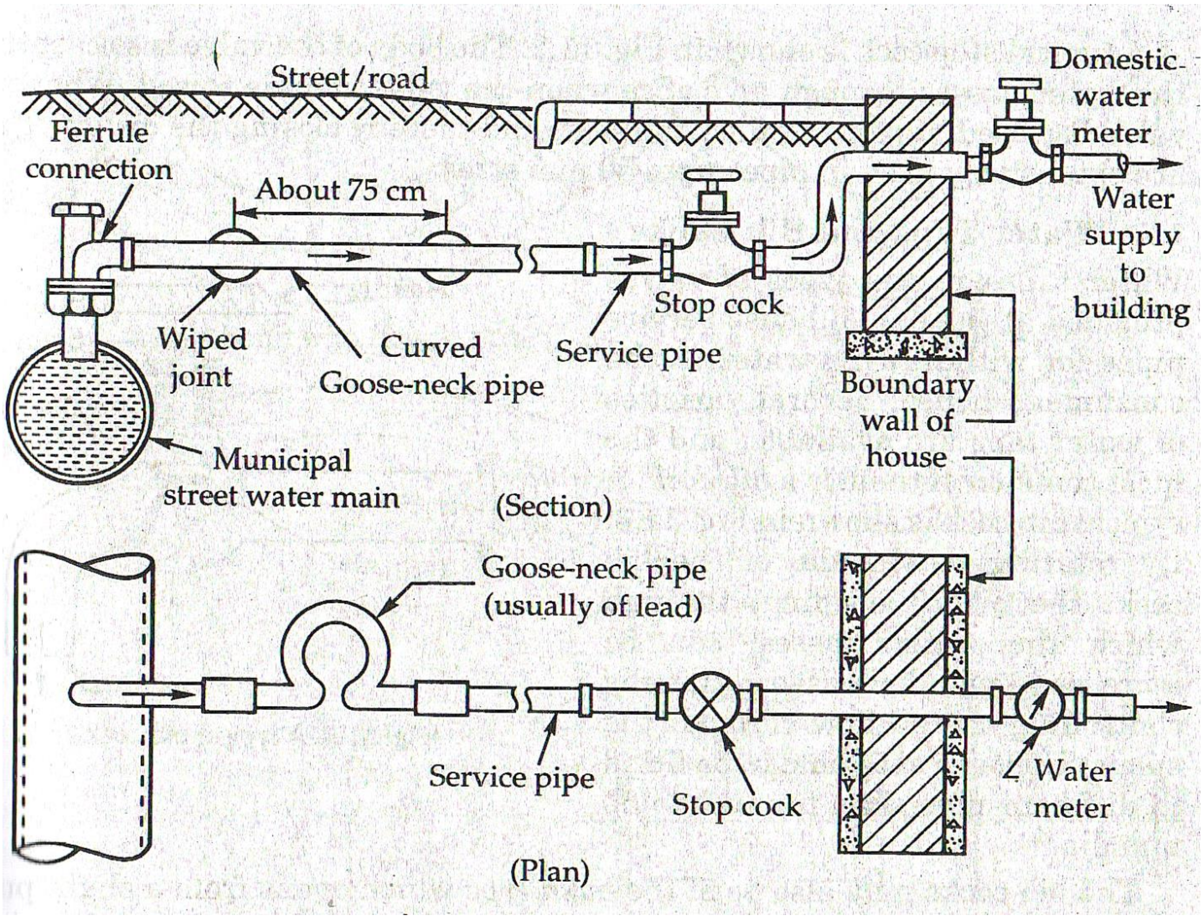
- The stop cock is provided before the water enters the water meter in the house. It is placed in a suitable masonry chamber with a removal cover and is fixed in the street close to the boundary wall in an accessible station.

Water meter

- It measures and records quantity of water consumed in the house.

TYPES OF STORAGE IN BUILDINGS

- OVER HEAD STORAGE
- UNDER GROUND STORAGE



OVER HEAD STORAGE

- R.C.C TANKS
- G.I TANKS
- HDPE TANKS

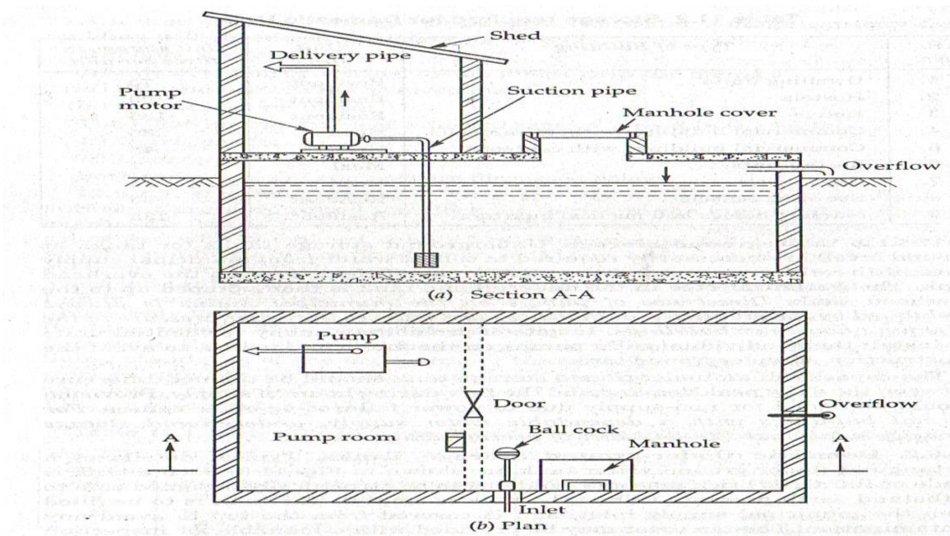


Fig. 11.5. A typical underground water storage tank.

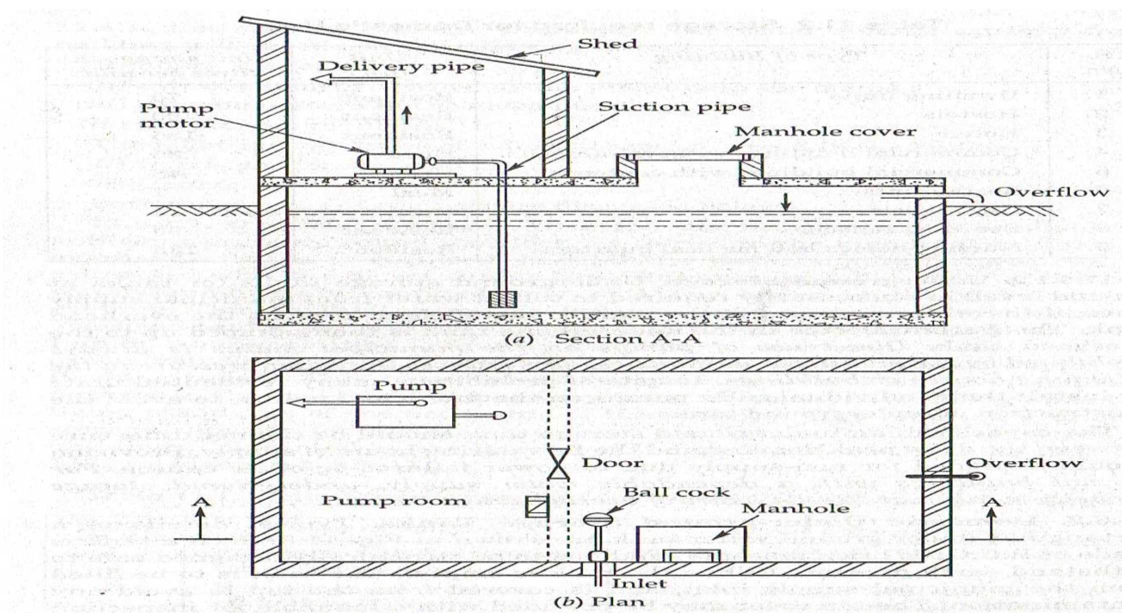


Fig. 11.5. A typical underground water storage tank.

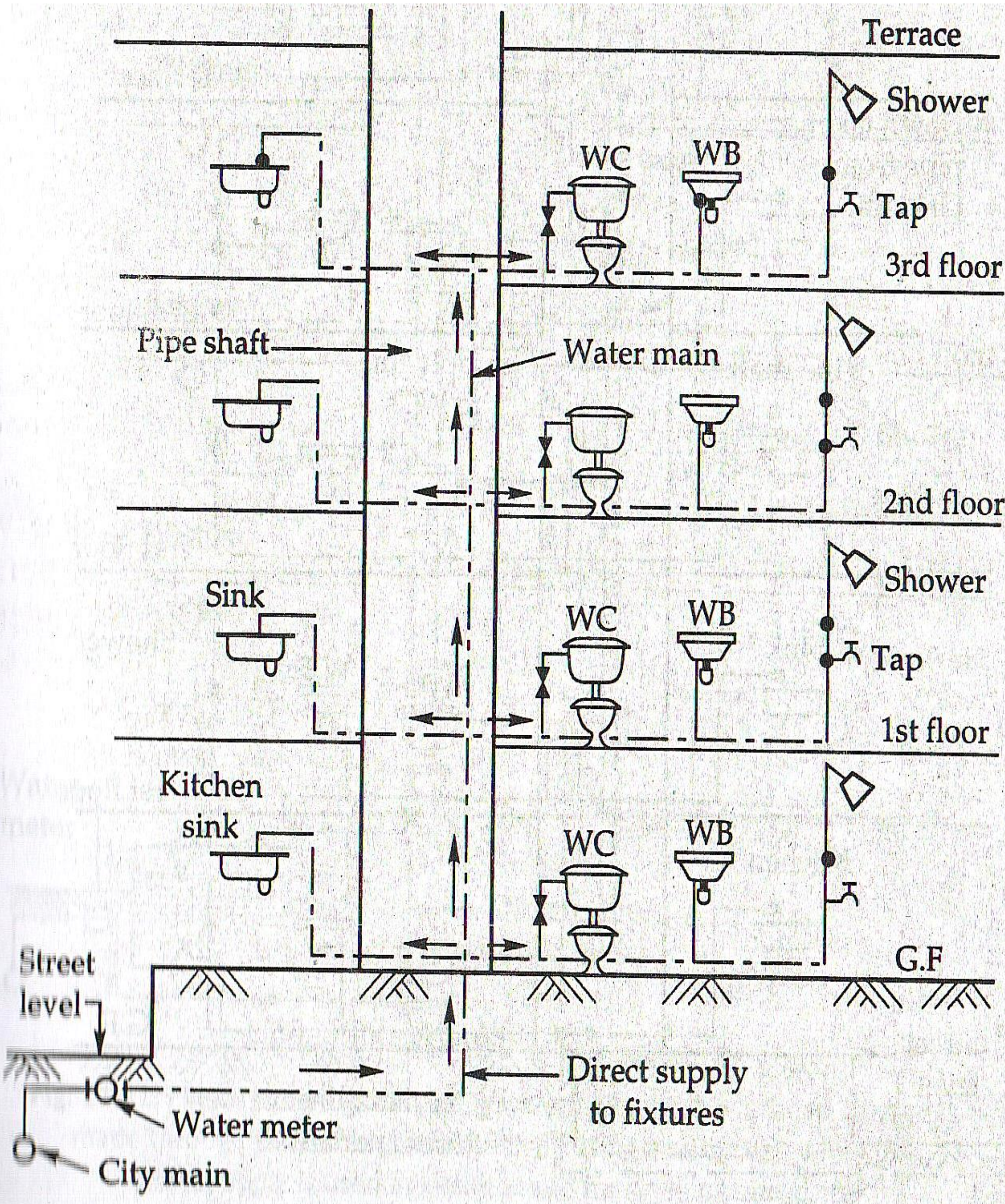
REQUIREMENTS OF WATER STORAGE TANKS

- The water storage tanks should be water tight and they should be constructed with non corrosive and non toxic materials.
- The water storage tanks should be provided with the vent pipe for ventilation and prevention of negative pressure.
- The water storage tanks should have an overflow pipe or warning pipe.

- The water storage tanks should have a scour pipe with a plug at the bottom so that it can be emptied easily.
- Under no circumstances should any overflow or scour pipe be directly connected to any drain or sewer.

WATER PIPING SYSTEM IN BUILDINGS

- Piping system using Direct water supply
- Piping system using Overhead Tanks
- Piping system using Underground - Overhead Tanks
- Pumped System



Terrace
Shower
WC
WB
Tap
3rd floor
Pipe shaft
Water main
2nd floor
Sink
Shower
WC
WB
Tap
1st floor
Kitchen sink
WC
WB
G.F
Street level
Direct supply to fixtures
Water meter
City main

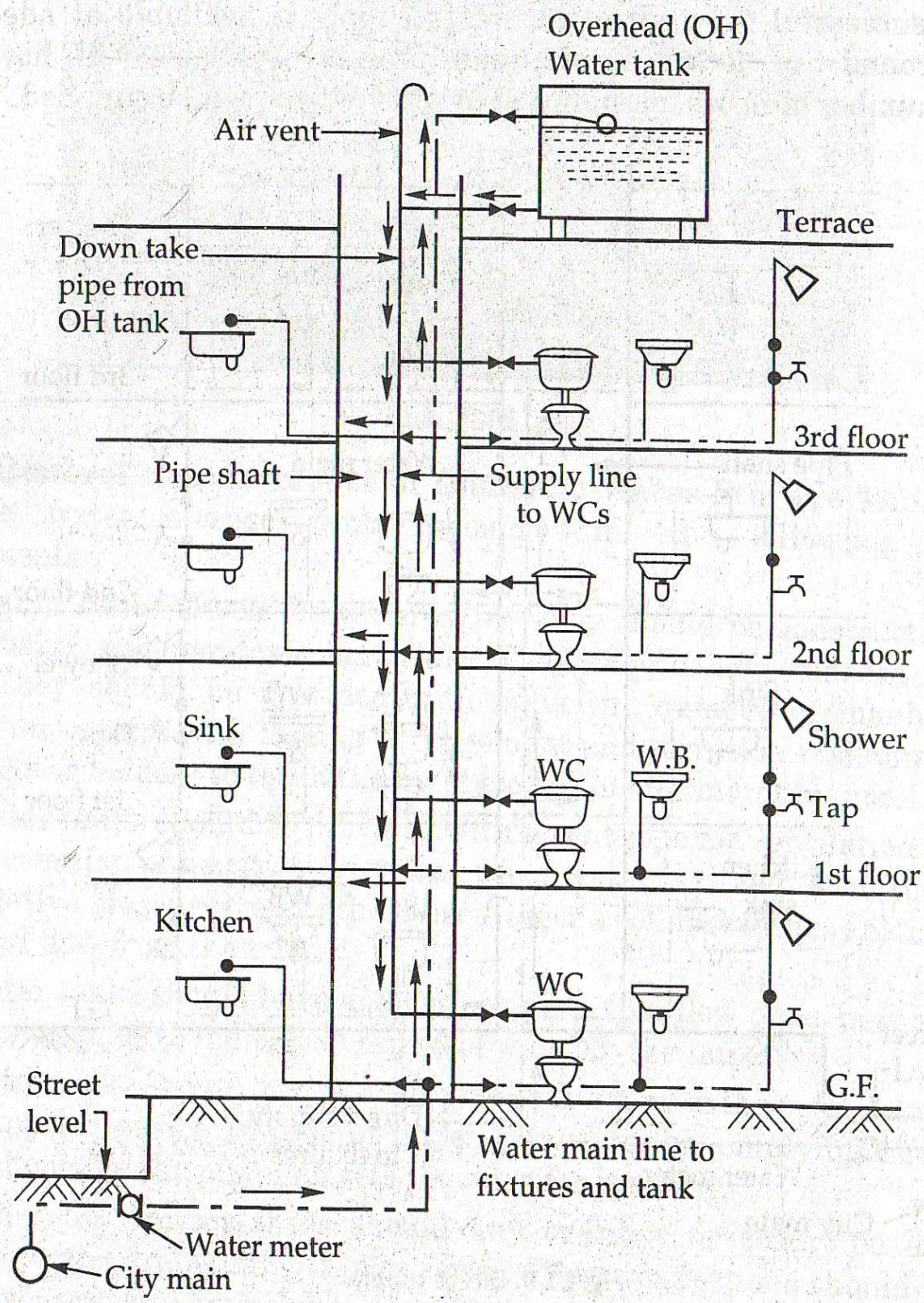


Fig. 11.10. Direct supply supplemented with an overhead tank supply.

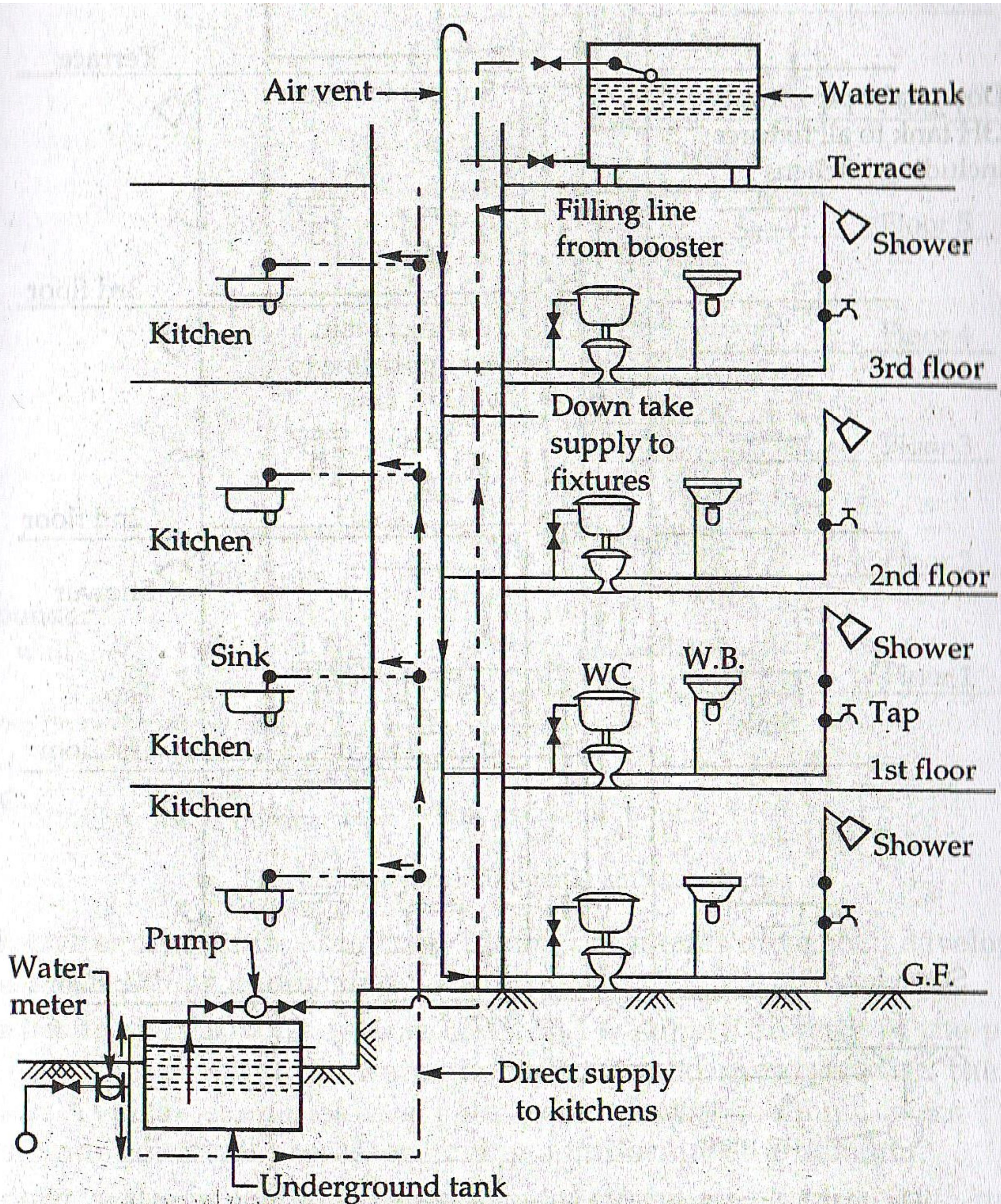


Fig. 11.11. Figure showing the piping system when the overhead storage is made through the underground tank by using a pump set, while the direct supply is used in kitchens and for drinking purposes.

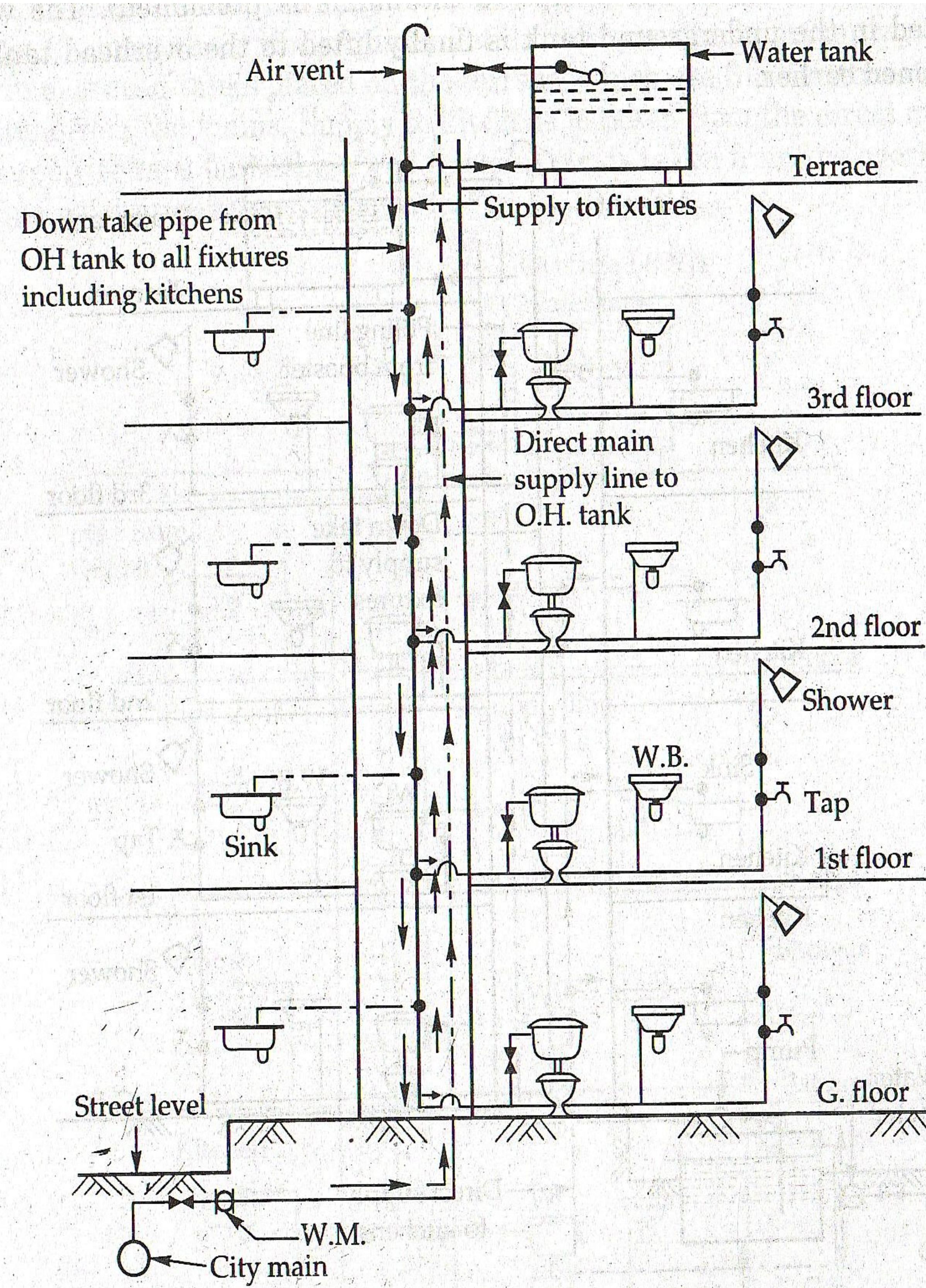


Fig. 11.12. Total overhead tank supply through underground tank.

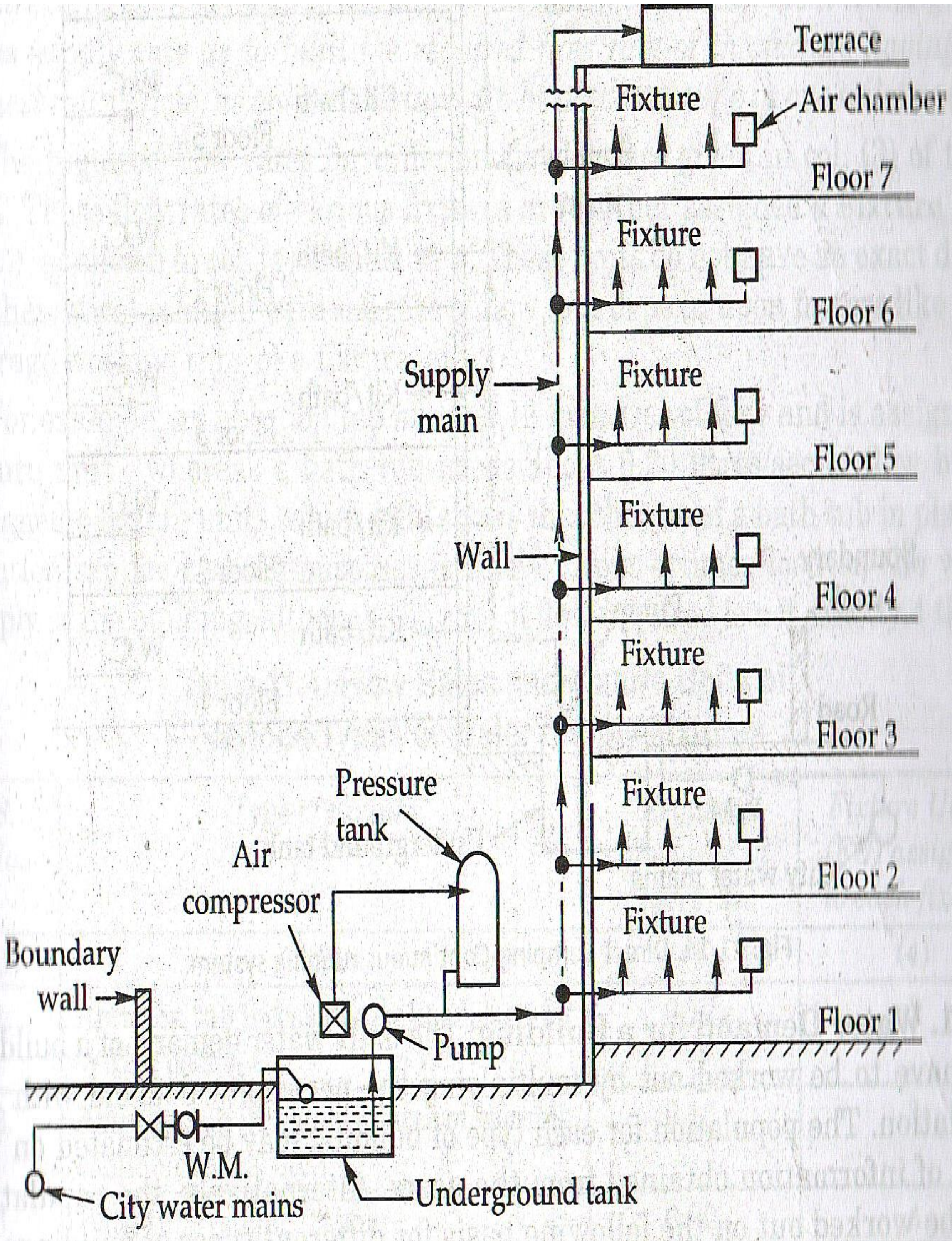


Fig. 11.13. Hydro-Pneumatic piping system.

V V COLLEGE OF ENGINEERING, TISAIYANVILAI.

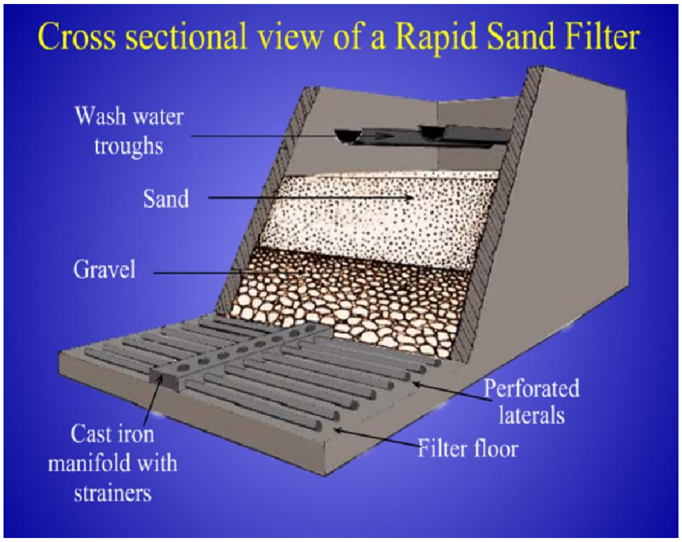
DEPARTMENT OF CIVIL ENGINEERING

P.MUTHURAMAN

Email:muthuraman@vvcoe.org **ASSISTANT PROFESSOR**

Date: 04.09.2014

<u>Class Notes on Filtration</u>



- The resultant water after sedimentation will not be pure, and may contain some very fine suspended particles and bacteria in it.
- To remove or to reduce the remaining impurities still further, the water is filtered through the beds of fine granular material, such as sand, etc.
- The process of passing the water through the beds of such granular materials is known as Filtration.

EN8491 – WATER SUPPLY ENGINEERING

TWO MARKS Question and Answers

UNIT I PLANNING FOR WATERSUPPLY SYSTEM

1. What are the methods of population forecasting?

- Arithmetic increase method
- Geometric increase method
- Method of varying increment (or) Incremental increase method
- Decreasing rate of growth method
- Simple graphical method
- Comparative graphical method
- Master plan method (or) zoning method
- The logistic curve method

2. Define design period?

The future period for which a provision is mode in the water supply scheme is known as design period.

3. What are the factors governing the design period?

The factors governing design period are,

a. Design period should not exceed the life period of the structure.

b. If the funds are not in a sufficient, the design period as to be decreased. c. The rate of interest on borrowing and the additional money invested.

4. What are various type of water demand?

a. Domestic water demand b. Industrial

c. Institution and commercial d. Demand for public use

e. Fire demands

5. What are the various type of water available on the earth?

1. Surface sources such as a. ponds and lakes

b. Stream and rivers c. Storage reservoirs d. Ocean.

2. Sub surface sources a. Spring

b. Infiltration galleries c. Infiltration wells

d. Wells and tube wells

6. What is hydrologic cycle?

Water is lost to the atmosphere as vapor from the earth. Which is then precipitated back in the form of rain, snow, hail dew, sleet or frost etc.This process is known as hydrologic cycle.

7. What are rivers? What are the types of river?

Rivers are the most important sources of water for public water supply schemes. Rivers are of two types, they are

a. Perennial rivers.

b. Non perennial rivers.

8. What is jack well?

The various infiltration wells are connected by porous pipes to a sump well called jack well.

9. What are springs?

The natural out flow of ground water at the earth surface is called as springs.

10. What are the types of springs?

a. Gravity springs. b. Surface springs. c. Artesian springs.

11. What are artesian springs?

The pervious layer which contains water combined between two impervious layers are called artesian springs.

12. What are the different types of wells?

a. Open wells

1. Shallow wells.

2. Deep wells. b. Tube wells.

13. What is artesian spring?

The pervious layer which contains water combined between two impervious layers is called artesian spring.

14. What are the factors governing the selection of a particular source of water?

The factors governing are as follows a. the quantity of available water

b. The quality of available water

c. Distance of the source of supply

d. General topography of the intervening area

e. Elevation of the source of supply.

15. What are the factors affecting per capita demand?

The factors affecting per capita demand are,

a. Climatic condition.

b. Habit of people.

c. Size of city.

d. Cost of water.

e. Industry.

f. Pressure in water tank. g. Quantity of water.

h. System of sanitation. i. Supply of system.

16. What are the factors governing design period?

The factors governing design period are,

a. Design period should not exceed the life period of structure.

b. If the funds are not in the sufficient the design period should has to be decreased.

c. The rate of interest is less for the borrowing funds.

d. The of population increases due to industries and commercial establishment.

UNIT II CONVEYANCE SYSTEM

17. What are various type pressure pipes?

a. Cast iron pipes b. Steel pipes

c. Rick pipes

d. Home steel pipes e.Vitrified clay pipes

f. Asbestos cement pipes

g. Miscellaneous type of pipes.

18. What are the advantages and disadvantages of cast iron pipes?

Advantages:

a. Moderate in cost

b. Easy to join

c. Strong and durable

d. Corrosion resistant

Disadvantage:

a. They can not be used for high pressures generally not used for pressures above

7kgkm

c. When large they are heavy and uneconomical.

d. They are likely to break during transportation or while making connection.

19. What are types of joint?

a. Socket and spigot joint B.Flanged joint

c. Mechanical joint called dresser coupling

d.Elexible joints

e. Expansion joints

20. How the corrosion of metal pipes is reduced?

The corrosion of metal pipes can be reduced by following method a. Protective coating

b. Selecting proper pipe material c. Quality of water

d. Cathodic protection.

21. What are the factors governing location of intake?

a. Intake structures are nearer to the treatment.

b. Intake structures must never be located near the disposal of water.

c. Intake structures should never be located near the navigation channel.

d. There should be sufficient scope for future expansion.

22. What are the types of intake?

1. Simple submerge intake. a. Simple concrete blocks. b. Rock fill timber blocks.

2. Intake structures. a. Wet intake.

b. Dry intake.

23. What are vitrified clay pipes?

They are not generally used as pressure pipe for carrying because they are weak in tension. They are extensively used for carrying sewage and drainage at partial depth.

24. What are the advantages and disadvantages of RCC pipes?

Advantages:

a. They can resist excessive compressive load and do not collapse under normal vacuums.

b. They are not corroded from inside by normal portable water.

Disadvantages:

a. By means of acid they are corroded.

b. They cannot with stand very high pressure.

25. What are tube wells?

Tube wells which a long pipe or a tube is bored or drilled deep in to the ground.

26. What are the various methods of purification of water?

The various methods of purification of water are, a. Screening.

b. Plain sedimentation.

c. Sedimentation aided with coagulation. d. Filteration.

e. Disinfection. f. Aeration.

g. softening.

h. Miscellaneous treatments such as fluoridation, recarbornation, liming, desalination.

UNIT -3 WATER TREATMENT

27. Define detention period?

Detention period of settling tank may be defined as the average theoretical time required for the water to flow through tank length.

28. Define coagulation?

The process of addition and mixing the chemical is called coagulation.

29. Define filtration? What are the 2 types of filter?

The process of passing the water through the beds of such granular materials is known as filtration.

The two types of filters are, a. Slow sand gravity filter. b. Rapid sand gravity filter.

30. What is schmutzdecke or dirty skin?

The harmless compound so formed, generally form a layer on the top which is called schmutzdecke or dirty skin. The layer helps in absorbing and straining out the impurities.

31. Define uniform coefficient

It is defined as the ratio of the sieve size in mm through which 60% of the samples of sand will pass, to the effective size of the sand.

32. Define sterilization?

The chemical used in killing these bacteria are known as disinfectants and the process is known as disinfection or sterilization.

33. What is chloramine?

Chloramine is the disinfectant compounds which are formed by the reaction between ammonia and chlorine.

34. What is softening?

The reduction or removal of hardness from water is known as water softening.

35. Define alkalinity?

It is defined as the quantity of ions in water that will react to neutralize the hydrogen ion. It will thus represent the ability of water to neutralize acid.

36. What is permutit?

The most common artificial zeolite is a white colored substance called permutit manufactured from feldspar, kaolin, clay, and soda.

37. Differentiate between slow and rapid sand filter with respect to

(a). Rate of filtration.

(b). loss of head.

38. What are the methods of removing permanent hardness?

The methods removing permanent hardness are,

a. Lime soda process.

b. Base exchange process called zeolite process. c. Demineralization.

39. How are aeration water carried out?

Aeration water are carried out as follows,

a. By using spray nozzles.

b. By permitting water to trickle over the cascades. c. By air diffusion.

d. By using trickling beds.

40. Define fluoridation?

The process of adding fluoride compounds in excess is called as the fluoridation.

41. What are the methods of desalination?

The methods of desalination are,

a. Desalination by evaporation & distillation. b. Electro dialysis method.

c. Reverse osmosis method. d. Freezing process.

e. Solar distribution method. f. Other method.

42. What is different system of distribution networks?

The different system of distribution networks is, a. Dead end system.

b. Grid iron system. c. Ring system.

d. Radial system.

43. What are various methods of distribution system?

The various methods of distribution system are, a. Gravity system.

b. Pumping system.

c. Combined gravity and pumping system.

44. Define fire storage?

It is sufficient amount of water available in the reservoir for throwing it over the fire in case of fire accidents is called fire storage.

45. Enumerate various chemical parameter of water?

Various chemical parameter of water are, a. Chlorine content.

b. Nitrogen content. c. Iron content.

d. Manganese and other metal content.

46. What are the two types of sewage system?

The two types of sewage system are, a. Combined system:

When the drainage is taken along with the sewage then it is called as combined system.

b. Separate system:

When the drainage and sewage are taken independently of each through two different sets of sewage is called as separate system.

47. What are the two types of water meter?

The two types of water meter are,

a. Inferential meter.

b. Displacement meter.

48. Define time of concentration?

The period after which the entire area will start contributing to the runoff is called time of concentration.

49. List the components of sewerage system?

The components of sewerage system are, a. House sewers.

b. Lateral sewers. c. Branch sewers. d. Main sewers.

e. Outfall sewers.

f. Man holes.

50. What is peak drainage disturbance?

The method estimating the maximum rate of storm runoff is called as peak drainage disturbance.

51.Mention some shapes of sewer pipes

- Circular shape
- Egg shape
- Horse shoe shape
- Parabolic shape
- Elliptical shape

52.What are the forces acting on sewer pipes?

 Internal pressure ofsewage

 Pressure due to external loads

 Temperature stress

 Flexural stress

53.What are the materials used for constructing sewer pipes?

 Vitrified clay

 Cement concrete

 Asbestos cement

 Cast iron

54.Give some qualities of the good sewer pipes

 Resistance to corrosion

 Resistance to abrasion

 Strength and durability

 Light weight

 Economy and cost

55.What are the tests conducted in sewer pipes after laying?

 Test for leakage(water test)

 Test for straightness of alignment and obstruction

56.Define sewer appurtenances

 Sewer appurtenances are those structures which are constructed at suitable interval along a sewerage system and help in its efficient operation and maintenance

57.Mention the classification of manholes

 Shallow manholes

 Nomr al manholes

 Deep manholes

58.What is meant by catch basins?

 Catch basins are nothing but street inlets provided with additional small setting basins for avoiding the entry of the particles like grit, sand ,debris in to the sewer pipes

59.Define inverted siphons

 Inverted siphon is defined as the sewer section constructed lower than the adjacent sewer section and it runs full under gravity with pressure greater than the atmosphere

60.What are the various methods of ventilation for sewers?

 Useof ventilating columns

 Use of ventilating manhole covers

 Proper design of sewers

 Use of mechanical devices

61.What are the different types of pumps used commonly for pumping the sewage?

 Centrifugal pump

 Reciprocating pump

 Pneumatic ejectors (or) Air pressure pumps

Unit -4 ADVANCED WATER TREATMENT

62. What is the purpose of using velocity control device in a grid chamber?

 The velocity control device in a grid chamber is providing for settling the grid particles in the sewer pipes and then it is removed by an endless chain to which perforated buckets are fixed

63. Mention the classification of treatment process of sewage

- Preliminary treatment
- Primary treatment
- Secondary treatment
- Complete final treatment

64. State the purpose of using the skimming tanks

 The skimming tanks are employed for removing oils & grease from the sewage and placed before the sedimentation tanks

65. Why baffles are provided in the sedimentation tank in sewage treatment?

 Baffles are required to prevent the movement of organic matters and it escapes along with the effluent and to distribute the sewage uniformly through the cross section of the tank and thus to avoid short circuiting

66. What are the types of trickling filters?

 Conventional trickling filter

 High rate trickling filter

67. What are the operational troubles in trickling filter?

 Fly nuisance

 Odour nuisance

 Ponding troubles

68. Define sludge

 The sludge age is defined as the average time for whichparticles of suspended soil remain under aeration

69. Define sludge volume index

 sludge volume index is defined as the volume occupied in ml by 1 gm of solids in the mixed liquor after settling for 30 minutes and is determined experimentally

70. What is meant by biodegradable organic matter?

 The organic matters is decomposed by bacteria under biological action is called biodegradable organic matter

71. What are the various tests for finding the quality of sewage?

 Turbidity test

 Colour test

 Odour test

 Temperature test

72.What is meant by relative stability of a sewage effluent?

 The relative stability of a sewage effluent is nothing but the ratio of oxygen available in the effluent to the total oxygen required to satisfy its first stage BOD demand

73. What are the methods of disposing the sewage effluent

 Disposal in water(dilution)

 By disposal on land

74.What are the different types of sewage treatment?

 Contact beds

 Intermittent sand filters

 Trickling filters

 Miscellaneous type offilters

75.Define sludge digestion

 The process of stabilization of the sewage particles are called sludge digestion

76.What are the stages in the sludge digestion process?

 Acid fermentation

 Acid regression

 Alkaline fermentation

77.What is meant by ripened sludge?

 The ripened sludge is nothing but the digested sludge is collected at the bottom of the digestion tank and it is alkaline in nature

78.What are the factors affecting sludge digestion and their control?

 Temperature

 pH value

 mixing and stirring of raw sludge with digested sludge

79.What are the types of incinerators has primary designed?

 multiple hearth furnace

 fluid bed furnace and infra red furnace

80.What are the methods of aeration ?

 diffused air

 mechanical aeration

combined aeration

81.What is meant by sludge concentrator unit ?

 the sludge obtained in a sludge digestion plant contains too much of moisture and is therefore very bulky may be reduced in its moisture content by sending into sludge thicker unit (or) sludge concentrator unit

82.Give different types of thicker unit

☐ Gravity thickener

☐ Floating thickener

☐ Centrifugal thickener

83.What are the methods of disposal of septic tank effluent?

☐ Soil absorption system

☐ Biological filters

☐ up flow anaerobicfilters

84.Define percolation rate

☐ percolation rate is defined as the time in minuets required for sewage of water through that ground by one cm

85.what are the soil absorption system

☐ dispersion trench

☐ seepage pit (or) soak pit

86.What are the methods of applying sewage effluents to forms ?

☐ surface irrigation

☐ free flooding

☐ border flooding

☐ check flooding

87.What is meant by oxygen sag curve?

☐ The amount of resultant oxygen deflect can be obtained by algebraically adding the de - oxygenation and re -oxygenation curves. The resultant curve so obtained is called oxygen sag curve

88.What is meant by sewage sickness?

 The phenomena of soil getting clogged when the sewage is applied continuously on a piece of land is called sewage sickness

89.What are the preventive methods for sewage sickness?

 Primary treatment of sewage

 Choice of land

 Under drainage of soil

 Giving rest to land and Rotation of crops

90.Define dilution factor

 The dilution factor is defined as the ratio of the amount of rvi er water to the amount of the sewage

<u>Unit -5 WATER DISTRIBUTION AND SUPPLY TO BUILDINGS</u>

91.What is meant by self purification?

 The automatic purification of natural water is known as self

92.List various natural forces of self purification

 Physical of rces

 Chemical forces

93.What are the factors affecting the reduction ?

 Temperature

 Turbulence effect of wind

 Hydrographic

 Available dissolved oxygen

□ Rate of re-aeration

94.What is meant by prim lake pollutant ?

□ The phosphorus which containsin domestic sewage as well as in the industrial waste which affect the water quality of the lake and its called prim lake pollutant

95.What is meant by de oxygenation curve?

□ The curve which represents (or) showing the depletion of D.O with time at the given temperature

96.How the river maintaining its clearness?

□ The turbulence in the water body helps in breaking the surface of the stream and helps in rapid re aeration from the atmosphere. Thus it helps in maintaining aerobic conditions in the stream and keeping it clear

97.Name the biological zone in lakes

□ Euphonic zone

□ Littoral zone

□ Benthic zone

98.What is meant by re -oxygenation?

□ In order to counter balancethe consumption of D.O due to the de – oxygenation

,atmosphere supplies oxygen to the water and the process is called the re -oxygenation

99.What is meant by zone of recovery?

□ The zone in which the river water tries to recover from its degraded conditions to its former appearance is called zone of recovery

100.What is meant by sludge banks?

□ When the solid waste are thrown into the sea water, chemical react with the dissolved matter of sea water and resulting in some precipitation of solid waste giving a milky appearance to sea water forming the sludge banks.